2018 PROFESSIONAL DEVELOPMENT RESOURCE GUIDE GROUND VEHICLE
CATALOG KEY
You will see the following icons alongside the course descriptions. These icons indicate:

• delivery formats available for the course
• the course is part of an SAE certificate
• that it is an ACTAR approved course

Many courses are available in multiple formats. See page XIV to get more information on the learning formats offered by SAE. In addition to finding courses that fit your technology need, look for courses with icons that fit the way you want to learn.

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To obtain official transcripts, please contact SAE Customer Service at +1.877.606.7323 (U.S. and Canada only) or +1.724.776.4970 (outside U.S. and Canada)

ACTAR Approved SAE Courses

Some SAE courses have been approved by the Accreditation Commission for Traffic Accident Reconstruction (ACTAR) for Continuing Education Units (CEUs). In addition, the ACTAR CEUs are also listed with the course description.

ACTAR approved courses feature the ACTAR icon.

Upon completion of any of these courses, accredited reconstructionists should contact ACTAR, +1.800.809.3818, to request CEUs. As an ACTAR approved course, the fee for the CEUs for each course is $5.00.
Explore classroom, live and online, or on-demand courses. Many courses are offered in multiple formats so be sure to watch for the icons that identify the format for each course.

Classroom offerings available as similar live, online Web Seminars will feature both icons and the course description for the Web Seminar will be listed immediately following the classroom title.

Live, online or classroom courses that have a similar course offered on-demand will include both icons – watch for those descriptions or notes on where to get additional information.

SEMINARS

SAE International offers over 200 seminar and classroom titles in 100+ separate technology and business skill topics. These courses range from one-to three-days and are led by highly-qualified, industry or academic experts. SAE live, classroom courses are interactive and encourage skill-development and problem solving. Each course includes comprehensive course materials to assist the learner in implementing the knowledge gained in the course.

Additionally, we offer courses throughout the year at the SAE International Office in Troy, Michigan; or at sites across the US and the world including at SAE International Engineering Events. View the public enrollment schedule on page 293 or at training.sae.org/calendar/.

A LEARNING FORMAT TO FIT EVERY NEED

Accommodate diverse learning styles and needs with SAE’s variety of learning formats.
SAE E-LEARNING

Learners can take advantage of the convenience and cost effectiveness offered by e-Learning from SAE. SAE maintains a growing menu of instructor-led, live online and SAE-produced on-demand courses; as well as courses from other training providers that have been reviewed and vetted by industry subject matter experts. These programs are listed throughout the catalog. Look for the icons that denote live online or on-demand.

Live, Online Courses

Informative and content-rich, SAE live, online courses are instructor-led programs delivered via WebEx® Training Center. Schedules and budgets can make it difficult to attend a classroom offering so SAE has developed a web seminar format to deliver technical courses directly. Delivered in one or a series of 90- to 120-minute sessions, Web Seminars feature audio delivered by telephone or VoIP, web-based presentations, interactive question-and-answer, and course-specific online forums for posting of supplemental materials, networking and course activities. Comprehensive course materials are also provided in PDF format. CEUs are awarded when course requirements have been met. Look for the live, online icon throughout the catalog.

On Demand Courses

Avoid travel expenses and time out of the office, and make learning fit into your schedule. Access SAE On Demand Courses right from your desktop, laptop or tablet device*. Many of our on-demand offerings are based on classroom seminars or are replays of our most popular SAE Web Seminars. We also provide short-courses designed to bring team members quickly up-to-speed on a specific subject. Look for the symbol in the course description to identify those titles that are delivered on-demand. Browse our growing library of individual and bundled technology and tools courses.

View the current on-demand course offerings in the On Demand Courses Resource Guide on pages 199-259.

*There are varying equipment requirements for the different online or on-demand options. Visit the webpage for each course to determine if your system meets the course equipment requirements.

On Demand Courses INCLUDE:

- Quick, short-duration courses on targeted topics
- Full length, self-paced courses based on our most popular instructor-led seminars
- Replays of recorded web seminars
- Courses on international standards, including ISO 9001, ISO 14001, ISO/TS 16949, and ISO 19011
- Course portfolios and bundles that focus on vehicle electrification, powertrain, quality, leadership, engineering tools and methods, metallurgy, additive manufacturing and more

Your company can subscribe to one title or multiple titles for just a few employees or the entire organization. Please contact the Corporate Learning Solutions hotline, +1.724.772.8529 for additional information or to get a proposal.

CATALOG KEY

You will see the following icons alongside the course descriptions. These icons indicate:

- delivery formats available for the ........ course
- the course is part of an SAE certificate
- that it is an ACTAR approved course

Many courses are available in multiple formats. See page XII to get more information on the learning formats offered by SAE. In addition to finding courses that fit your technology need, look for courses with icons that fit the way you want to learn.

Classroom – indicates the course is an instructor-led seminar or workshop offered in a classroom setting

Live, Online – indicates the course is an instructor-led web seminar offered live and online via two-way audio and internet connection

On Demand – indicates the course is available online anytime the participant has internet access and the time to learn

Certificate – indicates the course is part of an SAE International curriculum-based, multi-course certificate. See a list of the multi-course certificates on page XIV

ACTAR logo – indicates the course is an ACTAR approved course. For more information on ACTAR and ACTAR accredited courses, see page XI
SAE CERTIFICATION & CERTIFICATE PROGRAMS

SAE CREDENTIALING - ELEVATING KNOWLEDGE

Show the industry the depth of your organization’s expertise. SAE offers focused topic-specific credentialing programs for engineers and other professionals in ground vehicle and aerospace. Shine a light on their knowledge and expertise through SAE Credentialing.

Your team can earn an SAE Certification by passing industry-created and vetted exams. Get more information at training.sae.org/credentialing

How does it work?
• Complete established eligibility requirements (typically educational background and work experience)
• Pass an industry-developed, vetted, and proctored exam that tests mastery of an industry-defined body of knowledge
• Earn your industry recognized credential endorsing your experience and knowledge of the technology, and establishing a solid foundation on which to build a successful career.

Certifications must be maintained over 3-year period of time by fulfilling established maintenance requirements.

Or, expand their knowledge and build your organization’s reputation as an expert through industry-advised Certificate of Competency programs.

How does it work?
• Complete a course in a focused content area
• Pass an industry-vetted exam that verifies your understanding of the material
• Earn a Certificate of Competency or Certificate of Mastery

SAE Certification or Certificate of Competency – how does it benefit the ENGINEER?
• Validates their mastery of industry-driven training and learning objectives or confirms mastery of an industry-generated body of knowledge
• Imparts international recognition of experience and skills
• Provides a portable credential that is recognized across industry
• Demonstrates their commitment to continued growth and improvement

What is the value to the ORGANIZATION?
• Recognizes the capabilities of your people and enhances your company’s credibility with the industry as a supplier OR OE through an independent assessment
• Contributes to the hiring and promotion process – quickly illustrates the capabilities and experience of potential new hires or those you’d like to advance
• Encourages employee commitment to growth and opportunity
• Supports the promotion of professional competence

SAE currently offers the following Credentialing Programs:

The Connected Vehicle Professional™ Program: designed for all engineering, technical, and industry professionals who touch the “connected vehicle”, the multi-course program provides the understanding of vehicle and infrastructure connectivity necessary to operate within the rapidly advancing field of automated and connected vehicles.
EARN A CURRICULUM-BASED, MULTI-COURSE CERTIFICATE IN A SPECIFIC TECHNICAL AREA.

Need a directed learning plan to meet a specific technology or business goal? SAE multi-course, curriculum certificates offer a directed map of training in a specific technology area. Choose an established certificate program for your group or work with a Corporate Learning program developer to plot out a program for your business or technical need.

In addition to the Continuing Education Units (CEUs) earned, successful completion heightens expertise within the field and awards an SAE credential recognizing the achievement.

PLUS—completion of many of the multi-course certificate programs equates to graduate credits towards the SAE/Kettering University 20-credit Certificate in Automotive Systems and Kettering’s 40-credit M.S. in Mechanical Engineering. Visit training.sae.org/collegecredit for more information.

Watch for the certificate icon to indicate course titles that are part of an SAE multi-course certificate.

**Accident Reconstruction Certificate Program**

Professionals become more proficient in the practice of vehicle crash/accident reconstruction by successfully completing this certificate program from SAE. Required courses guide one through crash reconstruction methods, vehicle dynamics, and event data recorder (EDR) technology then completion of three elective courses suit the individual’s specific technical interest area.

The following are required courses:

- **Vehicle Crash Reconstruction: Principles and Technology** (I.D. # C1728)
- **Vehicle Dynamics for Passenger Cars and Light Trucks** (classroom - 99020; or on-demand option) OR **Applied Vehicle Dynamics** (I.D. # C0414)
- **Applying Automotive EDR Data to Traffic Crash Reconstruction** (I.D. # C1210) OR **Accessing and Interpreting Heavy Vehicle Event Data Recorders** (I.D. # C1022)

Choose three electives:

- **Advanced Vehicle Dynamics for Passenger Cars and Light Trucks** (I.D. # C0415)
- **Photogrammetry and Analysis of Digital Media** (I.D. # C1728)
- **Hydraulic Brake Systems for Passenger Cars and Light Trucks** (I.D. # C0509)
- **High-Performance Brake Systems** (I.D. # C0718)
- **Introduction to Brake Control Systems: ABS, TCS, and ESC** (classroom - I.D. # C0315; or on-demand option)
- **Basic Tire Mechanics and Inspection** (I.D. # C1423)
- **Tire Forensic Analysis** (I.D. # C1424)
- **Tire and Wheel Safety Issues** (I.D. # C0102)
- **The Tire as a Vehicle Component** (I.D. # C0101)
- **Injuries, Anatomy, Biomechanics & Federal Regulation** (I.D. # 85049)
- **Commercial Vehicle Braking Systems** (I.D. # C0233)
- **Fundamentals of Automotive All-Wheel Drive Systems** (I.D. # C0305)
- **Reconstruction and Analysis of Motorcycle Crashes** (I.D. # C1502)
- **Reconstruction and Analysis of Rollover Crashes of Light Vehicles** (I.D. # C1506)
- **Applying Automotive EDR Data to Traffic Crash Reconstruction** (if not taken as a required course – I.D. # C1210)
- **Accessing and Interpreting Heavy Vehicle Event Data Recorders** (if not taken as a required course – I.D. # C1022)

**Diesel Technology Certificate Program**

This certificate equips engineers with a solid understanding of diesel engines, emissions and aftertreatment strategies, and related components including fuel injection and air management. The program requires completion of courses that address these areas and offers further depth through a menu of electives.

The required courses are:

- **Diesel Engine Technology** (classroom - I.D. # 93014; or on-demand option)
- **Common Rail Diesel Fuel Injection** (I.D. # C0920)
- **Turbocharging Internal Combustion Engines** (I.D. # C0314)
- **Advanced Diesel Particulate Filtration Systems** (I.D. # C0502)

Choose one elective:

- **Diesel Engine Noise Control Web Seminar or Web Seminar RePlay** (I.D. # WB1041; PD331041ON)
- **Exhaust Flow Performance and Pressure Drop of Exhaust Components and Systems** (I.D. # C0235)
- **Exhaust Gas Recirculation (EGR) for Diesel Engines** (I.D. # C1214)
- **Selective Catalytic Reduction for Diesel Engines** (I.D. # C0913)
- **Variable Valve Actuation Design and Performance Impact on Advanced Powertrains** (I.D. # C1332)
- **Engine Failure Investigation and Analysis** (I.D. # C1344)

Completion of the Diesel Engine Technology Engineering Academy can be used as a substitute for Diesel Engine Technology and one elective.
General Management and Leadership Certificate Program

This program focuses on four core management and leadership competencies: management capability, team leadership, project management, and finance providing a basis for growth into a leadership or management role.

All of the following courses are required:

- Managing Engineering & Technical Professionals (I.D.# C0608)
- Engineering Project Management (I.D.# 99003)
- Principles of Cost and Finance for Engineers (I.D.# C0828)
- Leading High Performance Teams (I.D.# C0410)

Attending the Engineering Management Academy serves as a substitute for Managing Engineering and Technical Professionals and Leading High Performance Teams required courses.

Product Engineering Tools and Methods Certificate Program

This program focuses on the study, development, management and implementation of product engineering principles, methodologies and techniques. When used properly, these tools and methods become powerful productivity enhancers reducing product development time and cost through improved communication, documentation, problem-solving, and quality.

This certificate program can be completed entirely online through web seminar or on-demand course participation.

All of the following courses are required:

- Design of Experiments (DOE) for Engineers Web Seminar (I.D.# WB0932) OR classroom seminar - Design of Experiments for Engineers (DOE) (I.D.# C0406)
- Finite Element Analysis (FEA) for Design Engineers Web Seminar (I.D.# WB1241)
- Fundamentals of Geometric Dimensioning & Tolerancing (GD&T) Web Seminar or Web Seminar RePlay (live, online: I.D.# WB0933; on-demand I.D.# PD330933ON)
- Tolerance Stack-up Fundamentals Web Seminar or Web Seminar RePlay - (live, online: I.D.# C0842; on-demand I.D.# PD330842ON)
- Root Cause Problem Solving: Methods and Tools Web Seminar or Web Seminar RePlay (live, online: I.D.# WB0931; on-demand I.D.# PD330931ON)

Choose one elective:

- Accelerated Test Methods for Ground and Aerospace Vehicle Development (classroom - I.D.# C0316 or on-demand option)
- All three advanced web seminar/web seminar RePlay titles in the Geometric Dimensioning & Tolerancing Series (I.D.#s WB1319, WB1320, & WB1321)
- Design for Manufacturing & Assembly (DFM/DFA) (I.D.# 92047)
- Design Review Workshop (I.D.# C1306)
- Introduction to Design Review Based on Failure Modes (DRBFM) Web Seminar or Web Seminar RePlay (live, online I.D.# WB1047; on-demand I.D.# PD331047ON)

Choose one elective:

- Introduction to Failure Mode and Effects Analysis for Product and Process (I.D.# C1201)
- Robust Design (I.D.# C1231)
- Weibull-Log Normal Analysis Workshop (I.D.# 86034)

Additional elective courses:

Courses no longer offered by SAE but eligible to be used as electives for this program, providing they were completed within seven years of the date the Certificate is requested, include:

- Geometric Dimensioning & Tolerancing - classroom seminar (I.D.# C0133)
- Tolerance Stack-Up Analysis - classroom seminar (I.D.# C0022)
- Statistical Tolerance Design (I.D.# 88033)

Professional and Legal Issues Certificate Program

This program focuses on legal and risk management issues critical for engineers to master to facilitate the successful design and deployment of products from a safety and reliability perspective.

All of the following courses are required:

- Patent Law for Engineers (I.D.# 88007)
- Product Liability and The Engineer (I.D.# 82001)
- The Role of the Expert Witness in Product Liability Litigation (I.D.# 92054)
- Managing Programs and Associated Risks (I.D.# C0409)

SI Engine Certificate Program

This certificate is designed to familiarize engineers with key spark ignition engine components and technologies and how they function as a system. By completing the certificate, engineers can acquire fairly deep engine expertise and, at the same time, earn an SAE credential.

All of the following courses are required:

- Basics of Internal Combustion Engines (classroom - I.D.# C0103 or on-demand option)
- Internal Combustion Systems: HCCI, DoD, VCT/VVT, DI and VCR (I.D.# C0613)
- Turbocharging Internal Combustion Engines (I.D.# C0314)
- Powertrain Selection for Fuel Economy and Acceleration Performance (I.D.# C0243)

Choose one elective:

- Gasoline Direction Injection (GDI) (I.D.# C1009)
- Combustion and Emissions for Engineers (I.D.# 97011)
- Automotive Heat Transfer (I.D.# C1230)
- Exhaust Flow Performance and Pressure Drop of Exhaust Components and Systems (I.D.# C0235)
- Compact Heat Exchangers for Automotive Applications (I.D.# 97002)
- Fundamentals of Automotive Fuel Delivery Systems (I.D.# C0203)
- Engine Failure Investigation and Analysis (I.D.# C1344)
- Variable Valve Actuation Design and Performance Impact on
Advanced Powertrains (I.D.# C1332)
• Introduction to Commercial and Off-Road Vehicle Cooling Airflow Systems Web Seminar RePlay (I.D.# PD331240ON)

Additional elective courses:
Courses no longer offered by SAE but eligible to be used as electives for this program, providing they were completed within seven years of the date the Certificate is requested, include:
• Introduction to Commercial and Off-Road Vehicle Cooling Airflow Systems (classroom: I.D.# C0738; live online I.D.# WB1240)
• Piston Ring Design/Materials (I.D.# 86009)

Transmission/Drivetrain Certificate Program
This program familiarizes engineers with key drivetrain components and how those components function as a system. By completing the certificate, engineers can increase their expertise within the drivetrain body of knowledge and, at the same time, earn the SAE Certificate of Achievement.

All of the following courses are required:
• A Familiarization of Drivetrain Components (classroom - I.D.# 98024; or on-demand option)
• Fundamentals of Automotive All-Wheel Drive Systems (classroom - I.D.# C0305 or on-demand option)
• Fundamentals of Modern Vehicle Transmissions (classroom - I.D.# 99018; or on-demand option)
• Fundamentals of Gear Design and Application (I.D.# C0223)
• Powertrain Selection for Fuel Economy & Acceleration Performance (I.D. # C0243)

Vehicle Dynamics Certificate Program
Designed to equip engineers with key vehicle dynamics and handling theory and application from a systems perspective, the objective of this program is for engineers to understand the interaction and performance balance between the major vehicle subsystems. The program design requires completion of fundamental and advanced-level vehicle dynamics theory and application courses with three elective courses that best suit an individual’s interest areas or engineering emphasis.

All of the following courses are required:
• Vehicle Dynamics for Passenger Cars and Light Trucks (classroom - I.D.# 99020; or on-demand option) OR
• Fundamentals of Heavy Truck Dynamics (I.D.# C0837)
• Advanced Vehicle Dynamics for Passenger Cars and Light Trucks (I.D.# C0415)

Choose three from these electives:
• Applied Vehicle Dynamics (I.D.# C0414)
• Fundamentals of Steering Systems (I.D.# C0716)
• Introduction to Brake Control Systems: ABS, TCS, and ESC - (classroom - I.D.# C0315; or on-demand option)
• The Tire as a Vehicle Component (I.D.# C0101)
• Tire and Wheel Safety Issues (I.D.# C0102)
• Fundamentals of Vehicle Suspension Design (I.D.# C1618)
• Commercial Vehicle Braking Systems (I.D.# C0233)
• Hydraulic Brake Systems for Passenger Cars and Light Trucks (I.D.# C0509)
• High-Performance Brake Systems (I.D.# C0718)

Courses no longer offered by SAE but eligible to be used as electives for this program, providing they were completed within seven years of the date the Certificate is requested, include:
• Chassis & Suspension Component Design for Passenger Cars and Light Trucks (I.D.# 95025)
• Heavy Vehicle Ride Comfort Engineering (I.D.# C0948)
• Fundamentals of Heavy Truck Dynamics (I.D.# C0837)
• Vehicle Dynamic Basics for Off-highway Trucks (I.D.# C1239)

Get more information on the curriculum-based, multi-course certificates at training.sae.org/credentialing/certificate/

Here’s how you obtain your SAE Certificate
Once you complete all required courses in any of the certificate programs, contact SAE Customer Service, +1.877.606.7323 (or +1.724.776.4970 outside U.S. & Canada) or email: customerservice@sae.org and request your Certificate. Your SAE transcript will be reviewed to verify completion of required courses and your Certificate will be mailed to you within 30 days.

SAE Certificate Programs can also be conducted at your company site for groups of employees. For a price quote, call our Corporate Learning Solutions hotline, +1.724.772.8529.
BUILD YOUR SKILLS & KNOWLEDGE
ADVANCE YOUR CAREER

Stay current on the latest technology, increase your knowledge, and positively affect your organization’s bottom line with:

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training.sae.org
CHASSIS AND VEHICLE DYNAMICS

Includes ground vehicle dynamics, ride and handling, tires, suspension, and braking systems.

VEHICLE DYNAMICS AND HANDLING

Advanced Vehicle Dynamics for Passenger Cars and Light Trucks

3 Days
I.D.# C0415

This interactive seminar will take you beyond the basics of passenger car and light truck vehicle dynamics by applying advanced theory, physical tests and CAE to the assessment of ride, braking, steering and handling performance. Governing state-space equations with transfer functions for primary ride and open loop handling will be developed & analyzed. Building on the analysis of the state space equations, common physical tests and their corresponding CAE solutions for steady state and transient vehicle events will be presented. The “state-of-the-art” of vehicle dynamics CAE will be discussed. Common lab and vehicle tests and corresponding metrics used to assess chassis system and vehicle performance will be discussed in great detail. Hands-on workshops using CARSIM™ vehicle dynamics simulation software will help reinforce the material. Significant time will also be dedicated to the use of design of experiments (DOE) as a tool to assist in the analysis and optimization of chassis systems for multiple vehicle responses.

Participants should bring a scientific calculator to participate in the classroom workshops.

Learning Objectives

By attending this seminar, participants will be able to:

• Apply vehicle dynamics theory to practical evaluation and measurement
• Use governing state space equations and transfer functions to determine the effect of key parameters on primary ride and open loop handling
• Describe the current “state-of-the-art” of vehicle dynamics CAE
• Articulate various types of vehicle dynamics models
• Recognize kinematics and compliance (K&C) lab tests commonly used to quantify chassis system performance
• Identify and evaluate important K&C metrics used in vehicle dynamics development
• Identify and utilize important vehicle tests commonly used in industry to evaluate ride, steering and handling performance
• Relate chassis system characteristics to vehicle dynamic performance
• Utilize vehicle dynamics CAE software for the simulation of common physical lab and vehicle tests
• Apply design-of-experiments (DOE) to vehicle dynamics development

Who Should Attend

This seminar is designed for automotive engineers in the vehicle dynamics, chassis, suspension, steering and braking fields who work in product design, development, testing, simulation or research.

Prerequisites

Participants must have a working knowledge of the fundamentals of vehicle dynamics acquired through sufficient work experience or by participating in seminars such as the SAE seminars Vehicle Dynamics for Passenger Cars and Light Trucks (ID# 99020, page 8)
CHASSIS AND VEHICLE DYNAMICS

Topical Outline

DAY ONE
• Modeling Primary Ride Dynamics
  • 4-degree of freedom (DOF) primary ride model
  • 2-DOF primary ride model
• Modeling Vehicle Handling Dynamics
  • Developing the cornering compliance model
  • Developing the transfer function
• Introduction to Vehicle Dynamics CAE
  • Types of models
  • Strengths/Limitations
  • Commercial software packages
• Measurement and Simulation of Suspension Kinematics and Compliance (K&C)
  • Objectives of the K&C test
  • Definitions
  • Measurement equipment
  • Common tests
  • Simulation of the K&C test
• Measurement and Simulation of Primary Ride
  • Primary vs. Secondary Ride
  • Physical measurements
  • Common primary ride metrics
  • Olley Criteria for primary ride
  • Primary ride simulation
  • CarSim™ Exercise - Primary Ride Simulation

DAY TWO
• Measurement and Simulation of Acceleration and Braking
  • Steady state acceleration test and metrics
  • Steady state braking test and metrics
  • Simulation of steady state acceleration and braking
• Measurement and Simulation of Steering
  • On-center steering test and metrics
  • Low-g swept steer test and metrics
  • Simulation of steering tests
  • CarSim™ Exercise - Steering
• Measurement and Simulation of Open Loop Handling
  • Definition of open loop
  • Steady state open loop tests - High-g swept steer
  • Transient open loop tests - Step steer; Brake/throttle release in a turn; Fishhook; Sine with dwell
  • Simulation of open loop handling tests
  • CarSim™ Exercise - Open Loop Handling

DAY THREE
• Measurement and Simulation of Closed Loop Handling
  • Definition of closed loop
  • Steady state closed loop tests - Constant radius
  • Transient closed loop tests - Lane change; Slalom
  • Simulation of closed loop handling tests
  • CarSim™ Exercise - Closed Loop Handling
• Design of Experiments (DOE) Applied to Vehicle Dynamics Development
  • What is DOE
  • Why use DOE
  • Terminology
  • Types of DOE’s
  • Example - Screening DOE for primary ride
  • Example - Response Surface Method (RSM) DOE for Transient Handling
• Vehicle Dynamics Summary

Instructor: Richard Lundstrom and Timothy Drotar
Fee $1745 2.0 CEUs

Basic Tire Mechanics and Inspection

1 Day
I.D.# C1423

This course provides an introduction to basic tire mechanics, including materials, sidewall stampings, pressure, tread patterns, tire inspection and basic tire failure identification of passenger and light truck tires. Practical in nature and supplemented with samples and hands-on activities, the course will provide you with information that you can use immediately on-the-job and apply to your own vehicle. It serves as a good primer for the in-depth SAE Tire Forensic Analysis course (#C1424; see course description on page 6).

Learning Objectives

By attending this seminar, participants will be able to:
• Read the sidewall of a tire and explain all of the nomenclature
• Describe the various types of tread patterns and what they mean on a tire
• Describe what is inside the tire and how that relates to some of the sidewall stampings
• Photograph black objects and quickly inspect tires in the field
• Visualize and explain basic tire failures
CHASSIS AND VEHICLE DYNAMICS

Who Should Attend
This course is extremely helpful for Accident Reconstructionists, Law Enforcement and those with a thirst for knowledge on tires. The materials are basic in nature and not intended for individuals with substantial tire knowledge and is not intended to teach tire design.

Topical Outline
DAY ONE
• Tire Size
  • Service Description & tire size suffixes
  • Differences between LT and P type tires in load / pressure
  • Aspect ratio
  • Rim diameter and rim types
• Sidewall Stamping
  • UTQG
  • DOT code
  • DOT required stamping
• Inflation Pressure
• Load and Reserve Load
• Tire Terminology
• Tire Construction
  • Ply and plies
  • Belts
  • Tread
  • Overlay – the standing wave
  • Inner-liner
  • Bead and bead filler
  • Belt package types and casing construction layup
• Tire Types and Tread Patterns
  • All season, mud, all terrain, snow, summer
  • +1 concepts
  • Irregular wear
  • Wear bars
• Inspection and Photography in the Field
• Basic Failure Mode Identification

Instructor: Thomas Giapponi
Fee $810 .7 CEUs

Fundamentals of Vehicle Suspension Design
2 Days
I.D.# C1618
The design and development of vehicle suspensions significantly influences vehicle handling and ride comfort. Suspension system design excellence follows the basic laws of physics using design synthesis techniques, a methodical process for suspension geometry development. Suspension geometry is the foundation of vehicle performance from which high-confidence suspension components and tunings can be developed.

Suspension component design continues to move toward mass and cost efficient designs with high levels of stiffness being essential to achieving design requirements. Mass, cost and stiffness are expected to become increasingly important with higher fuel economy requirements, alternative energy sources and the move to autonomous vehicles. This course emphasizes the basic tenets of suspension design enabling strategically important product trends.

Learning Objectives
By attending this seminar, participants will be able to:
• Discuss the basic attributes of suspension design
• Evaluate various suspension types, identifying advantages and tradeoffs
• Convey an understanding of vehicle level boundary conditions for suspension geometry
• Analyze suspension designs and how they affect vehicle performance
• Assess the basics of ground lines and tire envelopes on vehicle design

Who Should Attend
This seminar is designed for automotive engineers with a need to understand the basics of suspension design as well as suspension integration into the vehicle environment. The course is intended for both OEM and Supplier Engineers working in applications, materials, product design, development, testing, simulation and/or research.
CHASSIS AND VEHICLE DYNAMICS

Prerequisites
Participants should have a basic knowledge of suspension design either acquired through work experience or as a hobby. This information presented in this seminar will be helpful to individuals interested in enrolling in other SAE seminars such as Vehicle Dynamics for Passenger Cars and Light Trucks (ID# 99020), page 8, or Advanced Vehicle Dynamics for Passenger Cars and Light Trucks (ID# C0415) page 1.

Topical Outline
DAY ONE
• Introduction
  • Suspension’s role in the vehicle
  • Definition of upper and lower suspension planes
  • Definition of dependent v. independent v. semi-independent suspensions
• Front and Rear Suspension Types
  • Identify various front suspension types and their advantages v. tradeoffs; also usage and application from solid axles to high performance multi-links
  • Optimize placement of springs and shock absorbers within a front suspension
• Vehicle Packaging
  • Execute basic elements of vehicle packaging design
  • Determine an allowable suspension envelope based on vehicle packaging
  • Identify “best choice” suspension type(s) based on compartment requirements
  • Class exercise - select the best suspension type for an autonomous vehicle

DAY TWO
• Suspension Geometry and Alignment
  • Terms and definitions related to suspension geometry - e.g., caster, camber, toe
  • Construct front view (FV) & side View (SV) suspension geometry e.g., front view swing arm (FVSA), roll center height, etc.
  • Execute basic elements of design synthesis in setting up a corner geometry
  • Determine various methods for achieving vehicle understeer
  • Assess steering affects from the suspension – e.g., lateral force compliance steer
• Tire Envelopes and Ground Lines
  • Discuss analytical and test methods for determining tire envelopes
  • Select appropriate methods for determining tire envelopes at each phase of the vehicle program
  • Interpret ground line criteria in view of vehicle usage, including break-over, approach and departure angles

SAE MULTI-COURSE CERTIFICATE PROGRAMS
Watch for the certificate icon to indicate course titles that are part of an SAE multi-course certificate.

Intended to provide a guide towards deeper knowledge in a specific area, SAE’s multi-course certificates outline required courses that offer foundational knowledge of the subject. Some certificate programs also feature additional electives designed to broaden your exposure to more specific aspects of the technology studied.

training.sae.org/credentialing/

Fundamentals of Steering Systems

3 Days
I.D.# C0716
Design and development of a modern steering system influences vehicle response to steering wheel input, driver effort, comfort, safety and fuel economy. In this interactive seminar participants will analyze the steering system from the road wheel to the steering wheel.

Day one will begin with a deep dive into the anatomy and architecture of the lower steering system (wheel end, suspension geometry, linkages and steering gear), its effect on vehicle response and how forces and moments at the contact patch are converted to a torque at the pinion. Next, the anatomy and architecture of the upper steering system (steering column and intermediate shaft) will be explored as well as the role of the upper steering in the occupant protection system, steering non-uniformity, and how torque and angle at the pinion is converted to torque and angle at the steering wheel.
Day two will be devoted to the power assist system anatomy/architecture for hydraulic, electro-hydraulic and electric power steering.

Day three will begin with a discussion of common steering objective tests and how system design and tuning affect steering response, torque feedback and error state performance. The seminar will conclude with a discussion of advanced steering systems such as rear wheel steer, active front steer, active park assist and other driver assistance systems.

Students will have the opportunity to participate in exercises throughout the seminar with the objective of calculating a power steering assist curve for both a hydraulic and electric power steering system. Many physical parts will be available for the students to examine.

Learning Objectives
By attending this seminar, participants will be able to:
• Identify common steering and suspension system architectures
• Compare and contrast different types of steering gears
• Describe the function of the steering column and intermediate shaft subsystem
• Describe the influence of system tuning on steering response and torque feedback
• Compare and contrast different types of power assist systems
• Describe the effect of power steering on fuel economy
• Calculate important parameters that affect steering response and torque feedback
• Describe some of the features of advanced steering systems

Who Should Attend
This seminar is designed for automotive engineers in the vehicle dynamics, chassis, suspension, steering and chassis controls fields who work in product design, development, testing, simulation or research.

Topical Outline
DAY ONE
• Introduction
  • Elements of the steering system
  • Coordinate systems
• The Lower Steering System
  • Kingpin axis -- Front versus rear steer; Caster angle and kingpin inclination; Caster trail and scrub radius; Steer arm
  • Class exercise - Calculate moment about the kingpin axis for cornering and parking loadcases
  • Linkages/steering geometry -- Rack and pinion; Haltenberger; Parallel linkage
• Steering gear anatomy and architecture -- Rack and pinion; Recirculating ball
• Friction and compliances
• Class exercise - Calculate pinion torque for cornering and parking loadcases
• The Upper Steering System (steering column & intermediate shaft)
  • Anatomy and architecture
  • Non-uniformity
  • Sources of friction and torsional compliance
  • Role of the upper steering system in the occupant protection system

DAY TWO
• Power Assist Systems
  • Hydraulic power assist including speed sensitive steering (incl. pump, valve, distribution system)
  • Electro-hydraulic assist (incl. pump and motor assembly)
  • Electric power assisted steering column, pinion, dual pinion, concentric drive and belt drive systems)
  • Class exercise - Calculate a power steering assist curve for hydraulic or electric power assisted steering system

DAY THREE
• The effect of steering system design and tuning parameters on vehicle level performance
  • Low speed maneuverability
  • High speed on-center steering response and torque feedback
  • High speed cornering response and torque feedback
  • Error states (nibble/wheelfight, pull/drift)
• Advanced Steering Systems
  • Active Park Assist
  • Active Front Steer
  • Driver assistance features
  • Active rear wheel steer

Instructor: Timothy Drotar
Fee $1745 2.0 CEUs
CHASSIS AND VEHICLE DYNAMICS

The Tire as a Vehicle Component
1 Day
I.D.# C0101
The principal functions of the pneumatic tire are to generate driving, braking, and cornering forces while safely carrying the vehicle load and providing adequate levels of ride comfort. This seminar explains how tire forces and moments are generated under different operating and service conditions and, in turn, demonstrates how these forces and moments influence various vehicle responses such as braking, handling, ride, and high-speed performance. The content focuses on the fundamentals of tire behavior in automobiles, trucks, and farm tractors, but also includes experimental and empirical results, when necessary.

The Pneumatic Tire, a 700-page E-book on CD, edited by Joseph Walter and Alan Gent, is included in the course material.

Learning Objectives
By attending this seminar, participants will be able to:
• Explain the force and moment generating behavior of tires as related to construction, materials, and operating conditions
• Predict vehicle response based on tire characteristics using basic laws of mechanics supplemented by experimental results as necessary

Who Should Attend
This course is designed principally for technical professionals in the automobile, tire, and wheel industries and their suppliers. In addition, some case studies and examples involve truck, agricultural, and aircraft tires.

Topical Outline
• Introduction
  • Brief history of tires and wheels
  • Types of tires
  • Tire construction features
• Longitudinal Tire Properties
  • Braking and driving forces
  • Rolling resistance
• Lateral Tire Properties
  • Cornering force
  • Camber thrust
  • Ply steer and conicity forces
• Combined Longitudinal and Lateral Forces
  • Friction ellipse
  • Load transfer in cornering
• The Tire as a Spring
  • Linear vs. non-linear springs
  • Rolling vs. non-rolling behavior
  • Tire frequency response
  • Tire and Wheel Non-Uniformities
    • Force and moment variations
    • Low speed/high speed effects
    • Tire manufacturing issues
• Influences of Tire Properties on Vehicle Response
  • Vehicle stopping distance
  • Vehicle ride
  • Vehicle handling
  • Vehicle high speed performance
  • European vs. North American requirements
• Future Technological Developments
  • Run-flat tires
  • Cordless cast tires
  • Intelligent tires

Instructor: Gerald R. Potts
Fee $810 .7 CEUs

Tire Forensic Analysis
2 Days
I.D.# C1424
This course provides a detailed description of tire failure modes, their potential causes, identification, and the sometimes subtle nuances that go along with determination of tire failure. In addition, proper inspection techniques of tires will be discussed and samples will be available to reinforce the concepts learned. The book, Tire Forensic Investigation, authored by the instructor, is included with the course materials.

This course has been approved by the Accreditation Commission for Traffic Accident Reconstruction (ACTAR) for 13 Continuing Education Units (CEUs). Upon completion of this seminar, accredited reconstructionists should contact ACTAR, 800-809-3818 FREE, to request CEUs. As an ACTAR approved course, the fee for CEUs is reduced to $5.00.

Learning Objectives
By attending this seminar, participants will be able to:
• Explain the methodologies of good tire inspection
• Describe tire failure causes
• Identify and determine root causes of tire failure

Who Should Attend
This course is extremely helpful for Accident Reconstructionists, Law Enforcement, Warranty investigators and individuals who need to be able to explore and explain tire failures.
CHASSIS AND VEHICLE DYNAMICS

Topical Outline

DAY ONE
- Belt Separation – Tread / Belt Intact
  - Identification
  - Working belt description
  - Reversion / bluing
  - Degradation of properties
  - Thick/Thin layering
  - Transition zones and identification of tear types
  - Road rash
- Belt Separation – Tread / Belt Intact
  - Identification
  - Rapid wear
  - Bulges / knots / bubbles
- Belt Separation Locations and rate of growth
- Other Belt separation Types
  - Typical & non-typical
- Identification of Causes and Contributors to Belt Separation
  - Punctures, penetrations and repairs
  - Wire break types
  - Intra-car cass pressurization (ICP) – oxygen deterioration
  - Over-deflection identification
- Overlaying and Time
- Impact
  - No immediate failure – identification
  - Damage to casing and rubber components
  - Wheel impact identification

DAY TWO
- Ozone Deterioration
- Mounting / Demounting Damage
- Physiological Damage
- Snags, Gouges, Cuts, Tears, Abrasions
- Cutting and Chipping (C&C)
- Poor Tire Storage
- Vehicle Caused Conditions
- Non-Belt Separation Types
- Runflats
- Liner Conditions
- Wheel Conditions
  - Matching tire to wheel
  - Flange indicators of overdeflection
- Tire Location on the Vehicle
- Brassy Wire Failure
- Manufacturing Imprints
- Overlays
- Tire Examination

Instructor: Thomas Giapponi
Fee $1450 1.3 CEUs

Tire and Wheel Safety Issues

1 Day
I.D.# C0102

One of the most important safety critical components on cars, trucks, and aircraft is the pneumatic tire. Vehicle tires primarily control stopping distances on wet and dry roads or runways and strongly influence over-steer/under-steer behavior in handling maneuvers of cars and trucks. The inflated tire-wheel assembly also acts as a pressure vessel that releases a large amount of energy when catastrophically deflated. The tire can also serve as a fulcrum, both directly and indirectly, in contributing to vehicle rollover. This seminar covers these facets of tire safety phenomena. Engineering fundamentals are discussed and illustrated with numerous practical examples and case studies of current public interest. The Pneumatic Tire, edited by Joseph Walter and Alan Gent, is included in the course material.

Learning Objectives

After completing this seminar attendees will be able to:
- Describe the most important performance parameters and operating conditions of pneumatic tires related to safety.
- Use fundamental equations of engineering science to predict and/or explain tire-vehicle interactions related to safety.

Who Should Attend

This course is designed principally for technical professionals in the automobile, tire, and wheel industries and their suppliers. In addition, some case studies and examples involve truck, agriculture, and aircraft tires.

Topical Outline

- Introduction
  - Vehicle accident statistics
  - The role of the tire in accident prevention/causation
- Tire construction features
  - Tire failure modes
- Tire Grip and Related Phenomena
  - Tire-road friction characteristics; Tire braking forces
  - Factors influencing vehicle stopping distance
  - Combined braking and cornering
  - Hydroplaning
  - High speed behavior and standing waves
- Brake Performance
  - Front wheel/rear wheel lock-up
  - Braking efficiency
  - Anti-lock braking and other systems
CHASSIS AND VEHICLE DYNAMICS

• The Tire as a Pressure Vessel
  • Burst pressure
  • Energy release in punctured tires
  • Wheel issues
  • Tire and/or wheel case studies
• Over-steering Vehicles
  • Meaning of under-steer coefficient
  • The contribution of the tire
• Vehicle Rollover Analysis
  • History of rollover and rollover threshold
  • Tripping mechanisms
  • Tire effects
  • Operating conditions
  • Public policy issues

Vehicle Dynamics for Passenger Cars and Light Trucks

3 Days
I.D.# 99020

Similar content is available in an on demand course. Review the description in the On Demand Courses Guide on page 199.

This seminar will present an introduction to Vehicle Dynamics from a vehicle system perspective. The theory and applications are associated with the interaction and performance balance between the powertrain, brakes, steering, suspensions and wheel and tire vehicle subsystems. The role that vehicle dynamics can and should play in effective automotive chassis development and the information and technology flow from vehicle system to subsystem to piece-part is integrated into the presentation. Governing equations of motion are developed and solved for both steady and transient conditions. Manual and computer techniques for analysis and evaluation are presented. Vehicle system dynamic performance in the areas of drive-off, braking, directional control and rollover is emphasized. The dynamics of the powertrain, brakes, steering, suspension and wheel and tire subsystems and their interactions are examined along with the important role of structure and structural parameters related to vehicle dynamics. Physical experiments, applicable to vehicle dynamics are also introduced.

Attendees will receive the Bosch Automotive Handbook and The Automotive Chassis: Engineering Principles by Reimpell, Stoll and Betzler.

SAE VEHICLE DYNAMICS CERTIFICATE PROGRAM

Watch for the certificate icon to indicate course titles that are part of an SAE multi-course certificate program.

Designed to equip you with key vehicle dynamics and handling theory and application from a systems perspective, the objective of this program is for you to understand the interaction and performance balance between the major vehicle subsystems. The program design requires completion of fundamental and advanced-level vehicle dynamics theory and application courses with three elective courses that best suit your specific interest areas or engineering emphasis. View the list of required and elective courses and more information on enrolling in this SAE certificate program-training.sae.org/certificate/vehicle_dynamics

Learning Objectives

By attending this seminar, participants will be able to:
• Summarize how vehicle dynamics is related to the voice of the customer
• Identify important vehicle system parameters useful for effective application of vehicle dynamics to chassis development
• List and explain parameters that effect vehicle performance relative to drive-off, braking, directional control and rollover
• Identify physical measurements needed to effectively apply vehicle dynamics to passenger cars and light trucks
• Define the value of vehicle dynamics simulation in the development and evaluation of vehicles
• Explain the balance required between ride, directional control and rollover and the essential process for this balance to be obtained for marketplace vehicles

Who Should Attend

Automotive engineers and quality professionals who work in product design, testing, quality, process or development will benefit from attending.

Topical Outline

DAY ONE
• The Role of Vehicle Dynamics in Passenger Car and Light Truck Product Development
• Vehicle Dynamics and the Voice of the Customer
  • Use of QFD to manage vehicle dynamics performance in drive-off, braking, ride and handling
  • Thinking systemically about automotive chassis design and development through the logic of vehicle dynamics
CHASSIS AND VEHICLE DYNAMICS

- Effective Metrics for Vehicle Dynamics
  - Vehicle system, subsystem and piece-part metrics used to link vehicle dynamics to vehicle system design and development: bounce frequencies, lateral acceleration gain, understeer gradient, roll gradient, roll stiffness, etc.
- Elementary Tire Patch Forces and Moments: Forces and Moments at the Tire Contact Patch During Steady Braking, Steady Cornering and Steady Drive-Off Maneuvers
- Acceleration (Drive-Off) Performance
  - Basic powertrain system anatomy and architecture
  - Power limited and traction limited drive-off including powertrain system dynamics required to produce vehicle motive force at the tire patch
  - Road load considerations: aerodynamic resistance, rolling resistance, grade resistance
  - Performance prediction in acceleration and fuel economy

DAY TWO
- Braking Performance
  - Basic brake system anatomy and architecture
  - Braking dynamics: braking forces, weight transfer, center of weight, brake force distribution, stability
  - Pedal force gain, brake proportioning, braking efficiency, anti-lock braking systems
  - Tire - road limitations
  - Federal requirements for braking performance
  - Brake system performance prediction
- Ride Fundamentals
  - Input excitation signals: road roughness, vehicle sources (tire/wheel system, driveline and engine)
  - Vehicle response properties: suspension isolation, tire vertical stiffness, spring rate ratio, suspension stiffness, ride rate, suspension damping, pitch and bounce frequencies
  - Quarter vehicle and pitch plane ride simulations
  - Ride performance prediction based on flat ride criteria

DAY THREE
- Cornering Fundamentals
  - Low speed turning
  - High speed cornering: tire forces, Bundorf bicycle model, understeer gradient, characteristic speed, lateral acceleration gain, yaw velocity gain, side-slip
  - Suspension effects on cornering: tire cornering stiffness, camber thrust, roll steer, lateral force compliance steer, aligning torque, lateral load transfer, steering system
  - Experimental methods for vehicle handling development
- Suspension Systems
  - Suspension system anatomy and suspension system performance requirements relative to drive-off, braking, ride and handling
  - Solid live axles, twist beam suspensions and independent suspensions
  - Side view pitch poles and pitch axis considerations: anti-squat and anti-dive suspension geometry, wheel travel and caster geometry
  - Role axis considerations: roll center location, roll axis geometry and location, wheel travel and toe geometry, wheel travel and camber geometry
- Steering Systems
  - Steering system anatomy, architecture and performance requirements
  - Steering geometry, wheel geometry, steering system forces and moments, steering ratio, steering compliance
  - Experimental methods for steering system performance evaluation and development
- Roll-Over Fundamentals
  - Vehicle system roll-over prevention requirements
  - Elementary and suspended vehicle simulations
  - Suspension system and steering system considerations

Instructor: Richard Lundstrom
Fee $1975 2.0 CEUs

Vehicle Dynamics for Passenger Cars and Light Trucks

15 Hours

Similar content is available in the classroom seminar–Vehicle Dynamics for Passenger Cars and Light Trucks – see course info above.

Convenient, portable, and with core content from the instructor-led seminar (content and description similar to the preceding classroom counterpart), this 4.5 hour on demand option offers an alternative way to receive the same instruction without the expense of travel and time away from the workplace. This course offers more than fourteen hours of instruction and simulations divided into nineteen video modules; The Automotive Chassis: Engineering Principles by Reimpell, Stoll and Betzler; a coordinated handbook that includes a resource guide and SAE papers and paper collections.

Learn more about this course in the On Demand Courses Resources Guide on pages 199-259.

Quantity discounts and Site License options are available – call SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.
Brake Friction Materials: Testing, Quality and Selection

1 Day  
I.D.# C1020

The choice of brake friction materials varies per application, but each must have the appropriate coefficient of friction and be able to disperse large amounts of heat without adversely affecting braking performance. This seminar provides an introduction to brake lining raw materials and formulation, manufacturing, quality control and testing and covers the critical elements that must be reviewed before arriving at a lining selection decision. Different classes of friction material and their use will be defined.

Learning Objectives

By attending this seminar, participants will be able to:

• Describe the principles of friction
• Define the basic elements of friction material formulations
• Identify the difference between OE and after-market friction materials
• Identify appropriate tests to distinguish the differences between friction materials
• Interpret friction material test results

Who Should Attend

Engineers and technicians working for friction material manufacturers, and suppliers to friction material industries, brake system designers, quality control auditors, product development engineers, application engineers, lab/bench/vehicle test technicians, managers/friction material sales and marketing will all gain valuable insight.

Prerequisites

Participants should have some knowledge of the brake industry.

Topical Outline

• Principles of Friction Materials
• Lining Coefficient of Friction
• Formulation/Compounding Friction Material
• Manufacturing Friction Material
• General Asbestos/Non-asbestos Friction Material Characteristics
• Friction Material Testing

ADAS Application: Automatic Emergency Braking

1 Day  
I.D.# C1704

Active Safety, Advanced Driver Assistance Systems (ADAS) are now being introduced to the marketplace as they serve as key enablers for anticipated autonomous driving systems. Automatic Emergency Braking (AEB) is one ADAS application which is either in the marketplace presently or under development as nearly all automakers have pledged to offer this technology by the year 2022. This one-day course is designed to provide an overview of the typical ADAS AEB system from multiple perspectives. A technical overview of the development cycle processes specific to AEB, including system level requirements and design architecture will be presented as well as design considerations for AEB from a functional safety (ISO-26262) perspective. A general overview of algorithm concepts for the various AEB subsystems will be demonstrated followed by a review of AEB system test and validation methods. Finally, discussion is facilitated toward understanding customer perception and acceptance of AEB at present. The participant should obtain a fundamental understanding of design principles and functional composition for a typical AEB system.

Learning Objectives

By attending this seminar, participants will be able to:

• Describe AEB features / functionality as provided by most OEMs, including the capabilities and limitations of typical AEB systems
• Identify key principles of vehicle dynamics and system engineering disciplines which are integral to AEB system development
• Describe the general activities required for driving and brak-
ing tasks and comment on how these form the bases for AEB system requirements
• Identify AEB system architectures and subsystem composition and describe the function and purpose of each subcomponent
• Identify functional safety (ISO 26262) implications specific to AEB including review of basic hazard and risk analysis examples
• Explain algorithm concepts and functions for each of the AEB subsystems
• Critically examine various methods and levels of testing specific to AEB
• Describe the current state of AEB development from a consumer perspective

Who Should Attend
This course is designed for engineers and managers within related professions who are looking for an in-depth technical overview of Automatic Emergency Braking systems.

Prerequisites
This course can be viewed as a subsequent application of material introduced in either SAE course, Introduction to Highly Automated Vehicles (#C1603; page 28), or Introduction to Brake Control Systems (#C0315; page 16). Either course would be an optional suggested prerequisite, however, an engineering background or specific interest in ADAS topics is most important.

Topical Outline
• Automatic Emergency Braking Overview
  • History: active safety origins
  • Key enablers for Automatic Emergency Braking (AEB)
  • AEB level of automation
  • AEB features and marketed benefits
• Primer: Basic Engineering Fundamentals
  • Vehicle dynamics
  • Wheel dynamics
  • System engineering requirements flow down
• AEB System Requirements
  • Basic driving tasks
  • Basic braking tasks
  • General system requirements
  • Refined system requirements
• AEB System Architecture and Decomposition
  • Functional architecture - sensing systems, warning systems, actuation systems
  • AEB operation modes
  • Physical architecture - sensors, adaptive cruise control (ACC), body control module (BCM), and electronic stability control (ESC) ECUs
• AEB System Design: Safety
  • ISO 26262 framework
  • Hazard analysis and risk assessment exercise
  • AEB safety goals and requirements
  • Safety of the intended function (SOTIF) considerations
• AEB System Design: Performance Objectives
  • Sensing technology and implementation
  • Computational objectives: AEB ECU computing platforms
  • Human Machine Interface (HMI) warnings and considerations
  • Actuator objectives: braking actuator control design
• AEB System Test and Validation
  • AEB validation objectives
  • Subsystem testing
  • Vehicle level testing
• Conclusions and Future Direction
  • Market penetration
  • Customer acceptance
  • Incremental steps towards full autonomy

Instructor: Eldon Leaphart
Fee $810 .7 CEUs

Brake Noise Problem Resolution

1 Day
I.D.# C0831

Brake noise is one of the highest ranked complaints of car owners. Grunts, groans, squeaks, and squeals are common descriptions of the annoying problem which brake engineers spend many hours trying to resolve. Consumer expectations and the high cost of warranty repairs are pushing the optimization of brake NVH performance. This course will provide you with an overview of the various damping mechanisms and tools for analyzing and reducing brake noise. A significant component of this course is the inclusion of case studies which will demonstrate how brake noise squeal issues have been successfully resolved.

Learning Objectives
By attending this seminar, participants will be able to:
• Describe the various brake shim damping mechanisms
• Compare the various brake shims available in the market place
• Describe the various tools available to reduce brake noise
• Utilize lessons learned in various brake noise problem case studies
**CHASSIS AND VEHICLE DYNAMICS**

**Who Should Attend**
The course is designed for a wide range of personnel from the brake test engineer who seeks to understand more about brake NVH to the experienced brake NVH/design engineer who wishes to know more about potential solutions. Anyone involved in the resolution of brake noise problems will find this course helpful.

**Prerequisites**
Participants should be familiar with brake hardware, basic terminology, and brake NVH measurement and testing. Previous attendance at the SAE seminars *Hydraulic Brakes for Passenger Cars and Light Trucks* (ID# C0509; page 15) and *Brake, NVH, Measurement, and Testing* (ID# C0802) or equivalent experience and knowledge are highly recommended.

**Topical Outline**
- Brief Review of Brake Noise
  - Types of brake noises
  - Frequency range
  - Source/path/receiver
- Principles and Applications of Brake Shims
  - Damping
  - Role and purpose of brake shims
  - Different types of brake shims
  - Brake shims damping mechanisms
- Tools for Brake Noise Analysis/Reduction
  - Brake noise categorization
  - Solution strategy
  - Investigative tools - Testing; Simulation
- Squeal
  - Brake pad design optimization
  - Pressure distribution optimization
- Low frequency squeal Moan/Groan
  - After-stop noise program - Problem identification; Transmission of the road to the lab; Measurement systems; Root cause analysis; Solution
- Questions and Answers Session

**Brake System Balance for Passenger Cars and Light Trucks**

*6 Hours*  
I.D.# WB1413

Designing a brake system requires the ability to balance a multitude of parameters against the required tradeoffs of system weight, system cost, and system performance. Understanding the basic fundamentals of how each brake component attribute contributes to the overall Force vs Deceleration behavior of the vehicle is critical to the design and release of a safe, legal and optimized system for today’s vehicles. Brake balance also is a contributing factor to other chassis control and safety systems, such as regenerative braking, ABS, and electronic brake distribution (EBD).

In three-sessions, this web seminar will cover the fundamentals of the development of braking forces generated by the brake system and the theory and principals to properly balance a brake system in accordance with legal requirements. Brake balance modifiers will also be presented.

This live online course allows for a detailed presentation of this topic for those unable to participate in the longer and broader classroom seminar, *Hydraulic Brake Systems for Passenger Cars and Light Trucks* (#C0509; page 15).

**Learning Objectives**
By participating in this web seminar, participants will be able to:
- Calculate the braking force on a vehicle from the installed brake components
- Determine the deceleration achieved by a vehicle for a given set of brake components
- Analyze and interpret the actual brake balance for a given vehicle and brake components
- Calculate the ideal brake forces required for a vehicle
- Evaluate tradeoffs between actual and ideal brake forces
- Calculate the impact of brake balance modifiers on vehicle braking performance

**Who Should Attend**
This course is designed for engineers interested in or responsible for: the specification, prediction and validation of braking system performance; brake component design by providing insight into the interaction of components and the contribution to system level performance metrics; the tuning and calibration of Chassis Control Systems including ABS, TCS, ESP, ROM and Regenerative Braking Systems. Practical experience in the design or validation of brake or chassis control systems is helpful in getting the most from this course.

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### Brake System Balance for Passenger Cars and Light Trucks

**6 Hours**

I.D.# WB1413

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This course is designed for engineers interested in or responsible for: the specification, prediction and validation of braking system performance; brake component design by providing insight into the interaction of components and the contribution to system level performance metrics; the tuning and calibration of Chassis Control Systems including ABS, TCS, ESP, ROM and Regenerative Braking Systems. Practical experience in the design or validation of brake or chassis control systems is helpful in getting the most from this course.

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3 ways to get a no-obligation price quote to bring a course to your company  
• Call SAE Corporate Learning at +1.724.772.8529
  • Fill out the online quote request at sae.org/corplearning  
• Email us at Corplearn@sae.org

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12
Commercial Vehicle Braking Systems

3 Days  
I.D.# CO233

Increased public pressure to improve commercial truck safety and new stopping distance regulations have intensified the need to better understand the factors influencing heavy vehicle braking performance. To assist individuals and their organizations in preparing for these new truck braking standards, this seminar focuses attendees on understanding medium-duty hydraulic brake systems and heavy-duty air brake systems and how both systems’ performance can be predicted, maintained and optimized. The function and application of the major brake system components will be explained and attendees will discover how brakes, tires and roadways interact as a system. Federal braking regulations for both hydraulic and air brake vehicles will also be covered. Attendees will receive the text, Commercial Vehicle Braking Systems: Air Brakes, ABS and Beyond written by Leonard C. Buckman.

Instructor: Paul Johnston  
Fee $1770  2.0 CEUs

Learning Objectives

By attending this seminar, participants will be able to:
- Design safe and efficient braking systems
- Test and measure braking performance
- Maintain and troubleshoot braking systems
- Comply with state and federal regulations on brakes
- Describe the brake implications of accident investigation
While most passenger car brake systems are quite robust and reliable under typical operating conditions, high-performance driving and/or racetrack operation generally require alternative design solutions to optimize consistency and longevity. Whether it is brake fluid fade, cracked rotor discs, chronic knockback, or insufficient brake pad life, the stresses of motorsports can pose unique challenges to even the very best brake system designs. Consequently, ceramic rotors, six-piston calipers, adjustable balance bars, and titanium backing plates have all made their way onto the high-performance brake system scene, but what is the right answer for your application?

This seminar has been designed to assist participants in answering that very question. The day begins with a concise yet thorough analysis of brake system design factors relevant to all types and categories of high-performance vehicles. The principles of energy conversion, gain, balance, and deceleration are discussed and supported with straightforward mathematical models, allowing attendees to realize the compromises that must be considered when designing from a system perspective.

From selecting an appropriate brake pedal ratio through the calculation of caliper effective piston area, the second portion of the seminar dives into the details of brake system component design. Based upon the principles learned earlier in the day, attendees will quickly realize that just as with proper system design, brake system component design is an exercise in managing engineering trade-offs. As a result, the material presented will not disclose what components to choose as much as how to choose them. Day two of the seminar concludes with a design exercise that will allow attendees to put into practice several of the key concepts learned throughout the seminar. Detailed course notes and illustrations are provided along with a copy of High-Performance Brake Systems: Design, Selection, and Installation for on-the-job reference.

Learning Objectives
By attending this seminar, participants will be able to:
• Estimate brake system energy capacity
• Approximate brake system gain requirements
• Calculate vehicle deceleration
• Establish brake proportioning for ideal balance
• Determine pedal ratios, booster output, and hydraulic system gain
• Discuss the differences between brake fluid chemistries
• Specify brake caliper components
• Differentiate between brake pad friction materials
• Select rotor technologies for application-specific needs

Who Should Attend
This course has been developed for individuals involved in the specification, design, installation, maintenance, and performance of brake systems and their associated components in high-performance and/or racing applications; however, the fundamental principles and design considerations presented apply to all facets of brake system engineering. In addition to individuals involved directly in brake system design, this course can be valuable to those responsible for chassis design, suspension tuning, tire optimization, and overall vehicle dynamics in high-performance applications.

Prerequisites
An undergraduate engineering degree or a strong automotive technical background is highly recommended. A basic knowledge of college algebra, college physics, and a familiarity with vehicle hydraulic brake system functionality is required to participate in the final seminar design exercise.

Topical Outline
DAY ONE
Module 1: Energy Conversion
• The Conservation of Energy
• Types of Energy
• Energy Transformation
• Calculating Brake System Temperatures
Module 2: Tires
• Brake Forces & Tire Slip
• The Mu-Slip Curve
• Calculating Maximum Deceleration
Module 3: Gain
• Gain & Force Distribution
• Brake Component Gain
• Brake System Gain
• Calculating Stopping Distance
• Compliance
Module 4: Brake Balance
• Brake Force and Corner Weight
• Static and Dynamic Weight Distribution
• Ideal Brake Balance
• Why Ideal Brake Balance Matters
Module 5: Apply System
• Brake Pedal Design & Function
• Brake Booster Design & Function
• Master Cylinder Design & Function
• Balance Bar Design & Function
• Proportioning Valve Design & Function
Module 6: Brake Fluid & Hoses
• Boiling Points and Water Adsorption
• DOT Ratings
• Hydraulic Circuit Design
• Brake Hose Design & Function
DAY TWO
Module 7: Calipers
• Caliper Design & Function
• Taper Wear and Piston Count
• Caliper Mounting
• Caliper Body Design
• Knockback
Module 8: Brake Pads
• Brake Pad Design & Function
• Brake Pad Fade
• Friction Material Categories & Chemistries
• Friction Mechanisms
Module 9: Rotors
• Rotor Design & Function
• Rotor Cooling
• Solid & Vented Rotors
• One-Piece & Two-Piece Rotors
• Cross-Drilled Rotors & Slotted Rotors
Module 10: Design Exercise
• Brake Force Analysis
• Deceleration Analysis
• Weight Transfer Analysis
• Brake Balance Analysis

Instructor: James Walker, Jr.
Fee $1370 1.3 CEUs

Hydraulic Brake Systems for Passenger Cars and Light Trucks

3 Days
I.D.# C0509

Hydraulic brake systems, one of the most important safety features on many road vehicles today, must meet manufacturer and customer requirements in addition to Federal Motor Vehicle Safety Standards. This course will analyze automotive braking from a system’s perspective, emphasizing legal requirements as well as performance expectations such as pedal feel, stopping distance, fade and thermal management. Calculations necessary to predict brake balance and key system sizing variables that contribute to performance will be discussed. Major components of a brake system, including calipers, boosters, master cylinders, drum brakes, and park brakes will be presented in detail highlighting the many design variations. An overview of the chassis control components and operating principles will be presented with an emphasis on ABS, traction control and stability control.

Learning Objectives
By attending this seminar, participants will be able to:
• Design a brake system in compliance with Federal Motor Vehicle Safety Standards
• Calculate the ideal brake balance for a vehicle under any loading condition
• Calculate the actual brake balance and brake output for a selected set of brake components and evaluate the effects of changing component parameters
• Determine the effects of variation in component parameters on the system performance
• Describe the basic function of major brake components
• Describe various chassis control systems and their role in vehicle safety
• Determine the appropriate design variation for a particular application

Who Should Attend
This course is designed for engineers interested in, or responsible for, the specification, prediction and validation of braking system performance. It will also benefit engineers responsible for brake component design by providing insight into the interaction of components and the contribution to system level performance metrics.
CHASSIS AND VEHICLE DYNAMICS

Topical Outline

DAY ONE
• System Level Requirements
  • Emphasis on FMVSS 135 and ECE 13 -- Effects of requirements on design; Tradeoffs with other system requirements; Partial system considerations; Loading conditions
  • Stopping Distance -- Actual vs. magazine; Contributions of subsystems; Effects of driver
  • Thermal management -- Conservation of energy; Abuse schedules; Mountain descents; Design for max speed vs. high use
  • NVH & pedal feel -- Metrics and criteria; Objective techniques
• Brake Balance and System Output Calculations
  • Ideal brake force derivation
  • Actual brake output
  • Effects of variation, planned and unplanned

DAY TWO
• Workshop - The student will design a brake system for a vehicle of their choice and predict the performance to key system level targets
• Component Functional Review
  • Brake pedal assembly -- Variable ratio; Adjustable; Composite
  • Brake booster options -- Vacuum; Hydroboost; Active
  • Master cylinder
  • Fluid, pipes, and hoses
  • Proportioning and metering valves
  • Disc brakes -- Fixed; Floating; Multi-piston; Vented; 2-piece

DAY THREE
• Component Functional Review (continued)
  • Drum brakes - Leading-trailing; Duo-servo; Self-adjusting; Static Brake
  • Parking Brakes - Foot vs. hand; Cables and tensioning; Drum-in-hat; Caliper mechanisms
• Workshop - The student will determine the effects of component variation on their design from Day 2
• Anti-lock Braking Systems
  • Mechanization
  • Performance
  • Dynamic rear proportioning/electronic brake force distribution
• Advanced Concepts and Technology
  • Panic brake assist
  • Hybrid/regenerative braking
  • Brake-by-wire
  • Electric parking brake

Introduction to Brake Control Systems:
ABS, TCS, and ESC

2 Days
I.D.# C0315

Similar content is available in an on demand course. Review the course info in the On Demand Courses Guide on page 199.

Once reserved for high-end luxury vehicles, electronic brake control systems are quickly becoming standard equipment on even the most inexpensive cars and trucks. Today, nearly every new vehicle benefits from the optimized braking, enhanced acceleration, or improved stability that these systems provide. This comprehensive seminar introduces participants to the system-level design considerations, vehicle interface requirements, and inevitable performance compromises that must be addressed when implementing these technologies.

The seminar begins by defining the tire-road interface and analyzing fundamental vehicle dynamics. Following an in-depth study of system electronics, hydraulic hardware, and sensor requirements, the participants learn about the control strategies employed by anti-lock brakes (ABS), dynamic rear proportioning (DRP), traction control (TCS), and electronic stability control (ESC) with strong emphasis placed on vehicle dynamic response.

The seminar concludes with a study of unique applications, a look forward to advanced brake control system integration, and an overview of Federal Motor Vehicle Safety Standard 126. Over 500 pages of detailed course notes and illustrations are provided for on-the-job reference.

Learning Objectives

By attending this seminar, participants will be able to:
• Analyze brake system design parameters and their vehicle performance effects
• Evaluate the compromises between stability, steerability, and stopping distance
• Identify the discrete mechanical components required for ABS
• Specify fundamental ABS performance attributes
• Calculate dynamic brake balance and explain the benefits of DRP
• Reconcile TCS performance expectations vs. method of implementation
• Define ESC performance metrics and physical limitations
• Assess features such as adaptive cruise control and brake assist
• Interpret federal requirements for the performance of ESC

Instructor: Thomas J. Hall
Fee $1745 2.0 CEUs
CHASSIS AND VEHICLE DYNAMICS

Who Should Attend
This course has been developed for engineers involved in all fields related to the design or development of vehicle dynamics, vehicle braking systems, powertrain systems, chassis systems, or suspension systems. In addition, this course can be valuable to those with component design responsibilities in brake, chassis, suspension, or tire disciplines.

Individuals new to the field of brake control systems will benefit most from the material; this introductory course is not intended for individuals with significant experience with brake control systems. In addition, please note that because of proprietary considerations this class does not provide details of algorithm design, algorithm performance, or algorithm application. Instead, the course places strong emphasis on vehicle dynamic responses.

Prerequisites
An undergraduate engineering degree or a strong technical background is highly recommended. A basic knowledge of college algebra, college physics, and a familiarity with vehicle brake and suspension systems is required.

Topical Outline
DAY ONE
• Tire-Road Interface Characteristics
  • Defining slip
  • Longitudinal mu-slip relationship
  • Longitudinal vs. lateral slip capacity
  • The friction circle
• Hydraulic Brake System Overview
  • What do braking systems do?
  • How does each component contribute?
  • What are the underlying fundamental relationships?
  • How does this apply to brake control systems?
• Stability, Steerability, Stopping Distance
  • Define stability, steerability, stopping distance
  • Illustrate with mu-slip curves
  • Illustrate with friction circle
• Mechanization of ABS
  • ECU functions and components
  • HCU functions and components
  • ABS hold, release, and apply functions
  • Diagnostics and warning lamp considerations
• ABS Sensor Overview
  • The role of sensors
  • Wheel speed sensors
  • Brake apply state sensors
  • Longitudinal accelerometers
• ABS Performance
  • ABS objectives and strategies
  • Basics of ABS wheel control
  • ABS performance on homogeneous surfaces
  • ABS performance under other conditions
DAY TWO
• DRP Performance
  • Weight transfer and brake proportioning
  • Proportioning valve design and performance
  • DRP strategies, wheel control, and performance
  • DRP benefits, design compromises, and limitations
• Mechanization of TCS and ESC
  • Additional ECU functions and components
  • Additional HCU functions and components
  • Pressure build sequence
• TCS Performance
  • TCS objectives and strategies
  • Basics of TCS wheel control
  • TCS performance under various conditions
  • Driveline architecture interactions
• ESC Sensor Requirements
  • The role of sensors
  • Steering angle sensors
  • Brake pressure sensors
  • Lateral accelerometers and yaw rate sensors
• ESC Performance
  • The physics of turning
  • ESC objectives
  • ESC strategies and basics of wheel control
  • ESC performance and driveline architecture
• Additional Features and Functionality
  • The evolution of control systems
  • What isn’t changing (for now, anyways)
  • Brake and chassis control systems
  • Adding radar and camera-based inputs
• Federal Motor Vehicle Safety Standard 126
  • ESC definitional requirements
  • ESC dynamic performance test
  • Stability and responsiveness requirements
  • Industry rollout requirements
• Learning Assessment

Instructor: James Walker, Jr.
Fee $1355 1.3 CEUs
CHASSIS AND VEHICLE DYNAMICS

Introduction to Brake Control Systems

9.5 Hours

Similar content is available in the classroom seminar – Introduction to Brake Control Systems: ABS, TCS, and ESC – see course info above.

Convenient, portable, and with core content from the instructor-led seminar (content and description similar to the preceding classroom counterpart), this 9.5 hour on demand option offers an alternative way to receive the same instruction without the expense of travel and time away from the workplace. The course is divided into 13 video modules, accompanied by a handbook.

Learn more about this course in the On Demand Courses Resource Guide found on pages 199-259.

Quantity discounts and Site License options are available – call SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.

Introduction to Brake Noise, Vibration, and Harshness

1 Day
I.D.# C1337

Brake Noise, Vibration, and Harshness (NVH) is recognized as one of the major problems currently faced by the automotive manufacturers and their suppliers, with customers warranty claims of more than $100 million per year for each manufacturer. With increasing consumer braking performance expectations, automotive OEM’s and suppliers need the ability to predict potential problems and identify solutions during the design phase before millions of dollars have been spent in design, prototyping, and manufacturing tooling. This seminar provides an introduction to brake NVH, including a concise summary of the various brake NVH problems, current lab and vehicle measurement techniques and SAE global standards which are utilized to characterize the noise correctly in order to get the best option/solutions quickly. The information provided will serve as an excellent foundation for understanding and characterizing brake NVH issues and is an excellent primer to the SAE seminar Brake Noise Problem Resolution (ID# C0831, page 11), also taught by instructor Eric Denys.

Learning Objectives

By attending this seminar, participants will be able to:
• Describe NVH and brake NVH
• Identify the various brake NVH problems
• Describe the components of a brake NVH dynamometer
• Configure and perform dyno and vehicle brake NVH tests measurements
• Utilize SAE J2521, the only international standard for brake NVH dynamometer evaluation
• Interpret basic noise and vibration data in the time and frequency domain
• Explain the premise behind various SAE Standards related to brake NVH

Who Should Attend

The information in this course is relevant to a wide audience, from the brake test technician who seeks to understand more about NVH and brake NVH, to the experienced brake NVH engineer who wishes to know more about the details of the tests performed and the meaning of the results. Brake development and brake component engineers who are not familiar with brake NVH will also find the course beneficial.

Topical Outline

• Basics of Noise and Vibration
  • Basic terminology
  • Spectral analysis
  • Modal analysis
  • Sound radiation
• Basics of Brake NVH
  • Different types of brake noise
  • Why do brakes make noise?
  • Source, path, and receiver description
• Basic Dynamometer Testing
  • Test set-up
  • SAE J2521 - Disc and Drum Brake Dynamometer Squeal Noise Matrix
  • Data analysis and reporting
• Vehicle Brake Testing
  • Basic instrumentation
  • Data analysis and reporting
  • SAE J2625 - Automotive Vehicle Brake Squeal Test Recommended Practice
• Brake SAE NVH Standards Currently Released and Under Development
  • SAE J2598 - Automotive Disc Brake Pad Natural Frequency and Damping Test
  • SAE J2786 - Automotive Brake Noise and Vibration Nomenclature
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RELATED TRAINING SOLUTIONS

Some of our courses apply to more than one technology category. Consider these related courses described in other sections of this resource guide.

Introduction to Highly Automated Vehicles

This course is designed to familiarize participants with the technologies enabling advanced driver assistance systems and how they integrate with existing passive occupant crash protection systems.

Read more about this course on page 28.
YOUR CONNECTION TO THE MOBILITY ENGINEERING COMMUNITY

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Automotive Lighting: Design and Technology

2 Days
I.D.# C0202

Since the invention of the automobile, lighting has been an important subsystem on all ground vehicles. Automotive lighting is vital to passenger safety, comfort and vehicle styling. The technology used in automotive lighting has rapidly expanded to make the lighting more value added, safer and pleasing to customers. This seminar provides broad information about automotive lighting systems with emphasis on lighting functions, effectiveness, and technologies. The intent is to assist attendees to gain sufficient knowledge about automotive lighting and its importance in overall vehicle design and development. Since only the exterior lighting devices on the ground vehicles are regulated by the federal and local governments, and standardized by the SAE Lighting Committee and the international communities, this course will only address automotive exterior lighting.

Learning Objectives
By attending this seminar, participants will be able to:
• Describe various automotive lighting technologies
• Articulate the legal aspects and implications related to automotive lighting
• Examine safety measurements used with lighting functions and human factors costs
• Discuss the latest advancements in lighting technologies and trends in lighting styling

Who Should Attend
This seminar is of benefit to a wide audience, including: Automotive body engineers responsible for lighting and vehicle interface and integration; vehicle stylists who are interested in lighting effects on vehicle cosmetics; regulatory personnel involved with the legal specifications of automotive lighting; marketing specialists who are interested in customers’ preferences based on the relationship of human vision and lighting; and newcomers in the automotive industry who need to obtain a general overview of lighting.

Topical Outline
DAY ONE
• Introduction
• Fundamentals of Automotive Lighting
  • Light - What is light; Definition of light; Types of light; Visible light; Generation of light
  • Light Measurements -- Basic concept; photometry and radiometry; Color of light; Terms of photometry; Photometry units comparison; Photometry and radiometry unit conversion; Photometry and radiometry calculations
  • Lighting; Illumination Devices -- Functions of an illumination device; Types of illumination devices; Basic structure of illumination devices
  • Classification of Automotive Lighting -- Forward lighting and signal lighting; Headlamps; Fog lamps (front and rear);
ELECTRICAL/ELECTRONICS AND ELECTRONIC SYSTEMS

Daytime running lamps; Stop & tail lamps; Turn signal lamps (front and rear); Other lamps
• Requirements for Automotive Lighting -- Regulations and industry standards; Performance; Testing
• Light Sources Used in Automotive Lighting
  • Basics of Light Source -- Incandescent; Discharge; Fluorescent; Solid-state; Electroluminescent; Light source comparison
  • Light Source Characteristics -- Light emitter geometry; Light output from a light source; Life; Light source operation and testing; Bulb accuracy levels
  • Types of Light Sources Used for Automotive Exterior Lighting -- Incandescent bulbs; Tungsten halogen bulbs; HID subsystem (burner, starter & ballast); Neon light source (emitter & ballast); LED source (LED package, circuit board & control device)
• Major North America Automotive Light Source Suppliers -- Osram (OSI & OOS); Philips (including Lumileds); Others
• Automotive Lamp Photometry Design
  • Optical Design Principles - Optics; Geometrical optics; Imaging optics; Non-imaging optics; Reflection; Refraction; Transmission; Dispersion
  • Light Control; Collections and Manipulations - Light collectors; reflectors and lenses; Light manipulators (reflector optics, lens optics, diffusers, light guides and fiber optics, reflex); Etendue

DAY TWO
• Optical Design for Automotive Lamps - Automotive lamp configurations; Optical design step 1; feasibility study; Optical design step 2; setup strategy; Optical design step 3; design optics; Optical design step 4; simulations; Other considerations; Light source selection; CAE for optical design and simulation
• Automotive Lamp System Configuration
  • Automotive Lamp System Design Overview - System level specifications; Vehicle interface
  • Automotive Lamp Thermal Analysis - Purpose; Heat transfer; Empirical database; CFD lamp thermal model
  • Automotive Lamp Ventilation Analysis - Understanding moisture; Moisture and condensation in a lamp; Venting analysis; Vent design
  • Automotive Lamp System Analysis - CAD tools used in automotive lamp design; Lamp thermal analysis; Lamp venting analysis; Lamp structural analysis; Lamp mold accuracy analysis; Lamp assembly analysis
  • Human Factor Considerations - What are human factors; Headlamp safety; seeing distance; Glare; Headlamp aiming issue; Headlamp mounting height issue; Headlamp lens issue; Signal detection; Lamp design for human factor optimizations
• New Automotive Lighting Technologies
  • Advanced Optical Structures for Automotive Lamps - Combination of projector & free-form reflectors (P&F) headlamps
  • Improved projector modules
  • Dual-Function HID (Bi-Xenon) Lamps - System; Reflector type dual-function HID lamp; Projector type dual-function HID lamp
  • Distributive Lighting System (DLS); a Remote Lighting System Using Fiber Optics - System; DLS headlamp application; Other DLS applications
  • Adaptive Forward-lighting System (AFS); an Intelligent Lighting System - System; Desired beam pattern variations; Driving and environment condition measurements; AFS design option I; add beam contributor(s); AFS design option II; rotate headlamps; AFS design option III; vary component(s) in the headlamp
  • Night Vision System - System definition; Infrared and IR cameras; Types of night vision systems; Examples of night vision systems

Instructor: Jianzhong Jiao
Fee $1370 1.3 CEUs

Automotive Lighting: LED Applications

1 Day
I.D.# C0727

Lighting Emitting Diode (LED), a new generation semiconductor light source often referred to as Solid-State Lighting (SSL), has been broadly adopted in illumination, display, visualization, and other areas due to its higher efficacy and longer life. LEDs, first introduced for automotive interior applications such as indicators, expanded to exterior applications including center high mounted stop lamps and other automotive signal lighting devices. Today, LED technologies are being used for night vision, occupancy detection, and many other automotive application areas. This seminar is designed to provide the attendee with an overview of LEDs and their applications in automotive lighting and illumination.

Learning Objectives
By attending this seminar, participants will be able to:
• Describe the basic LED configurations, characteristics, and classifications
• Assess LED and SSL technologies used in automotive applications
• Identify technical challenges and limitations of LEDs
• Select appropriate equipment for measurement of various conditions

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• Fill out the online quote request at sae.org/corplearning • Email us at Corplearn@sae.org
• Evaluate LEDs for conformance to SAE standards
• Establish a basic design strategy for specific applications including forward lighting devices
• Manage a design activity to deal with thermal management

Who Should Attend
This seminar can be of benefit to a wide audience including LED automotive body and system engineers responsible for lighting and vehicle interface and integration; vehicle stylists who are interested in lighting effects on vehicle cosmetics and lighting developers and manufacturers; marketing specialists who are interested in customers’ preferences based on the relationship of human vision and lighting; and newcomers in the automotive industry who need to obtain a general overview of lighting.

Topical Outline
• Introduction
• LED - Definitions and Classifications
  • Types of LEDs
  • Basic LED characteristics
  • LED efficiency
  • Life and lumen maintenance
• LED Measurements and Standardization
  • Photometric measurements - Light output measurements; Color of the light source; Measurements of LED life and lumen maintenance
  • Thermal measurements - Thermal resistance and de-rating
  • Measurement equipment - Photometric measurement and thermal management equipment
• LED binning - Luminous flux, voltage, and color bin
• LED automotive lighting standards - Signal lighting and forward lighting standards; Human factors evaluations for white LEDs
• LED component standards - Definitions; Industry trends
• LED Automotive Exterior Lighting Applications
  • LED lamp design basics
  • Photometric design requirements -- Basic design procedure; Design flow and optimization process
  • LED lighting system thermal and electronic design -- Why thermal management?; Effects of LED junction temperature; Cooling systems; LED bin selection; Electronic design - dual level lamps
  • LED signal lighting design concepts and examples -- Direct lighting: with or without secondary optics; Indirect lighting: TIR - prism, light guide and light pipe
  • LED headlamp design concepts and examples -- Comparison of light sources used for headlamps; Design restrictions and strategies
  • LED Automotive Interior Applications -- Interior lighting basics (Types of interior lighting, Performance evaluations); LED applications (Backlight for display, Interior illumination, Occupancy detection)

Instructor: Jianzhong Jiao
Fee $810 .7 CEUs

Automotive Lighting: Testing and Requirements
1 Day
I.D.# C0618

It has not been commonly known that automotive exterior lights are safety devices and must comply with governmental regulations. Since the 1930s, the SAE Lighting Standards Committee has been actively working with the automotive industry OEMs, lamp makers, tier-two suppliers, and human factor experts to develop automotive lighting standards. These standards have been widely used or referenced by the U.S. federal or state governments in establishing and enforcing the lighting regulations. This seminar emphasizes the safety importance of automotive lighting devices and provides important information on lighting functions, standards or regulations, testing and evaluations.

Learning Objectives
By attending this seminar, participants will be able to:
• Describe the legal aspects and implications related to automotive lighting
• Search for and use the lighting related standards for all exterior or lighting devices
• Establish or assist with lighting tests and evaluations

Who Should Attend
Automotive engineers and product development personnel who are responsible for lighting design, manufacturing, quality assurance, installation, vehicle interface and integration will benefit from attending this seminar. Regulatory personnel who are involved with the legal specifications of automotive lighting and law enforcement agencies or individuals responsible for lighting regulations will find the information valuable and relevant as will testing engineers or technicians who are responsible for evaluating and verifying the compliance of lighting standards and regulations.
Prerequisites
Participants should have a technical background and some knowledge related to automotive lighting devices; an undergraduate engineering or related degree is preferred.

Topical Outline
• Introduction — SAE Lighting Standards Committee
  • Current organization
  • History
  • Duties, responsibilities and membership
• Definitions and Terminologies Used in Automotive Lighting
  • Illumination devices — Functions; Types; Basic structure
  • Classification of automotive lighting — definitions and operations - Forward lighting; Signal lighting; Auxiliary lamps
• Automotive lighting terminology — Terminology; Identification code; Inspection code
• Testing and Evaluations
  • General categories — What needs to be tested?; Photometry tests; Environmental tests; Electrical tests; On-vehicle tests; Special tests for selective devices using HID, LED, neon and other light sources
  • Testing equipment — Photometry test equipment; Environmental tests equipment; Electrical tests equipment
  • Test methods: lighting sources, subsystems, and devices — Light source test; Special test for subsystems; Device test
• Material tests — Weatherability; High deformation temperature (HDT); Optical characteristic; Chemical and physical behavior
  • Human factor evaluations — What are human factors?; Headlamp safety - seeing distance; Driver’s comfort and glare; Signal detection
• Automotive Lighting Requirements
  • Industry standards and government regulations
  • SAE Requirements — Classification; Component related requirements; Device related requirements
  • U.S. federal government requirements — NHTSA; FVMSS 108; Petition and interpretation; Recalls
  • Comparison of SAE vs. U.S. federal regulations — Light source and subsystem requirements; Photometry requirements for all lamps; General environmental requirements for all lighting devices; Additional environmental requirements for forward lighting devices; Additional environmental requirements for device functions - forward lighting and signal lighting devices; Technology specific requirements; Material requirements
• International requirements — Economic Commission for Europe (ECE); International Harmonization; Global Technology Regulations (GTR)

Control Systems Simplified
2 Days
I.D.# C0525

The advent of digital computers and the availability of ever cheaper and faster micro processors have brought a tremendous amount of control system applications to the automotive industry in the last two decades. From engine and transmission systems, to virtually all chassis subsystems (brakes, suspensions, and steering), some level of computer control is present. Control systems theory is also being applied to comfort systems such as climate control and safety systems such as cruise control or collision mitigation systems.

This seminar begins by introducing the highly mathematical field of control systems focusing on what the classical control system tools do and how they can be applied to automotive systems. Dynamic systems, time/frequency responses, and stability margins are presented in an easy to understand format. Utilizing Matlab and Simulink, students will learn how simple computer models are generated. Other fundamental techniques in control design such as PID and lead-lag compensators will be presented as well as the basics of embedded control systems. During this interactive seminar, attendees will utilize case studies to develop a simple control design for a closed loop system. And, with the aid of a simple positioning control experiment, students will learn the major components and issues found in many automotive control applications today.

Learning Objectives
By attending this seminar, participants will be able to:
• Determine performance characteristics of open and closed loop systems such as time and frequency responses and stability margins
• Analyze compromises and select the best compromised solution between stability and closed loop performance metrics
• Model simple physical systems in MatLab/Simulink environment
• Analyze and design simple compensators in MatLab/Simulink environment
• Evaluate issues associated with digital control systems including effects of sampling time, word length, and throughput
• Explain the functions of various components found in today’s automotive embedded control systems including ECU I/O section, software/algorithm, power electronics, and sensors and actuators
• Communicate with control systems designers more effectively in terms of technical issues as well as toolsets, and functional needs
Who Should Attend
This introductory course is designed for individuals with little or no background in control systems. Engineers, managers, and technical managers with backgrounds in systems, mechanical, electrical, or industrial engineering who work with vehicle chassis (suspension/brakes/steering), powertrains, comfort systems, vehicle dynamics, sensors/actuators, and diagnostics will find the seminar beneficial. Test engineers and technicians, patent attorneys, and business executives may also find this course valuable.

Prerequisites
An undergraduate engineering degree or a strong technical background is highly recommended. Basic knowledge of college algebra, college physics, and a familiarity with vehicle systems is required.

Topical Outline
DAY ONE
• Background Information
  • Examples and block diagrams - Open and closed loop systems
  • Dynamic systems (time and frequency domains)
  • Stability
  • Compromises of a closed loop system
• Model Development
  • Modeling philosophies
  • Case study - Problem description; Governing equations; Create a model based on transfer function; Create a model based on Simulink blocks
• Model Analysis
  • Case study - Simulation issues (numerical integration); Linear analysis - frequency domain; Nonlinear analysis - time domain
• Compensation (Controller Design) Methods
  • On-Off
  • Gain
  • PID
  • Lead-Lag
DAY TWO
• Control System Design
  • Case study - Design philosophies; Time domain based design; Frequency domain based design
• Embedded Systems
  • Elements of embedded control systems
  • Experiment
  • Digital control
  • Implementation issues
• Design Implementation
  • Case Study - Digital issues; Experiment; Sensors and estimation; Software architecture;

• Advanced Subjects
  • Nonlinear/adaptive control
  • Robust control
  • Trends, tools and references

Instructor: Farhad Bolourchi
Fee $1370 1.3 CEUs

Controller Area Network (CAN) for Vehicle Applications
2 Days
I.D.# C0120
The Controller Area Network has become the standard of choice for most automotive manufacturers. Approved for use as an ISO and EPA diagnostic network, its usage continues to grow. This seminar covers the theory and use of the CAN protocol, and its applications in the automotive industry.

Details on how the CAN protocol and other standards (J2411, J2284, J1939, ISO 11898, etc.) complement each other will be presented. Attendees will learn about CAN application layers; the latest J1939, J2284, J2411, and IDB standards, regulations, and implementation requirements; and details of device hardware and software interfaces. Also presented will be demonstrations using system development tools. The SAE standard, J1939 Recommended Practice for a Serial Control and Communications Vehicle Network, is included in the course materials.

Learning Objectives
By attending this seminar, participants will be able to:
• Explain CAN protocol.
• Demonstrate how CAN is used in various automotive applications.
• Employ CAN-related standards and specifications.

Who Should Attend
This seminar is geared toward validation engineers, test engineers, embedded programmers, and those who are currently working (or will be in the future) with applications using CAN. Participants should have an undergraduate engineering degree.

Topical Outline
DAY ONE
• In-vehicle market overview
• General network topology overview
• CAN protocol; CAN controller programming
• CAN physical layers
• Overview of J2411, J2284, IDB, J1939, Diagnostics on CAN, etc.
ELECTRICAL/ELECTRONICS AND ELECTRONIC SYSTEMS

DAY TWO
- J1939 in-depth review
- IDB in-depth review
- Demonstrations

Instructor: Mark Zachos
Fee $1445 1.3 CEUs

Fundamentals of Shielding Design for EMC Compliance
1 Days
I.D.# C0835

It is important for electronic and hardware engineers to not only be knowledgeable of a product’s intended function and performance, but also its ability to perform within electromagnetic compatibility (EMC) limits. This seminar introduces practical shielding theory, design fundamentals, and configurations, including shielding products, common and differential modes, electromagnetic fields, and enclosure shielding. A segment on enclosure testing is presented in conjunction with an aperture attenuation modeling program (which is used to model attenuation characteristics at various frequencies and aperture size prior to expensive FCC/CE compliance or MIL-STD 461 testing). Honeycomb vent panels, plating attenuation comparisons, and galvanic compatibility per MIL-STD 1250 will also be discussed. Although the concepts presented in this seminar may be applicable to the automotive industry, the examples and standards presented are primarily focused on military and commercial vehicle applications.

Learning Objectives
By attending this seminar, participants will be able to:
• Identify the basic characteristics of Common and Differential Mode
• Recognize E,H, and Plane wave fields, Surface current and “Skin effect” based on increased frequency
• Specify Galvanic compatibility of various metal plating
• Specify industry standard shielding products for EMC compliance
• Evaluate waveguide effect of EMI/RFI shielded honeycomb ventilation panels
• Analyze aperture attenuation modeling for EMC design

Topical Outline
- EMC Fundamentals
  • Definitions
  • Maxwell equations
  • EMI and apertures
  • EMI environment and characteristics
- Practical Shielding Theory
  • Common / Differential modes
  • BLS Crosstalk / Radiated fields
  • Reciprocity
  • Emitter location effects
  • Partial shields
  • H, E, and PW fields
  • Shielding material testing
  • Absorption and reflection
- Shield Apertures
  • Skin depth
  • EM Leakage
  • Aperture calculation
  • Multiple apertures
  • RF current flow
- Aperture Attenuation Modeling Program
  • Aperture Calculations
  • PCB test data comparisons
  • Attenuation Modeling and Test Factor
- Honeycomb Vent Panels
  • Design - waveguide effect
  • Attenuation of various panels
  • Galvanic compatibility
- EMC Shielding Products and Materials
  • Board Level Shields (BLS)
  • Gaskets (BeCu fingerstock, conductive fabric, conductive elastomer, wire mesh)
  • Ferrites Materials
  • RF Absorber
  • Shielding principles
- EMC Shielding Specifications and Applications
  • MIL-STD 461 / 464 test specifications
  • Shielding applications
- Question/Answer Session
  • Learning assessment
  • Group discussion on specific EMC design concerns and applications

Instructor: Michael J. Oliver
Fee $810 .7 CEUs

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**Emissions-Related OBD Systems: A Design Overview**

1 Day  
I.D.# C0708

On-board diagnostics, required by governmental regulations, provide a means for reducing harmful pollutants into the environment. Since being mandated in 1996, the regulations have continued to evolve and require engineers to design systems that meet strict guidelines. This one day seminar is designed to provide an overview of the fundamental design objectives and the features needed to achieve those objectives for generic on-board diagnostics. The basic structure of an on-board diagnostic will be described along with the system definitions needed for successful implementation.

Please note that because of proprietary considerations, this class does not provide details of algorithm design, algorithm performance, or algorithm application. The class will cover general OBD algorithm designs and the features required to promote sound OBD system design.

Individuals desiring a more in-depth look at On-Board Diagnostics should consider attending SAE seminar Designing On-Board Diagnostics for Light and Medium Duty Emissions Control Systems (I.D# C0707).

**Learning Objectives**

By attending this seminar, participants will be able to:
- Articulate the underlying design objectives of on-board diagnostic systems
- Apply the design features that all diagnostics need for successful implementation
- Apply basic design techniques to deal with variation
- Use a diagnostic design template in the development of an on-board diagnostic

**Who Should Attend**

This course is designed for engineers involved in either the design or control of on-board diagnostic systems for engines or transmissions. Individuals working in the heavy duty industry will find the information relevant, but should note that the examples will be based on spark ignition engines and light and medium duty regulations. In addition, engineers involved in engine and transmission hardware will benefit by obtaining a better understanding of the design of OBD systems. Engineers new to the area of OBD system design and engineers involved in the design of control systems wishing to obtain a better understanding of OBD requirements will also find the course valuable.

**Prerequisites**

An undergraduate engineering degree or a strong technical background is highly recommended. A basic knowledge of college algebra, college physics, and a familiarity with modern engine or transmission systems is required.

**Topical Outline**

- Fundamental Design Objectives for OBD Systems
- Basic Design Features for OBD Systems
- Defining “Good” vs. “Bad” Systems
- Exercise: Defining Good vs. Defective Systems
- Anatomy of an On-Board Diagnostic
- Diagnostic Modeling
- Understanding and Dealing with Variation
  - Decision making processes
  - Design guidelines for Exponentially Weighted Moving Averages (EWMA)

**Instructor:** John Van Gilder or Igor Anilovich

**Fee:** $885  .7 CEUs

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**Designing On-Board Diagnostics for Light and Medium Duty Emissions Control Systems**

3 Days  
I.D.# C0707

On-board diagnosis of engine and transmission systems has been mandated by government regulation for light and medium vehicles since the 1996 model year. The regulations specify many of the detailed features that on-board diagnostics must exhibit. In addition, the penalties for not meeting the requirements or providing in-field remedies can be very expensive. This course is designed to provide a fundamental understanding of how and why OBD systems function and the technical features that a diagnostic should have in order to ensure compliant and successful implementation.

Fundamental design objectives and features needed to achieve those objectives for generic on-board diagnostics will be covered. The course will also include a review of the California Air Resources OBD II regulation, providing students with a firm foundation for reading and understanding the requirements, including the in-use rate portion of the regulations and how to properly calculate and output the required rate information. Relationships between the regulation and various SAE and ISO recommended practices will be reviewed. The course will also...
explore the relationship of the OBD system with the underlying control system.

Note that because of proprietary considerations, this class does not provide details of algorithm design, algorithm performance, or algorithm application. The class will cover general OBD algorithm designs and the features required to promote sound OBD system design.

**Learning Objectives**

By attending this seminar, participants will be able to:

- Articulate the underlying design objectives of on-board diagnostic systems
- Use the latest California Air Resources Board On-Board Diagnostic Regulation for Light and Medium Vehicles to find and apply OBD requirements
- Apply the design features that all diagnostics need for successful implementation
- Design diagnostics to comprehend variation
- Successfully implement algorithms to track in-use rates in accordance with the CARB OBD II Regulation
- Use SAE J1979 to implement generic scan tool support in diagnostic design
- Implement OBD design requirements in control system design

**Who Should Attend**

This course is designed for engineers involved in either the design or control of on-board diagnostic systems for engines or transmissions for light and medium duty on-road vehicles. Individuals working in the heavy duty industry may also find the information interesting, but should note that the examples will be geared towards spark ignition engines and light and medium duty regulations. In addition, engineers involved in engine and transmission hardware will benefit by obtaining a better understanding of the design of OBD systems. Engineers new to the area of OBD system design and engineers involved in the design of control systems wishing to obtain a better understanding of OBD requirements will also find the course valuable.

**Prerequisites**

An undergraduate engineering degree or a strong technical background is highly recommended. A basic knowledge of college algebra, college physics, and a familiarity with modern engine or transmission systems is required.

**Topical Outline**

**DAY ONE**

- Fundamental Design Objectives for OBD Systems
- Basic Design Features for OBD Systems
- Exercise: “Customers” and their OBD Requirements
- Overview of the World Wide OBD Regulatory Structure
- California Air Resources Board (CARB) Regulatory Process
- How to use the CARB Light/Medium Regulation
  - Malfunction and diagnostic system requirements
  - Enforcement of malfunction and diagnostic system requirements

**DAY TWO**

- CARB Regulation - an in-depth look at:
  - In-use rates
  - Comprehensive component requirements
  - Introduction to a Diagnostic Design Process (Box, Graves, Bisgaard, Van Gilder, et al)
  - Defining “Good” vs. “Bad” Systems
    - Exercise: Defining Good vs. Defective Systems
  - Anatomy of an On-Board Diagnostic
    - Diagnostic Modeling
    - Exercise: Induction System Modeling
  - Understanding and Dealing with Variation
    - Decision making processes
    - Design guidelines for Exponentially Weighted Moving Averages (EWMA)

**DAY THREE**

- SAE J1979 - An Overview
- Exercise: Finding Information in J1979
- System Design for Diagnosibility
- Overview of Regulatory Requirements Related to OBD
  - In-use Enforcement
  - Emissions warranty
  - OBD Certification Process
  - The Relationship between the Control and OBD System Design

**Instructor:** John Van Gilder or Igor Anilovich

**Fee:** $1865 2.0 CEUs

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**Introduction to Highly Automated Vehicles**

2 Days
I.D.# C1603

Every year, the U.S. experiences more than 32,000 traffic deaths and over 3.8 million crash injuries. While the trend in traffic deaths has been downward for the past decade, most of this reduction has been the result of optimizing passive occupant crash protection systems such as seatbelts and airbags. Advanced driver assistance systems (ADAS) now offer the potential to significantly reduce or eliminate most vehicle crashes by perceiving a dangerous situation before the crash has occurred and taking action to avoid or mitigate the crash. This course is designed to familiarize participants with the technologies enabling advanced driver assistance systems and how they integrate with existing...
passive occupant crash protection systems. You will learn how ADAS functions perceive the world, make decisions, and either warn drivers or actively intervene in controlling the vehicle to avoid or mitigate crashes. Examples of current and future ADAS functions, various sensors utilized in ADAS, including their operation and limitations, and sample algorithms, will be discussed and demonstrated. The course utilizes a combination of hands-on activities, including computer simulations, discussion and lecture.

**Learning Objectives**

After completing this seminar attendees will be able to:

- Explain the SAE Levels of Automation and where different ADAS functions fit in the hierarchy
- Explain the ADAS functions and articulate their limitations
- Identify different sensors used in advanced driver assistance systems, how they operate, and their limitations
- Analyze how different sensors can be combined to improve overall system performance
- Describe the current and future methodologies used in developing ADAS algorithms
- Articulate how ROC curves, DOE and Monte Carlo techniques can be used to measure and improve algorithm performance
- Critically examine the proposed federal rules and validation methods for advanced driver assistance systems
- Analyze how active safety systems may affect the performance of existing passive occupant safety systems and how integration of the systems might be accomplished
- Describe liability and policy considerations for OEM’s and Tier suppliers

**Who Should Attend**

This course is designed for all professionals - technical or managerial - who are involved either directly or indirectly with vehicle safety performance. Professionals in legal and regulatory and compliance areas concerned with proposed NHTSA rulemaking, and insurance industry analysts developing coverage standards for vehicles with active safety technologies will also find this course useful.

**Topical Outline**

**DAY ONE**

- The Role of Vehicle Automation in Reducing Traffic Fatalities
  - Passive safety highly optimized
  - Recent increase in vehicle crash rates
- Three Main Functions Provided by Highly Automated Vehicles (HAVs)
  - Increase situational awareness
  - Provide proactive driver warnings
  - Intervene to prevent / mitigate crashes where driver response is late or non-existent (distracted driver)
- Sensors Used in Highly Automated Vehicles
- Current Development Efforts and Market Leaders
- Levels of Automation
  - BASt
  - NHTSA
  - SAE (Prior to September 2016)
  - SAE (September 2016 Operational Driving Domain revision)
  - Comparison of the Three Versions
  - Level 3 Handoff Problem

**DAY TWO**

- Sensors: Active and Passive
  - Operating Principles, Performance, Advantages and Limitations of Various Sensors Used in HAV Capabilities
    - GPS
    - GLONASS
    - IMU
    - Gyros
    - Cameras - monocular, stereo, monochrome (grayscale), color, CCD, CMOS
    - Ultrasonic
    - Radar
    - Lidar
    - Leddar
    - Matrix TOF camera
    - DSRC
  - SAE Level of Automation Corresponding to Each Application
  - Advantages and Limitations of Each Capability
  - Sensor(s) used in Each Capability
  - Technology Spread and Effects on Insurance Claims
ELECTRICAL/ELECTRONICS AND ELECTRONIC SYSTEMS

- Sensor Recalls
- Sensor Fault Detection and Diagnostics
- ECU Consolidation
- Algorithms
  - Types (classifications) of Algorithms
  - Algorithm Examples - Haversine, Kalman filter, particle filter, neural net, SLAM
  - Using ROC Analysis to Measure Algorithm Performance
- Testing Processes Used in the Development of HAV Systems
- Statistics Driving Vehicle Testing
- Why Software Can Never be “Fully” Tested
- Different Testing Approaches, and Their Strengths and Weaknesses
  - White box
  - Black box
  - Grey box
  - Unit
  - Integration
  - Interface
  - System
  - Static code analysis
  - Formal methods
  - Dynamic code testing
- Sl (Software in the loop) - Monte Carlo, DOE
- Sensor characterization
- HiL (Hardware in the loop) - Driving simulators, HiL Radar target simulation
- Soft targets
- Closed track testing - IIHS, Virginia smart road, MCity, AstaZero, Fort Monmouth, VeHIL
  - On-road testing - states, federal, international
- Testing Requirements That Must be Met Before a Vehicle Can be Tested On-road
- Basic Network Architecture of a Modern Vehicle
  - ECUs
  - Communication busses - CAN, FlexRay, LIN
- Probable Attack Surfaces and Their Vulnerabilities
  - Remote anti-theft system (Key fob)
  - TPMS
  - Remote keyless entry / start
  - Bluetooth
  - Radio data system
  - Telematics / Cellular / WiFi
- OBD II Vulnerabilities
- Possible Defenses Against Attacks
  - Minimize attack surfaces
  - CAN message injection mitigation
  - CAN message cryptography
  - Vehicle network architecture changes
  - Clock based intrusion detection
- NHTSA October 2016 Best Practices Guidance
- Ethical Challenges and Human Behaviors
- Differences Between Human and Autonomous Crash Decision Making
- Rational Decision-making Approaches; Deontology and Consequentialism
- Artificial Intelligence Approach - Strengths and Weaknesses
- Differences Between Negligence, No Fault Liability and Strict Liability Theories
  - Case Study - Tesla Crash and How Liability was Determined
- Regulations
- States Permitting On-Road Testing
- Testing Requirements
- Current Federal Regulations and Their Application to Active Safety Technologies
  - FMVSS
- Analysis of Ongoing Rulemaking Activities and Research and Their Applicability to Active Safety Technologies
  - NHTSA “Policy on Automated Vehicle Development” May 2013
  - NHTSA - Letters of interpretation
  - NHTSA Advance notice of proposed rulemaking August 2014 (FMVSS 150)
  - SPY Car Act of 2015
- Federal Lane Departure Warning and Forward Collision Warning Tests
- IIHS Automatic Emergency Braking Tests
- HAV Implications for Passive Safety (Integrated Safety)
- HAV Public / Industry Misconceptions
- Vehicle Design / Use Changes

Instructor: Jeffery Blackburn
Fee $1370 .1.3 CEUs
Introduction to Radar for Automotive Applications

2 Days
I.D.# C1627

This course covers radar fundamentals, emphasizing the understanding of physical principles and limitations of radar systems from the perspective of radar returns from objects of interest to automotive radar including vehicles, pedestrians and transportation infrastructure. Participants will be exposed to all aspects of radar design at a level detailed enough to understand system engineering estimates for the major functions by examining the basic functions of radars, from the waveform generation in the transmitter, all the way to matched filter detection in the receiver. Students will gain an understanding of how to characterize the impact on these basic functions due to radar design parameters. Trends in hardware and the associated benefits and trade-offs of new technologies will be discussed. The course will be taught from the perspective of a system level that can be used to evaluate design choices and understand their impact on the radar system as a whole.

Learning Objectives

By attending this seminar, participants will be able to:
- Define basic radar operation from the perspective of waveform generation, RF carrier insertions, transmitter, channel effects, receiver mixing, and matched filtering
- Define basic radar design parameters including wavelength, bandwidth, antenna size, beam-schedule, and transmitter power
- Compute basic radar design parameters using signal to noise ratio, range resolution, unambiguous range, Doppler resolution, and unambiguous Doppler
- Discuss the concept of a radar cross section and use statistical models for realistic performance estimates for radar cross-section, scattering from canonical objects, scattering from extended targets, and statistical models
- Characterize system performance using design parameters and quantities for Receiver Operating Characteristic (ROC) curves, and Detector Error Trade (DET) curves

Who Should Attend

This course will be particularly valuable for assisted driving advanced system engineers, active safety technology engineers, radar engineers, and safety test engineers.

Topical Outline

DAY ONE
- Basic Radar Architecture
  - Radar Range Equation
  - Equivalent isotropically radiated power
  - Computing signal to noise ratio
- Antenna Basics
  - Aperture and radiation pattern
  - Mono-static vs bistatic
  - Electronically steered antenna
- Radio Frequency Mixing
  - Carrier frequency mixing
  - Homodyne and heterodyne receiver
- Waveform Design
  - Bandwidth
  - Pulse-Doppler
  - Frequency modulated continuous wave radar
  - Pseudo-noise modulated continuous wave radar
  - Pulse repetition interval
- Matched Filter
  - Envelope detector output
  - Range resolution
  - Doppler resolution

DAY TWO
- Radar Range Equation Revisited (review with exercises)
  - Signal to noise ratio
  - Range resolution
  - Unambiguous range
  - Doppler resolution
- Automotive Radar Types
  - Overview of applications
  - Automotive radar parameters
- Radio Propagation Channel
  - Signal to clutter ratio
  - Channel fading
  - Radio frequency interference
- Character of Radar Targets
  - Radar cross section definition
  - Canonical shapes
  - Wavelength effects
  - Polarization effects
  - Statistical character of extended targets
- Estimating Performance
  - Hypothesis testing for detection
  - Statistics of detector output
  - Receiver operating characteristic and detector error trade curves

Instructor: William Buller
Fee $1370 .1.3 CEUs
Understanding and Using the SAE J2534-1 API to Access Vehicle Networks

1 Day
I.D.# C0733

With the increase in vehicle electronics, the need to gather data from the vehicle has never been greater. From vehicle development, through vehicle test to vehicle validation, engineers are required to collect data from the vehicle’s network. The SAE J2534-1 API (Recommended Practice for Pass-Thru Vehicle Programming) gives engineers the tool to collect vehicle data from multiple network types including CAN, ISO15765, J1850, ISO9141 and Chrysler SCI, using standard J2534 interface devices. In addition, the aftermarket can access the vehicle’s OBDII information from the diagnostic connector. Using the SAE J2534-1 API, an engineer can write a single program that communicates on multiple protocols, uses an off-the-shelf interface device and is scaleable.

This course is designed to give you an understanding of the J2534-1 API, enabling you to create your own programs that accomplish your vehicle communication needs. In addition to learning how to use each of the J2534-1 functions, you will have the opportunity to write a program that collects messages off of the CAN vehicle bus and another program that reads trouble codes off of a J1850 vehicle.

Attendees will receive a copy of the SAE J2534-1 Recommended Practice for Pass-Thru Vehicle Programming.

Learning Objectives
By attending this seminar, participants will be able to:
• Write programs that use the SAE J2534-1 compliant hardware to communicate with vehicles
• Reduce your dependency on proprietary vehicle communication hardware
• Increase your productivity by collecting the specific vehicle information you need when you need it
• Solve vehicle integration problems by capturing events from the vehicle network
• Protect your software investments by writing your application using a standard API

Who Should Attend
This seminar is designed for engineers involved with automotive design and development who need to write programs that interact with vehicles through the in-vehicle network. This includes engineers who validate OBDII, engineers developing

and validating new electronic control modules, engineers writing reprogramming application, test engineers who log vehicle data, system integrators who need to validate system operation, and after-market engineers who add new functionality to vehicles. The seminar would also be helpful for people who develop end-of-line tests, service diagnostics or inspection and maintenance cells for vehicles.

Topical Outline
• What is the SAE J2534-1 PassThru API
• Why use the SAE J2534-1 PassThru API
• Overview of the SAE J2534-1 PassThru API
• Overview of vehicle communication
• History of the SAE J2534-1 PassThru API
• Future of SAE J2534-1, J2534-2, J2534-3
• PassThru PC Setup
  • Using the registry to find devices
  • Loading the SAE J2534-1 DLL
• PassThru Open and Close
• PassThru Connect and Disconnect
  • PassThruConnect: protocols, connect flags, baudrates
  • PassThruDisconnect
• Lab 1: PassThru on the PC: Simple SAE J2534-1 Program
  • PassThru Read Messages and Write Messages
    • The PassThru message structure
    • PassThruReadMsgs: read, loopback and indication messages
    • PassThruWriteMsgs
• PassThru Start Message Filter and Stop Message Filter
  • PassThruStartMsgFilter: pass, block and flow control filters
• PassThru StopMsgFilter PassThru Other Functions
  • PassThruSetProgrammingVoltage
  • PassThruReadVersion
  • PassThruGetLastError
• Lab 2: A Complete SAE J2534-1 Program
  • PassThru Start Periodic Message and Stop Periodic Message
• PassThru I/O Control
  • GET_CONFIG and SET_CONFIG
  • Other parameters
• ISO15765 in J2534-1
  • Flow control filters
  • Indication messages
• Lab 3: Enhancing your PassThru Program
  • Changing device configuration
  • ISO15765 message reader

Instructor: Mark Wine
Fee $865 .7 CEUs
Wireless Communications in the Autonomous Connected Vehicle

1 Day
I.D.# C1025

Wireless communication is a key enabler for vehicle connectivity. This seminar provides participants with an engineering overview of the various technologies that comprise a wireless communication system as it relates to automotive and commercial vehicle applications. It is intended to develop the skill set necessary for an educated understanding of the challenges and opportunities related to Connected Vehicles and connected applications.

Section One provides an immersion in the fundamentals of wireless communications. It begins with the physics of the technical challenges caused by propagation (e.g. multipath, Doppler spread) and interference that can impact the communication budget link. Then, it will introduce the basic mitigation techniques (wireless channel: models, capacity, modulation, detection, diversity) and their performance measured in terms of signal to noise ratio (SNR) and error probability.

Section Two addresses networking. It starts with the principles of wireless networks and reviews the TDMA and CDMA systems. It then discusses concepts related to Ad Hoc Networks including an overview of the Vehicular Area Network (VANET). It concludes with discussions on security issues and approaches relating to Mobile Ad Hoc Networks (MANET).

Section Three describes how wireless communications techniques can be applied in vehicle to infrastructure (V2I) and vehicle to vehicle (V2V). It provides details in the most recent developments of the Dedicated Short Range Communications (DSRC) technology as well as related standardization topics (IEEE 1609, IEEE 802.11p, and SAE J2735). Module Three concludes with insights about how the cellular 4G/LTE (Long Term Evolution) technology can be used to accelerate the development of V2X communications (where X can stand for I as in Infrastructure, V as in Vehicle, P as in Pedestrian, C as in Cyclist, etc.).

Learning Objectives

By attending this seminar, students will be able to:

• Describe the technical challenges relating to wireless communications
• Identify and compare the different components of a wireless communication system
• Develop a first-hand experience on connected vehicles through V2V and V2I demonstrations
• Identify the key automotive/commercial vehicle wireless communications forums dealing with standardization/regulation and business opportunities
• Recognize the role, both current and future, connected vehicle technologies will play in our collective future

Who Should Attend

This course is appropriate for engineers or managers who want a better understanding of the technologies involved in vehicle to vehicle and vehicle to infrastructure applications. Those interested in wireless communications application to vehicular environments, vehicle positioning systems used for connected vehicles, vehicular software architectures and security, and vehicle system applications such as active safety as they apply to automotive/commercial vehicles will find this course useful.

Other professionals who will benefit from this course include: managers seeking to evaluate technology/regulation/standardization/business trends; fleet operators looking to increase business productivity, better manage their assets, meet regulatory requirements more efficiently, and improve asset utilization; business stakeholders involved in controlling/exploiting data transmitted from/to vehicles; those involved with autonomous/unmanned vehicles; and professionals interested in the perspective that the mobility, data security, and safety aspects of connected vehicle systems can enhance the reliability and control of driver-assisted vehicles.

Topical Outline

Fundamentals of Wireless Communication
• Wireless Communications Overview
• Technical Challenges
  • Math tools
  • Mobile radio propagation
• Mitigation Techniques
  • Channel capacity
  • Digital modulation and detection
  • Performance of digital modulation over wireless Channels
• Diversity
• Recent Advances
  • Multiple antennas and space-time communications
  • Ultra-WideBand (UWB) technology

Wireless Networks
• Cellular Networks
  • Principles
  • TDMA-based
  • CDMA-based
ELECTRICAL/ELECTRONICS AND ELECTRONIC SYSTEMS

- Ad Hoc Networks
  - Characteristics of MANETs
- Vehicular Area Network (VANET)
- Security issues V2X Communications
  - DSRC-based
  - V2I
  - V2V
  - Specific issues
  - Trends and policies
- Wireless Access in Vehicular Environments
  - IEEE 1609
  - Dedicated Short Range Communications (DSRC)
  - SAE Message Set J2735
- Status of application by region

While the idea of taking apart a complicated piece of hardware may seem overwhelming, with both the technical background and reverse engineering techniques presented in this seminar you will soon find that you are not only up to the task but more comfortable doing so in the future. To expedite the learning process and remove some of the potential over complexities of embedded systems, the material presented in this seminar will focus on a custom made embedded device which has been designed with simplicity of understanding in mind. At the end of the seminar, students are free to take home with them the embedded device, a starter kit of physical exploitation tools, and the pre-built work environment that was used in the seminar.

Learning Objectives
By attending this seminar, students will be able to:
- Identify key hardware components of embedded systems
- Research and use datasheets
- Interpret basic schematics
- Locate and utilize hidden communication paths (i.e. debug ports)
- Interface target hardware with a PC
- Use a logic analyzer to capture communications between an Micro Controller Unit (MCU) and external memory
- Extract firmware from an embedded system

Who Should Attend
This seminar is intended for engineers who want to develop a basic understanding and the corresponding skill set needed for the hardware reverse engineering of embedded systems. The seminar assumes students have at least a basic understanding of both electronics and programming. Other prospective students who will benefit from this course include computer security researchers, digital forensic investigators, software engineers, and senior management.

Topical Outline
DAY ONE
- Overview of Hardware Reverse Engineering
  - Accepted definitions
  - Why would we hack hardware
  - Limitations
  - Adopting a hacker mindset
- Engineer Bling – Gather Your Tools
  - Soldering / desoldering
  - Multimeters, logic analyzers, and oscilloscopes
  - MCU reader / writers (programmers)
  - Prototyping MCU
  - Miscellaneous item

Instructor: Heri Rakouth, Ph.D.
Fee $810 .7 CEUs

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• Fill out the online quote request at sae.org/corplearning • Email us at Corplearn@sae.org
Cybersecurity: An Introduction for the Automotive Sector

1 Day
I.D.# C1619

The automotive industry is the new “battleground” for cybersecurity. Following the path of desktops/laptops, tablets, and mobile phones, the automotive industry is now the “hot” area for both academic researchers and hackers. This will transform the automotive industry just as it transformed traditional information technology and the mobile markets; it is inescapable, but it can be beneficial and a well prepared company can find significant benefit in being a market leader.

What does cybersecurity mean? Who is attacking and why? What must we change? What can stay the same? What is the larger organization’s role in cyber? What will the government likely do and how will it affect us? Are there measurements - what does “secure” look like? These questions and more will be answered by this seminar.

We live in an age when cyber-related recalls will happen, when remote, over-the-air updates will become routine, and in which our cars have more lines of code than a small office. This seminar introduces critical cybersecurity concepts and puts them in an automotive context. It cuts through to the “so what” basics that enable understanding and provides ideas to implement in your company. Interaction and discussion is important, so after each lecture block there is a discussion period and a written work product.

Learning Objectives

By attending this seminar, students will be able to:

• Describe key concepts in automotive cybersecurity such as the InfoSec Triad; Threat, Vulnerability, and Risk; Defense in Depth, etc.

• Understand the importance of organizational roles and support, and how doing this can make cybersecurity an operational value proposition and not just a costly after-thought

• Understand and recognize good software and embedded security practices

• Understand why “hackers” are focusing on the automotive industry, and how they tend to think and operate

Who Should Attend

This seminar is intended for anyone not familiar with automotive cybersecurity. The material covered is introductory and appropriate for both engineering staff and management looking to learn about the cybersecurity issues that affect all aspects of the automotive industry.
ELECTRICAL/ELECTRONICS AND ELECTRONIC SYSTEMS

Topical Outline
- Introduction
  - Definitions
  - Vulnerability
  - Threat
  - Risk
- TARA (Threat Assessment and Remediation Analysis)
- Architecture
- Attack classes
- State of the Standards (SAE, NIST, ISO)
- InfoSec Triad - “Plus”
  - Confidentiality
  - Integrity
  - Availability
  - Non-repudiation
  - Apply to automotive
  - Discuss critical design features (e.g. availability vs integrity)
- Exercise: Short question and answer with problem assignment
- InfoSec Governance
  - Standards
  - Roles and responsibilities
  - Ongoing monitoring
  - Oversight
  - Value
- Secure Software Development
  - Scope/scale of problem
  - Proper design of software quality assurance/testing
  - Continuous integration
  - Evaluation of 3rd party code
  - Techniques (e.g. overflows, data protection, etc.)
  - Cryptography
- The Adversary - Hackers
  - Changing demographics, motivation, and identity
  - Work process (e.g. flash dumping dynamic analysis, etc.)
  - Case study
- Exercise: Short question and answer with problem assignment
- Embedded Security
  - How embedded security differs from “traditional” security – pros and cons
  - Embedded hardware lock-down
  - Key software development for embedded systems
- Diverse Topics
  - Overview of some hardware and software cybersecurity techniques and products
  - Resiliency
  - Supply chain cybersecurity
  - Understanding built-in vs bolt-on argument and how to evaluate efficacy
- Defense in depth
- Stepping through an exemplar layered system
- Final Exercise: Question and answer with guided exercise

Instructor: Robert Dekelbaum
Fee $810 .7 CEUs

Keys to Creating a Cybersecurity Process from the J3061 Process Framework

7 Hours
I.D. # WB1604

Connected vehicles are increasingly seen as a target for cybersecurity attacks. A key differentiator for the automotive industry is the use of cyber-physical systems, where a successful cybersecurity attack can affect physical entities. Often involving embedded electronics and real time control, these systems require different solutions in addition to established IT security principles and reactive responses to threats. Cybersecurity needs to be designed and built into cyber-physical systems throughout the development lifecycle to provide defense in depth. SAE J3061 provides an engineering process to design and build cybersecurity into vehicle systems in a comprehensive and systematic way, to monitor for and respond to incidents in the field, and to address vulnerabilities in service and operation. J3061 is unique in describing a process framework for cybersecurity that an organization can tailor against its other development processes. This allows an organization to develop an internal cybersecurity process consistent with its other processes in order to build cybersecurity robustness into their cyber-physical systems.

This web seminar will define key concepts in cybersecurity and discuss what a cybersecurity process consists of and why one is needed for the development of cyber-physical vehicle systems. Featuring instructors from the SAE Vehicle Cybersecurity Systems Engineering Committee, the course will feature the process framework described in J3061 that will enable participants to relate it to their own organization’s processes, including cybersecurity and safety activities. The instructors will provide guidance on how to tailor the standard’s process framework into an internal process to build cybersecurity robustness into cyber-physical systems. Different approaches to integrate the process within the participant’s organization, including the key issues and potential pitfalls with respect to implementation of a cybersecurity process, will be discussed. Key analysis activities that support the process, including Threat Analysis and Risk Assessment and Attack Tree Analysis, will also be presented.
Note: Due to the complexities and unique internal processes within each organization, participants will not be given a complete process implementation that can be directly applied in their organization. The information provided in the course will equip participants with the necessary foundation to begin tailoring the J3061 process framework for application within their organization.

Learning Objectives
By connecting with this web seminar, students will be able to:
• Define key cybersecurity concepts
• Describe what a process consists of and why a cybersecurity process is needed
• Relate the process framework described in J3061 to your own development processes
• Recognize ways to integrate cybersecurity and safety within your organization
• Describe analysis activities to be performed with respect to an effective cybersecurity process
• Recognize potential pitfalls and key issues with respect to implementation

Who Should Attend
This course will be beneficial to anyone involved in cybersecurity including those wishing to lead their organization in implementing and applying a cybersecurity process. Cybersecurity engineers will learn the need for a cybersecurity process and comprehend the J3061 process framework for tailored application in their organization. Quality management professionals will learn that a cybersecurity process is another important factor in internal process improvement and auditing. Executives and management representatives will better understand how to use J3061 to build defense and in-depth cyber-physical vehicle systems and how to drive cost savings through a systematic process. Human Resources will comprehend the need for seeking out individuals with the skills needed to address cybersecurity within their organizations.

Topical Outline
• Brief History of Automotive Security and Cybersecurity
  • Introduction to Connected Vehicle Applications
• Cyber-Physical Systems
  • Difference between cyber-physical systems security (cybersecurity) and IT security
• Five Levels of Vehicle Attack: wireless, wired; ECU external / internal; software / silicon
• Reactive vs. Proactive Approach to Cybersecurity
• What is a Process?
• Key Concepts in Cybersecurity Defined
• Introduction to J3061
  • What components of a process are captured
  • Scope, rationale and intent
  • Tailoring from the ISO 26262 process framework
  • When to Apply a Cybersecurity Process
  • Cybersecurity Process Overview
  • Motivation for a well-defined and well-structured process
  • J3061 process framework
  • Milestone and gate reviews
  • Cybersecurity Process Details
  • Overall management of cybersecurity
  • Concept phase
  • Product development at the system, hardware and software levels
  • Production, Operation and Service
  • Supporting Processes
  • Relationship between Cybersecurity Process and Safety Process
  • Review of Appendices A, C-E, G-I
  • Tailoring the J3061 Process Framework into an Internal Process
  • Examples of Key Analysis Activities
    • Threat Analysis and Risk Assessment
    • Attack Tree Analysis

Instructor: Barbara Czerny and David Ward
Fee $610 .7 CEUs

Performing a Cybersecurity Threat Analysis and Risk Assessment
6 Hours
I.D.# WB1742

SAE J3061 sets out a recommended cybersecurity engineering process framework for organizations developing cyber physical systems. One of the recommendations of this framework is to carry out a threat analysis and risk assessment early in the product development. A threat analysis identifies and models the relevant threats against assets, and a risk assessment classifies the impact and likelihood associated with each threat. The approach enables the prioritization of risks and appropriate risk treatment measures to be determined in subsequent development phases. This live, online course, delivered in three, two-hour sessions, provides participants with the knowledge of appropriate methods to carry out threat analysis and risk assessment for the development of a typical vehicle feature.
Learning Objectives
By connecting with this web seminar, students will be able to:
• Identify relevant threats
• Carry out threat modelling
• Create attack tree analyses
• Develop risk assessment
• Determine Cybersecurity Assurance Levels and Security Goals

Who Should Attend
To get full benefit from the course, participants should have prior knowledge and experience of J3061; Participation in the SAE web seminar, *Keys to Creating a Cybersecurity Process from the J3061 Framework* (I.D. WB1604; description immediately proceeding), or equivalent training / experience is strongly recommended within their organizations.

Topical Outline
Session 1
• Introduction
• Threat Analysis
  • Threat identification
  • Threat modeling
  • Attack trees
  • Exercise 1: Threat Analysis
Session 2
• Risk Assessment
  • Severity classification
  • Likelihood classification
  • Exercise 2: Risk Assessment
Session 3
• Assurance Levels and Cybersecurity Goals
  • Determining the assurance level
  • Developing cybersecurity goals
• Worked example: Cybersecurity Goals
• Summary

Instructor: David Ward and Paul Wooderson
Fee $550 .6 CEUs
ELECTRICAL/ELECTRONICS AND ELECTRONIC SYSTEMS

Topical Outline

- HEV/BEV Systems Operation Modes, Torque Production and Component Contributions
  - HEV
  - PHEV
  - BEV
- High Voltage Safety – Personal Protection Equipment
  - High Voltage Safety Gloves
  - High Voltage Systems and Test Equipment
  - Using Meters, Oscilloscopes, Insulation Meters, and HiPot Equipment to Test High Voltage System Components
- HEV/BEV – Vehicle Safety Systems, Controls and Diagnostics
  - Battery Pack Manual Disconnect Systems
  - High Voltage Interlock Circuits
  - High Voltage Bus Active and Passive Discharge Circuits
  - Isolation Fault Detection Circuits
  - CAN Parameter ID Structure for Safety Systems and Diagnostics
- Rechargeable Energy Management (Battery Pack) Systems, Controls and Diagnostics
  - Hardware Components
  - Overview of NiMH and Li-Ion Battery Technologies
    - NiMH and Lithium Battery Families
    - Module/cell sensing systems (voltage, temp, air, etc.)
    - Lithium Battery Pack Balancing Systems
    - Battery systems service considerations
  - Thermal Management Systems
    - Passive and Active Air Heating and Cooling Systems
    - Liquid Heating and Cooling Systems
    - Using Air Conditioning Low Pressure Gas System to Cool Battery Modules
  - Battery Pack/Module Testing
    - HEV/PHEV/BEV Power Testing
    - HEV/PHEV/BEV Energy (Capacity) Testing
    - Lab and Field Grade Equipment for Battery Testing
    - Automotive Field Experiences with NiMH and Lithium Battery Systems
- HEV/BEV – Permanent Magnet (PM) and Induction Machine (IM) Electric Machine and Power Inverter Technologies
  - PM and IM Technologies
    - Permanent Magnet Electric machine construction and operation
    - Induction Electric machine construction and operation
    - Rotor position and speed sensing: Resolvers
    - PM-IM failure modes
    - On/off-board electric machine testing – insulation meter, electric signature, oscilloscope, and HiPot
  - Power Inverter Technology and Electric Machine Control
    - Power electronics devices: IGBTs and Gate Drives
    - Sensing circuits: Current Sensing and Using External Controller CAN Inputs/Outputs
    - Electric machine controls - torque and speed controls, wave shaping (sine wave, six-step), current regulation
    - Failure modes
    - dc-dc Converter Systems
      - Buck converter
      - Buck/Boost converter
      - Failure modes
      - Testing

Instructor: Mark Quarto
Fee $1745 2.0 CEUs

Introduction to Hybrid and Electric Vehicle Battery Systems

2 Days
I.D.# C0626

Driven by the need for lower emissions, better fuel economy and higher efficiency, hybrid vehicles are appearing in many different configurations on today's roadways. While the powertrain components such as the drive motor, motor controller and cooling system are somewhat familiar to the automotive industry, the battery systems are a relatively unfamiliar aspect. This seminar will introduce participants to the concepts of hybrid vehicles, their missions and the role of batteries in fulfilling those requirements. Battery topics including limitations, trends in hybrid development, customer wants and needs, battery system development timelines, comparison of electrochemistries and safety will be examined. Current offerings, cost factors, pack design considerations and testing will also be reviewed.

Students will have an opportunity to perform a battery pack analysis exercise using a real world application and are requested to bring a calculator to class.

Learning Objectives

By attending this seminar, participants will be able to:

- Capture customer wants and expectations of the battery system
- Identify factors that drive power and energy requirements
- Determine test program structure
- Compare and contrast the newest relevant battery technologies
- Calculate estimates of electric range and quantify the assumptions
- Critically assess media claims of new battery discoveries
Who Should Attend
This seminar is primarily intended for vehicle systems engineers, battery system integration engineers, testing engineers, electrical engineers and thermal management engineers recently assigned to their roles or returning to hybrid or electric vehicle programs. It will also be beneficial to those involved in the specification, design, development, testing and planning of hybrid vehicle programs. Product planners and program managers will find the overview aspects helpful.

Prerequisites
Material presented will be practical in nature with basic mathematics used to describe quantitative measures. An undergraduate degree in electrical or electromechanical engineering will assist in gaining maximum benefit from the material presented. Experience or training in battery electrochemistry is helpful, but not essential.

Topical Outline
DAY ONE
- Terminology, Definitions and Conventions
- Brief Review of the Hybrid Market
  - Market drivers and expectations
  - Market influences
  - Competing technologies
  - Customer expectations
- Review of Common Vehicle Product Offerings (battery descriptions, power, technology, size, architecture)
- Fundamentals
  - Fossil fuel vs. hybrid vs. electric
  - Source ragone plot
  - Efficiencies, weights
  - Cost of fuel (fossil vs. electrons)
- Role of Battery
  - ICE vs. electric systems
  - Energy vs. power
  - Expectations over vehicle lifetime
- Product Liability / FMEA
- Battery Development Cycle
  - You don’t know what you don’t know!
  - Why does it take so long and cost so much?
- Cost Factors
  - Scope of product: system vs. cells vs. sticks
  - $/kW vs. $/kWh
- System Considerations
- Electrochemistry Selection
- Safety
  - Advance planning for safety tests
  - Thermal runaway
  - String configuration (series, parallel)

DAY TWO
- Range Estimation (hybrid vs. electric)
- Real-life Battery Analysis Exercise (using a contemporary vehicle as an example)
- Battery Pack Design Considerations
- Failure Modes
  - Wear-out
  - Power and energy degradation
  - High resistance / open circuit
  - Controller / signal malfunction
- Vehicle Trends
  - Plug-in hybrid
  - Battery electric
  - Demanding applications
  - Fuel cell hybrids
- Battery Trends
- Battery Warranty
- Battery Recycling

Instructor: Erik J. Spek
Fee $1370 1.3 CEUs

High Voltage Vehicle Safety Systems and PPE
1 Day
I.D.# C1732
High voltage vehicle safety is a primary concern for every technician or engineer involved in developing, diagnosing or repairing hybrid or electric vehicles. Engineers/technicians working in this field should complete safety training before they interface with hybrid, plug-in or electric vehicles. This course provides participants with fundamental technical and safety information on high voltage personal protective equipment (PPE) such as how to test high voltage gloves, when and where to send high voltage gloves for periodic testing, and how to safely use test equipment for measuring high voltage components in live and disabled high voltage systems.

Much of the high voltage vehicle safety systems information covered in this course is based on the FMVSS requirements and SAE Recommended Practices. The vehicle safety systems contain interlock circuits, passive and active bus (capacitor) discharge circuits, and DC and AC isolation detection systems that are monitored by high voltage controllers to maintain the required resistance barrier between the vehicle technician/engineer and...
the vehicle body/chassis to mitigate the possibility of an electrical shock event.

**Learning Objectives**

By attending this seminar, participants will be able to:
- Properly care for high voltage electrical gloves
- Field test high voltage electrical gloves
- Identify providers that test high voltage gloves required by ASTM requirements
- Disable a vehicle high voltage system
- Safely acquire measurements on a high voltage system
- Describe the operation of automotive AC and DC isolation fault detection systems
- Apply FMVSS 305 requirements and SAE J1766 Recommended Practice to testing high voltage vehicle safety systems
- Describe the operation of high voltage interlock circuits and passive and active bus discharge circuits
- Test the high voltage system for isolation faults, interlock circuit failures and passive and/or active discharge circuits
- Describe how and when to use high voltage gloves, serial data (Scan Tool), insulation meter, and DVOM to test the high voltage system and components

**Who Should Attend**

This course will benefit vehicle electrification engineers involved in the design or development of high voltage systems as well as lab and vehicle technicians (beginner to intermediate level) who perform systems diagnostics as well as vehicle proto builds. This course will also benefit automotive technicians with an automotive certificate, A.A.S. or B.S. (experienced auto techs but are beginners in vehicle electrification) who service automotive systems. This course would assist all disciplines and personnel working with automotive high voltage systems found in vehicle electrification in understanding how high voltage vehicle safety systems operate, and how to use safe practices and the necessary equipment to analyze, test, and repair them.

**Topical Outline**

- High Voltage Safety & PPE
  - Characteristics of AC and DC Electrical Power
  - Ground Circuit Paths
  - Tools & Equipment CAT Ratings
  - Tool & Equipment Usage
  - High Voltage Glove Selection, Field Testing, Testing Requirements, and Storage
  - Insulation Meters and Usage on High Voltage Components
- High Voltage Vehicle Safety Systems
  - High Voltage Cabling
  - High Voltage Cable and Electrical Symbol Identification
- Service Disconnect Types, Locations, and Removal/Install
- High Voltage Fuse
- Interlock Systems and System Types, Location, Circuits, Operation, Failure Modes and Diagnostics— Serial Interlock; Local (component) Interlock; Testing and Diagnosing of Interlock Systems; Use of standard and special tools for testing
- Active and Passive Bus Discharge Systems, Location, Circuits, Operation, Failure Modes and Diagnostics— Bus Discharge Active Circuit Operation; Bus Discharge Passive Circuit Operation; High Voltage Battery Contactor Control with Bus Discharge Systems; Testing and Diagnosing Bus Discharge Systems; Use of standard and special tools for testing
- Isolation Fault Detection Systems, Circuits, Operation, and Diagnostics— DC Detection System Operation; AC Detection System Operation; Diagnostics associated with Isolation Fault Systems; Use of standard and special tools for testing

**Instructor:** Mark Quarto

**Fee:** $810 .7 CEUs
ELECTRICAL/ELECTRONICS AND ELECTRONIC SYSTEMS

RELATED TRAINING SOLUTIONS
Some of our courses apply to more than one technology category. Consider these related courses described in other sections of this resource guide.

Safe Handling of High Voltage Battery Systems
The battery system forms a key part of any of these vehicles and is probably the least understood. With practically no moving parts the battery systems show no visible or audible warning of any latent dangers. This seminar will introduce participants to the risks encountered in handling high voltage battery systems and their component parts.
Read more about this course on page 174.

Applying Automotive EDR Data to Traffic Crash Reconstruction
This course will provide the participant with the skills necessary to analyze EDR data that has already been imaged, apply it to crash reconstruction, and reconcile it with calculations using other data sources.
Read more about this course on page 261.

Driver Distraction from Electronic Devices: Insights and Implications
This course provides an overview of driver distraction (predominantly electronic devices): the problem; how to define it; the current state of research and how to critically evaluate that research to make informed decisions; and the effectiveness of state laws and fleet policies to reduce it.
Read more about this course on page 262.

ADAS Application: Automatic Emergency Braking
This course is designed to provide an overview of the typical ADAS AEB system from multiple perspectives. A technical overview of the development cycle processes specific to AEB, including system level requirements and design architecture will be presented as well as design considerations for AEB from a functional safety (ISO 26262) perspective.
Read more about this course on page 10.
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Accelerated Test Methods for Ground and Aerospace Vehicle Development

2 Days
I.D.# C0316

Similar content is available in an on demand course. Review the course info in the On Demand Courses Guide on page 199.

Engineers and managers involved with product development are constantly challenged to reduce time to market, minimize warranty costs, and increase product quality. With less and less time for testing, the need for effective accelerated test procedures has never been greater. This course covers the benefits, limitations, processes, and applications of several proven accelerated test methods including accelerated reliability, step stress, FSLT (Full System Life Test), FMVT® (Failure Mode Verification Testing), HALT (Highly Accelerated Life Testing), and HASS (Highly Accelerated Stress Screening). A combination of hands-on exercises, team activities, discussion, and lecture are used throughout the course. Participants will also receive a copy of the instructor’s book, Accelerated Testing and Validation Management, which includes numerous hands-on exercises and a CD with analytical spreadsheets. Attendees are requested to bring a calculator to the seminar.

Learning Objectives

By attending this seminar, participants will be able to:
• Choose the accelerated test method for a given application
• Analyze accelerated testing results
• Explain how to accelerate one’s current test methods
• Explain how to accelerate one’s validation program
• Adjust accelerated test programs for business situations
• Describe how product development cycles can be reduced from 18 to 6 months

Who Should Attend

This seminar is designed for anyone involved in product design, life testing, reliability testing and validation for ground and aerospace vehicles, including reliability engineers, validation engineers, design engineers and their managers. Individuals who need to achieve shorter time to market or higher quality through custom test plans will find this course to be especially valuable. Purchasers or users of testing or engineering services will also find this course to be valuable. There are no prerequisites for this course although a technical background is helpful.

Topical Outline

• Statistical model for reliability testing
  • Fundamentals of a statistical reliability test
  • Effects of automotive supply chain on sample size and duration
  • Common pitfalls
  • Examine and solve two or three real life statistical data set problems
• Key Accelerated Tests, Terms, and Methods
  • Definitions: Information Goal, Basic Method, Limitations
  • Full System Life Test (FSLT)
  • Step Stress
  • Accelerated Reliability Highly Accelerated Life Test (HALT)
  • Failure Mode Verification Test (FMVT) — Development; Warranty; Life Prediction
• Test Acceleration vs. Program Acceleration
  • Advantages of accelerating a full validation program compared to an individual test
  • Examples of time/cost saved on individual test acceleration
  • Examples of time/cost saved on program acceleration
• Hybrid Acceleration Methods
  • Using information goals of individual test methods to combine and leverage tests
ENGINEERING TOOLS & METHODS

- Hands-on team exercise: combine test methods to solve a particular information need
- Decision and selection process
  - How to choose which method
  - Considering position in supply chain
  - Considering business model and product type
  - Considering development phase
  - Considering component, subsystem, and system level testing
  - Hands on team exercise: selecting optimal testing solution for several scenarios

Instructor: Alexander (Alex) J. Porter
Fee $1405 1.3 CEUs

Accelerated Test Methods for Ground and Aerospace Vehicle Development
10 Hours

Similar content is available in the classroom seminar – see course info above.

This course offers more than 10 hours of instruction divided into fourteen modules; a coordinated handbook; and a copy of the instructor’s book, Accelerated Testing and Validation Management, which includes numerous hands-on exercises and a CD with analytical spreadsheets. Convenient, portable, and with core content from the instructor-led seminar (view description for classroom seminar above), the on demand course option offers new and alternative ways to receive the same instruction as the live classroom learning without the expense of travel and time away from the workplace.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.

ANOVA for Design of Experiments
1 Day
I.D.# C0714

This seminar is suggested for product or process experts who have a need to utilize more detailed information concerning Design of Experiments analysis. It primarily addresses the subject of ANOVA, analysis of variance, which is a statistically based, objective decision-making tool. This is an advanced seminar that covers the fundamentals required to analyze orthogonal experiments, interpret, and recommend further action based on the analysis. Emphasis is placed on the analysis phase of the DOE process. The seminar covers DOE basic review, simple and complex ANOVA situations, process capability estimation, and a review of available computer software for experimental design and analysis.

Learning Objectives
By attending this seminar, participants will be able to:
• Perform ANOVA for DOE analysis
• Interpret ANOVA results
• Estimate process capability from ANOVA information

Who Should Attend
This seminar is designed for product and process design engineers, manufacturing engineers, quality engineers (control, assurance, or supplier), testing and development engineers, and technical managers who are interested in more comprehensive experimental analyses and information. Although, more statistical in nature, this seminar does not require a statistical education or background to comprehend the contents; only fundamental mathematical skills are necessary. This seminar is also very helpful in providing a statistical foundation for those seeking certification in quality engineering.

It is strongly recommended that the registrant attend a Basic Design of Experiments course or have experience with fractional factorial experiments based on orthogonal arrays before attending the ANOVA for Design of Experiments course.

Topical Outline
• Training Objectives
• Design of Experiments Process Flowchart
• Planning and Conducting Phase Review
• Analyzing and Interpreting Results
  - observation method review
  - column effects method review
• raw data ANOVA - one-way; two-way; multi-way with orthogonal arrays
• variation ANOVA
• attribute data ANOVA
• interpreting experimental results
• plotting
• prediction of mean and confidence interval
• confirmation experiment
• process capability estimates
• Software Review and Comparison

**Design and Process Failure Modes and Effects Analysis (FMEA)**

**2 Days**
**I.D.# C1510**

This seminar covers the five types of FMEAs with emphasis on constructing Design and Process FMEAs. Each column of the FMEA document will be clearly explained using an actual FMEA example. The course covers various methods for identifying failure modes, effects and causes with special attention given to severity, occurrence, and detection tables and how to develop effective recommended actions strategies. Throughout the class, participants will be involved in exercises/actual projects that demonstrate and incorporate direct application of learned principles.

**Learning Objectives**

By attending this seminar, participants will be able to:
• Describe the benefits, requirements and objectives of an FMEA
• Describe the five types of FMEAs and how to use them
• Develop and interpret a Design and Process FMEA form
• Identify and utilize various tools when performing an FMEA
• Describe the standard requirements/recommendations for an FMEA
• Select suitable projects and teams for completing an FMEA
• Complete a typical Design and Process FMEA form

**Who Should Attend**

This seminar is designed for core members of a Product Development Team such as project managers, product design, test, manufacturing, quality, reliability engineers and those responsible for assisting the PDT in design and development of product, manufacturing, assembly or services processes.

**Topical Outline**

• Understanding and Application of FMEA
  • FMEA as Part of the Product Development Life Cycle
  • The Various Industry FMEA standards
  • Why and When to use Concept, System and Design FMEAs
  • The FMEA as a Risk Management Technique
  • FMEA, Robust Design, and Design Reviews
  • FMEA vs FMECA
  • Using FMEA to Address Product and Process Liability Issues
• Managing the FMEA Process
  • The Steps to Generating a Quality FMEA
  • The Essentials of an Effective FMEA Database and Template FMEAs
  • Methods for Selecting Suitable Projects for Templating Design and Process FMEAs
  • FMEA Team Development
  • Champion and Facilitator Roles during FMEA Development
• Introducing the FMEA Exercise – Designing a Great Flashlight
• Constructing a Useful FMEA
  • The Five Types of FMEAs and the Uses
  • Design FMEA
  • Constructing the boundary and block diagrams
  • Column by column review of the Design FMEA form
  • Development of a company-specific table structure for severity, occurrence and detection
  • Techniques for RPN prioritization and developing recommended action
  • Developing effective design control techniques
  • Exercise 2 – Completing the Flashlight Design FMEA
• Process FMEA
  • Gathering the necessary process documents
  • Column by column review of the Process FMEA form
  • Development of a company-specific table structure for severity, occurrence and detection
  • Techniques for RPN prioritization and developing recommended action
  • Exercise 3 – Completing the Flashlight Process FMEA
• Application of the Machinery FMEA
  • Effective use of the occurrence and detection tables
  • Validating process and machinery control techniques

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**Instructor:** Phillip J. Ross
Fee $810 .7 CEUs

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**Instructor:** Angelo E. Mago
Fee $1370 1.3 CEUs
Instructors Wanted...

To shape the future of mobility engineering, SAE International Professional Development is seeking experienced engineering professionals with industry and/or academic backgrounds to develop and teach live classroom or online courses; we are seeking expertise in a variety of topics including:

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- Heavy Duty High Voltage Systems
- Heavy Duty Hybrid
- Heavy Duty Electric Drive
- Diesel Emissions and Regulations
- Alternative Fuels and Energy Sources
- Strategies for Diesel Engine Downsizing
- Cybersecurity
- V2V Technologies
- High Speed Digital Design for Rugged Applications
- Material Performance Data

Contact SAE Professional Development to explore how you can help to shape the future of industry.

Classroom Seminars contact Bev Longdon at Beverly.Longdon@sae.org

Online Web Seminars contact Sam Minehart at Sam.Minehart@sae.org.

Design for Manufacturing & Assembly

2 Days  
I.D.# 92047

Design for Manufacturing and Assembly (DFM+A), pioneered by Boothroyd and Dewhurst, has been used by many companies around the world to develop creative product designs that use optimal manufacturing and assembly processes. Correctly applied, DFM+A analysis leads to significant reductions in production cost, without compromising product time-to-market goals, functionality, quality, serviceability, or other attributes. In this two-day seminar, you will not only learn the Boothroyd Dewhurst Method, you will actually apply it to your own product design!

This seminar will include information on how DFM+A fits in with QFD, Concurrent Engineering, Robust Engineering, and other disciplines. In addition, there will be a brief demonstration of computer software tools, which simplify the DFM+A analysis.

Each participant will receive and use the hard-bound authoritative reference textbook Product Design for Manufacture and Assembly, written by Geoffrey Boothroyd, Peter Dewhurst and Winston Knight.

Learning Objectives

Upon successful completion of this course, participants will be able to:
- Perform Design for Assembly (DFA) Analysis using the BDI Manual (Worksheet) Method
- Perform DFM Analysis (manufacturing cost estimation)
- Apply Design for Service (DFS) Principles
- Reduce your company’s production costs by analyzing and eliminating the factors that greatly affect the time, cost, and quality of manufacturing, assembly and service processes
- Utilize effective analysis, brainstorming, and trade-off techniques for redesigning assemblies and subassemblies

Who Should Attend

Product designers, product engineers, or manufacturing engineers will benefit by attending this seminar. Individuals involved in a new or ongoing product development process will also benefit by learning how to help synchronize and optimize fabrication and assembly activities. This course is most effective when attended by product development team members; however, this is not a requirement for attendance.

NOTE: You are strongly encouraged to bring a sample or drawing of one of your own designs to analyze during the course on Day Two. You are also asked to bring a calculator capable of making simple calculations.

Topical Outline

DAY ONE
- What is DFM+A
- The history of DFM+A
- The various “Design fors”
- Why companies are using DFM+A
- DFM+A success stories
- DFM+A benefits
- Key factors in ensuring DFM+A success
- DFA Good Design Principles
- The Boothroyd Dewhurst Design for Manual Assembly Method
- Using the manual handling and insertion tables
### Design of Experiments (DOE) for Engineers

**2 Days**  
I.D.# C0406

Similar content is available in the live online Web Seminar – Design of Experiments (DOE) for Engineers Web Seminar – see course description below.

Design of Experiments (DOE) is a methodology that can be effective for general problem-solving, as well as for improving or optimizing product design and manufacturing processes. Specific applications of DOE include identifying proper design dimensions and tolerances, achieving robust designs, generating predictive math models that describe physical system behavior, and determining ideal manufacturing settings. This seminar utilizes hands-on activities to help you learn the criteria for running a DOE, the requirements and pre-work necessary prior to DOE execution, and how to select the appropriate designed experiment type to run. You will experience setting up, running, and analyzing the results of simple-to-intermediate complexity, Full Factorial, Partial Factorial, and Response Surface experiments utilizing manual methods as well as a hands-on computer tool that facilitates experimental design and data analysis. You will also receive an overview of Robust DOE, including the Taguchi DOE Method.

Participants will be given information on how to receive, install and configure a fully-functional 30-day trial version of Minitab for their use in class, and/or for their personal evaluation. While some computers will be available, attendees are encouraged to bring a laptop computer and/or a calculator to the seminar to provide additional hands-on time.

**Learning Objectives**

By attending this seminar, participants will be able to:

- Decide whether to run a DOE to solve a problem or optimize a system
- Set-Up a Full Factorial DOE Test Matrix, in both Randomized andBlocked forms
- Analyze and Interpret Full Factorial DOE Results using ANOVA, (when relevant) Regression, and Graphical methods
- Set-Up a Fractional (Partial) Factorial DOE, using the Confounding Principle
- Analyze and Interpret the results of a Fractional Factorial DOE
- Recognize the main principles and benefits of Robust Design DOE
- Decide when a Response Surface DOE should be run
- Select the appropriate Response Surface Design (either Placket-Burman, Box-Behnken, Central Composite, or D-Optimal)
- Interpret Response Surface Outputs
- Utilize the MiniTabTM Software tool to analyze data

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**Instructor:** Kevin Zielinski  
Fee $1550  
1.3 CEUs
**Who Should Attend**

This seminar will benefit engineers, designers and quality professionals in research, design, development, testing and manufacturing who are interested or active in one or more of the applications listed above.

**Topical Outline**

• Icebreaker: Team Problem Solving Exercise Using Engineering Judgment  
• What is DOE?  
  • Types of Designed Experiments  
  • Application Examples  
  • Where DOE Fits in with Other Tools/Methods  
• DOE Requirements: Before You Can Run an Experiment  
  • Writing Problem and Objective Statements  
  • Ensuring DOE is the Correct Tool  
  • Selecting Response Variable(s) and Experimental Factors  
  • Actual vs. Surrogate Responses  
  • Attention to Experiment Logistics  
  • Test Set-up and Data Collection Planning  
  • Selecting and Evaluating a Gage  
• Full Factorial Experiments  
  • Introduction to Cube Plots for 3- or 4-factor 2-level Experiments  
  • Experiment Set-Up  
  • Factor Levels, Repetitions, and “Right-Sizing” the Experiment  
  • Experiment Terms to Estimate (Main Effects and Interactions)  
  • High-Level Significance Evaluation  
• DOE Statistical Analysis  
  • ANOVA Principles for Simple Full Factorial Experiments  
    -- Statistics Basics; Significance Test Methods; Effect of Non-Random Experiments; Estimating Significance Test “Power”; Confidence Intervals; Estimating Random Error  
  • Analysis Plots -- Normal and Half-Normal Plots; Main Effect and Interaction Plots  
  • Regression Analysis of Simple Full Factorial Experiments  
  • Using MiniTab™ for Full Factorial DOE Experiments  
• Fractional (Partial) Factorial Experiments  
  • The Confounding Principle — How it Works; What Information We Lose with Confounding (and why we might not care!)  
  • Selecting and Using Generators (Identities) to Set Up Confounding Strings  
  • Determining Which Factor Combinations to Run  
  • Analyzing Fractional Factorial Experiment Data  
  • Using MiniTab™ for Fractional Factorial Experiments  
• Robust Design Experiments (Overview)  
  • What is Robustness?  
  • Control and Noise Factors  
  • Classical and Taguchi Robust DOE Set-Up  
  • Robustness Metrics  
  • Analytical and Graphical Output Interpretation  
• Response Surface Modeling  
  • What Response Surface Models do BEST  
  • Available Response Surface DOEs (Plackett-Burman, Box-Behnken, etc.) — Ideal Situation(s) to Use Each Response Surface DOE Type; Cube Plot Set-up of Each Response Surface DOE  
  • Analyzing Response Surface Experiment Data  
  • Methods for Finding Optimum Factor Values  
  • Using MiniTab™ for response Surface Experiments  
• Notes and Wrap-up

**Instructor:** Kevin Zielinski  
**Fee:** $1,420  
**1.3 CEUs**

**Design of Experiments (DOE) for Engineers Web Seminar and Web Seminar RePlay**

12 Hours  
**Web Seminar:** I.D.# WB0932  
**Web Seminar RePlay:** I.D.# PD330932ON

**Similar content is available in the classroom seminar – Design of Experiments (DOE) for Engineers – see course description above.**

Design of Experiments (DOE) is a methodology that can be effective for general problem-solving, as well as for improving or optimizing product design and manufacturing processes. Specific applications of DOE include, but are not limited to, identifying root causes to quality or production problems, identifying optimized design and process settings, achieving robust designs, and generating predictive math models that describe physical system behavior. This competency-based web seminar utilizes a blend of reading, discussion and hands-on to help you learn the requirements and pre-work necessary prior to DOE execution, how to select the appropriate designed experiment to run, DOE execution, and analysis of DOE results. You will experience setting up, running, and analyzing simple-to-intermediate complexity Full Factorial and Partial Factorial experiments both by hand and using computer software. You will also set-up and analyze Robust/Taguchi and Response Surface experiments utilizing computer software.
Each participant will receive a 30 day Minitab™ product trial copy for use in the Web Seminar. Due to the nature of the Web Seminar format, each participant will be expected to dedicate approximately one hour to complete “homework” and/or short reading assignments in preparation for each session.

Learning Objectives
Upon successful completion of this course, participants will be able to:
• Determine when DOE is the correct tool to solve a given problem or issue
• Select the appropriate DOE experiment type (DOE Goal) for a given application
• Set up simple Full Factorial DOEs by hand, using cube plots
• Set up and analyze any Full Factorial DOE using Minitab
• Select the appropriate partial factorial design(s) based on one’s application
• Set-up and analyze Partial Factorial DOEs, simple Robust Design (Taguchi) DOEs, and simple Response Surface DOEs using Minitab
• Identify and execute the structured process steps recommended when executing a DOE project

Who Should Attend
This course will benefit: engineers involved in problem-solving such as product design or product formulation (e.g., fluid/material composition, prepared food recipes/preparation, etc.) and/or optimization; process design and/or optimization; quality improvement efforts such as defect elimination, warranty avoidance or similar initiatives; test engineers who wish to maximize learning of system behavior with a minimum number of tests; and technicians, analysts and managers who support engineers in the above efforts, so they may be effective participants in DOE activities. This course has no specific course prerequisites. However, participants are expected to have some math background, including the ability to calculate elementary statistics parameters such as an average and a range. Since the course includes demonstration and hands-on use of Minitab, participants should have some familiarity with Windows-based personal computer applications.

Topical Outline
Session 1
• Introduction
• What is DOE (with Initial Data Collection Exercise)
• Full Factorial Experiments using Cube Plots
  • Identifying main effect and interaction terms
  • Determining effects for all terms
• Estimating How Much Experiment Data is Enough
• Assignment for Session 2: Hands-on Exercise in the use of Minitab using Simulator to Generate Data

Session 2
• Review of Exercise Assigned at the end of Session 1
• Set up and Analysis of a Full Factorial Experiment using Minitab
• Review of Minitab’s DOE Results
• Review of Methods for Determining Significance
• ANOVA and Regression Overview
• Assignment for Session 3: Hands-on Exercise using Minitab to Analyze Data and Interpreting Statistical and Graphical DOE Results

Session 3
• Review of Exercise Assigned at the end of the Session 2
• The Confounding Principle
• The Benefits and Disbenefits of Confounding and of Partial Factorial Experiments
• How Confounding Occurs in a DOE, including Generators and ‘Design Resolution’ Importance of the “Alias String”
• Minitab Demonstration: Setting up Partial Factorial Experiments using Default Generators and by Specifying Generators
• Assignment for Session 4: Partial Factorial Exercise using Minitab and a Simulator to Generate Data for the DOE

Session 4
• Review of Exercise Assigned at the end of the Session 3
• When Robust/Taguchi DOE is Appropriate
• How Robust/Taguchi DOE is Different
  • Two-Step Optimization Concept
  • Control vs. Noise
  • Importance of Control-by-Noise Interactions
• Studying Robustness with Classical DOE vs. Taguchi
• Taguchi’s Robustness Statistics: Signal-to-Noise (S/N) and Loss
• Applications of Taguchi DOE (incl. Set-up and Analysis in Minitab)
• Minitab Demonstration: Setting Up a Taguchi DOE
• Assignment for Session 5: Robust/DOE Exercise using Minitab and a Simulator to Generate Data for the DOE

Session 5
• Review of Exercise Assigned at the end of the Session 4
• When Response Surface DOE is Appropriate
• How Response Surface DOE is Different
  • Box-Behnken Concepts (with Demonstration of Minitab Set-up)
  • Central-Composite Concepts (with Demonstration of Minitab Set-up)
• Overview of Other Designs/Application: Plackett-Burman and Mixture
• Minitab Demonstration: Response Surface Set-up and Analysis
• Assignment for Session 6: Response Surface DOE Exercise using Minitab and a Simulator to Generate Data for the DOE

Session 6
• Review of Exercise Assigned at the end of the Session 5
• Best Practices: The Problem Solving Process
Engineering Tools & Methods

- **Best Practices: The Structured DOE Process**
  - The Multi-Step Process for Ensuring Effective DOE Execution and Meaningful Results
  - Discussion “Exercises”: Selecting Factors, Responses, Measurement Systems, etc. for Sample Situations
  - In-class Exercise: How to Conduct a DOE to Evaluate the Quality of a Gauge (Measurement System Assessment or “MSA”)
- **FAQ Review and Question and Answer**
- **Summary**

**Instructor:** Kevin Zielinski

**Fee:** $835 1.2 CEUs

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### Design of Experiments - Basic Simplified Taguchi

**2 Days**

**I.D. # C0231**

Design of Experiments is a statistically based, structured approach to product or process improvement that will quickly yield significant increases in product quality and subsequent decreases in cost. Products and processes can be designed to function with less variation and with less sensitivity to environmental factors or customer usage. While still maintaining high quality from a customer’s viewpoint, products and processes can utilize lower cost materials and methods. Specifications can be opened-up with wider tolerances while still maintaining high quality for customers. In summary, products and processes can be designed and developed in shorter times to reduce costs and become more competitive in the marketplace from a delivery and profit standpoint.

This seminar covers the fundamentals required in planning, conducting, and analyzing orthogonal experiments, which are the major steps in the Design of Experiments (DOE) process. Emphasis is placed on the DOE process, which, if diligently followed will yield an effectively completed experiment.

An introduction to parameter design is included. A short video introduces the experimental approach; the end of the session allows practice with the new methods in a hands-on workshop.

For more advanced study, attend ANOVA for Design of Experiments (#C0714; page 46). It is strongly recommended that any registrant attend a Basic Design of Experiments course prior to taking the advanced course.

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**Learning Objectives**

By attending this seminar, students will be able to:

- Choose appropriate factors and factor levels to effectively plan DOEs
- Define an appropriate set of tests to evaluate the chosen factors and levels
- Utilize appropriate randomization strategies and choose appropriate sample sizes for conducting tests for DOE
- Utilize basic analytical methods to identify influential & non-influential factors in analyzing and interpreting DOE results
- Set specification limits for all factors for effective performance and low cost

**Who Should Attend**

This seminar is designed for product and process design engineers, manufacturing engineers, quality engineers, testing and development engineers. Although it would be helpful, no statistical education or background is required for this course; only fundamental mathematical skills are necessary.

**Topical Outline**

- Training Objectives
- Design Of Experiments Background
  - DOE definition
  - DOE and Taguchi history
  - DOE in the product life cycle
  - implementation strategy
- Design Of Experiments Process
  - flowcharts
  - injection molding case study
  - water pump leak case study overview
- Planning Phase
  - state problem(s)
  - state objective(s)
  - determine measurement method(s)
  - quality characteristic(s)
  - select factors
  - identify control and noise factors
  - select levels of factors
  - select orthogonal array
  - assign factors
  - locate interactions
  - modification of standard orthogonal arrays
  - parameter design
- Conducting The Experiment
  - trial data sheets
  - testing logistics & assignments
  - identification of trial results
  - sample size per trial
  - randomization
  - good and bad data sets

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In today’s highly competitive and liability minded environment, Design Reviews (DR) are a must for all major mobility industries such as Automotive, DOD, Aerospace, Agriculture, Recreation, Marine and Rail. While Design Reviews are becoming increasingly important in product liability litigation, they also serve as an effective way to transfer organizational best practices for specific concerns and issues.

This hands-on workshop describes how formal Design Reviews can be used in conjunction with other new product development methods to improve product designs by uncovering potential problems before they are discovered at a later stage of development or application when the costs of correction are much higher. A range of effective techniques for organizing and conducting Design Reviews will be presented. Participants will receive specific guidance and tools to assist them in tailoring Design Reviews to reflect their own organization’s requirements. Topics are applicable to a broad range of new product development programs, ranging from components to complete systems, for both OEMs and suppliers.

LEARN THEN DO -
In this workshop the attendee not only learns the essential elements of a robust Design Review process but also has the opportunity to apply these principles in the conduct of a mock Design Review. Participants will also experience some of the frequently encountered real-world issues that distract from accomplishing good results. During these “reviews” the attendee will experience each of the roles in a typical Design Review; leader, facilitator, recorder, and participant. An after-action review will be performed following each DR session to discuss positive outcomes and identify opportunities for improvement.

Learning Objectives
By attending this seminar, participants will be able to:
• Describe the relationship of the process to concurrent engineering and knowledge management
• Establish the requirements for a successful Design Review process
• Describe the types and timing of reviews
• Organize a typical Design Review
• Conduct a review and get positive results

Who Should Attend
The workshop is designed for individuals who are involved in the development of new products and who seek to improve that process. Product development team members including, but not limited to, directors, manager, project and program managers, design, development, process, product, quality, and application engineers will find the course valuable. It is aimed primarily at engineers and managers who will be facilitating or leading such reviews, but will also benefit manufacturing, marketing and purchasing personnel.

SAE PRODUCT ENGINEERING TOOLS AND METHODS CERTIFICATE PROGRAM
Watch for the certificate icon to indicate course titles that are part of an SAE multi-course certificate program.

This program focuses on the study, development, management and implementation of product engineering principles, methodologies and techniques. When used properly, these tools and methods become powerful productivity enhancers and facilitate the reduction of product development time and cost. Complete this certificate and earn up to seven graduate credits towards the SAE/Kettering University 20-credit Certificate in Automotive Systems and Kettering’s 40-credit M.S. in Mechanical Engineering. Visit training.sae.org/collegecredit for more information. For the complete list of required and elective courses and additional information on enrolling in this SAE certificate program, visit training.sae.org/certificate/engineering_tools.
Design for Manufacture and Assembly (DFM/DFA)

2 Days
I.D.# C0418

This seminar provides a functional understanding of the principles involved in conducting a Design for Manufacture/Design for Assembly study. DFM/DFA can support both manual and automated processes resulting in significant cost savings through simpler designs with fewer components. Related topics include workstation layouts, ergonomic considerations and errorproofing. Actual examples from the automotive industry are used to support the lecture and participants complete actual design efficiency using the DFM/DFA worksheet.

Learning Objectives

By attending this seminar, participants will be able to:

- Recognize and list the benefits of the DFM/DFA method in creating product designs which support manufacturing processes leading to short and long term product cost savings
- Outline a Robust Manufacturing Plan that optimizes and simplifies product design without sacrificing quality
- Objectively determine which designs would be suitable as DFM/DFA candidates
- Perform the essential stages of a Design for Manufacture process including the analysis required to overcome typical manufacturing difficulties encountered in product design
- Construct an actual DFM/DFA worksheet and calculate design efficiency using an instructor provided project

Who Should Attend

Product Engineers, Designers and Managers, Manufacturing and Tooling Engineers, and Project Managers who desire to understand DFM/DFA as a product design tool to increase manufacturability of product assemblies. The course is best suited for individuals in the manufacturing industry and is beneficial to OEMs and Tier suppliers.

Topical Outline

DAY ONE

- Introduction to DFM/DFA and DFM/DFA objectives
  - DFM, DFA and Product Life Cycle
  - Six Steps of the DFM/DFA Life Cycle Model
  - DFM and DFA advantages and challenges in a Product Development environment
- Design Considerations
  - Creating the DFM/DFA Environment
  - Guidelines for selecting DFM candidates
  - Integrating FMEA and DFM/DFA
  - Material Selection process
  - Project Cost Estimation
This six-session web seminar provides design engineers with the skills necessary for proper use of FEA in the design process and to ensure that this powerful tool is implemented in the most efficient and productive way. Participants will study different types of analyses typically performed, discuss common misconceptions and traps in the FEA, and review Implementation of Management of FEA in the design environment. The online format will allow for some customization so problems of particular interest to participants and an exchange of FEA experiences may be discussed during the live sessions. Hands-on exercises focusing on the analysis of FEA errors and proper modeling techniques will be assigned.

All topics are illustrated by hands-on examples using FEA software SolidWorks® Simulation for which participants will be provided a Student License (compatible with Windows 7 SP1, 8, 8.1, 10; IE 10,11; MS Excel and Word 2010, 2013, 2016). Acquired skills, however, are not software specific and no prior exposure to FEA software is required. The eBook, “Engineering Analysis with SolidWorks® Simulation” by Paul Kurowski, will also be included in the course materials. In-class, hands-on exercises and between-session assignments will provide an opportunity to put what is learned into practice.

**Learning Objectives**

By connecting with this web seminar, participants will be able to:
- Select preferable modeling approaches
- Analyze errors inherent to FEA results
- Identify FEA advantages and shortcomings
- Avoid mistakes and pitfalls in FEA
- Produce reliable results on time
- Request FEA analysis and use FEA results
- Provide effective FEA project management
- Ensure quality and cost-effectiveness of FEA projects

**Who Should Attend**

This course addresses the needs of design engineers who are not specialized analysts but need to use the Finite Element Analysis to analyze new product during the design process. Also non-specialist FEA users, R&D engineers and managers, project engineers, and product engineers will benefit from its coverage of different FEA formulations, tools for error analysis, common errors, traps and misconceptions, and an introduction to FEA project management.

Looking for more advanced FEA courses? Consider *FEA Beyond Basics: Nonlinear Analysis* and *FEA Beyond Basics: Thermal Analysis* - descriptions immediately following.
Topical Outline
Session 1
• Fundamental Concepts in the FEA
• Finite Element Analysis Process
• Origins and Types of FEA Errors
• Finite Element Mesh
• In-class Exercises
Session 2
• Control of Discretization Error – Convergence Process
• Verification and Validation of FEA Results
• In-class Exercises
• Homework Assignment
Session 3
• Control of Modeling Error
• Types of Finite Elements Types of Boundary Conditions
• Useful Modeling Techniques
• In-class Exercises
• Homework Assignment
Session 4
• Modal Analysis
• Buckling Analysis
• In-class Exercises
• Homework Assignment
Session 5
• Nonlinear Geometry Analysis
• Nonlinear Material Analysis
• Contact Stress Analysis
• In-class Exercises
• Homework Assignment
Session 6
• Steady State Thermal Analysis
• Transient Thermal Analysis
• FEA Implementation
• FEA Project Management
• FEA Traps and Misconceptions
• Quiz in preparation to post-course learning assessment

Instructor: Paul Kurowski
Fee $870 1.2 CEUs

FEA Beyond Basics: Nonlinear Analysis
Web Seminar
7 Hours
I.D.# WB1725

Finite Element Analysis (FEA) has been an indispensable tool for design simulation for several decades but this widespread use has been limited to simple types of analyses. Relatively recently, more advanced analyses have given easy to use interfaces enabling design engineers to simulate problems formerly reserved for analysts. This three-session web seminar targets the FEA users who wish to explore those advanced analysis capabilities.

The course demonstrates how to move past the ubiquitous linear structural analysis and solve structural nonlinear problems characterized by nonlinear material, large displacements, buckling or nonlinear connectors. The discussion will help participants identify, set up and solve complex nonlinear problems and as well as use results of nonlinear analysis to support the product design process.

Learning Objectives
By connecting with this web seminar, participants will be able to:
• Identify a need for a nonlinear structural analysis
• Identify the types of nonlinearities
• Employ correct problem definition and solution strategy
• Select applicable modeling techniques
• Assess and implement results of nonlinear analysis

Who Should Attend
The course is intended for design engineers who already have a foundational understanding of FEA but need to elevate its use to an advanced level to predict product behavior more closely. Familiarity or experience with FEA equivalent to or as covered in the Finite Element Analysis for Design Engineers web seminar (I.D.# WB1241; page 55) or on-demand course (I.D.# PD531241; page 57) is recommended.

Topical Outline
Session 1
• Modal Analysis and Linear Buckling Analysis
  • Analogies and differences between modal analysis with pre-stress linear buckling analysis
  • Linear buckling analysis as an entry to nonlinear analysis
  • Structural stability
Session 2
• Nonlinear Geometry Analysis
  • Large displacement
  • Stress stiffening/softening effect
  • Force and displacement boundary conditions
ENGINEERING TOOLS & METHODS

- Contact Analysis
  - Contact
  - Interference
  - Bolt connectors

Session 3
- Nonlinear Material Analysis
  - Plasticity
  - Residual stress
  - Hyper-elasticity

Instructor: Paul Kurowski
Fee $595 .7 CEUs

FEA Beyond Basics: Thermal Analysis Web Seminar
7 Hours
I.D.# WB1726

Finite Element Analysis (FEA) is a powerful and well recognized tool used in the analysis of heat transfer problems. However, FEA can only analyze solid bodies and, by necessity thermal analysis with FEA is limited to conductive heat transfer. The other two types of heat transfer: convection and radiation must by approximated by boundary conditions. Modeling all three mechanisms of heat transfer without arbitrary assumption requires a combined use of FEA and Computational Fluid Dynamics (CFD).

This three-session web seminar is for FEA users who need expand thermal analysis to include heat transfer in solids and fluids without the use of arbitrary convective or radiative boundary conditions. The course demonstrates how FEA and CFD work together to solve conjugate heat transfer problems producing results that simulate real life problems.

Learning Objectives
By connecting with this web seminar, participants will be able to:
- Identify mechanisms of heat transfer present in an analysis problem
- Implement FEA and/or CFD to analyze heat transfer
- Perform conjugate heat transfer analysis
- Select applicable modeling techniques
- Assess and implement results of thermal analysis

Who Should Attend
The course is intended for design engineers who already have a foundational understanding of FEA but need to elevate its use to an advanced level to predict product behavior more closely. Familiarity or experience with FEA equivalent to or as covered in the Finite Element Analysis for Design Engineers web seminar (I.D.# WB1241; page 55) or on-demand course (I.D.# PD531241; page 57) is recommended.

Topical Outline
Session 1
- Modeling Different Mechanisms of Heat Transfer
- Steady State Thermal Analysis
- Transient Thermal Analysis

Session 2
- Overview of Computational Fluid Dynamics (CFD)
- Comparison between FEA and CFD
- Internal and External Fluid Flow Problems
- Interfacing between FEA and CFD
- Conjugate Heat Flow

Session 3
- Analysis of Convective Heat Transfer with CFD and FEA
- Analysis of Radiative Heat Transfer with CFD and FEA

Instructor: Paul Kurowski
Fee $595 .7 CEUs

Finite Element Analysis for Design Engineers
8 Hours
I.D.# PD531241

Similar content is available in the web seminar, Finite Element Analysis (FEA) for Design Engineers. See the course description above.

This online on demand course provides the skills necessary for proper use of FEA in the design process and ensures that the powerful tool is implemented in the most efficient and productive way. Participants will begin with the foundational FEA process, observe expert demonstrations showing how FEA is conducted using real models, study different types of typically performed analysis, discuss common misconceptions and errors made, and explore how FEA can be implemented within the design environment. Hands-on exercises focusing on FEA fundamentals, different types of analysis, and proper modeling techniques are included.

An introduction module and various bundling options are available for this topic. Contact Corporate Learning Solutions to discuss the course options that best fit your need.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.
Introduction to FMEA: What, Why, When and How

25 Minutes
I.D.# PDS31422ON

This is an introductory module; more in-depth content is available in the webinar, FMEA for Robust Design: What, Why, When, and How. See the course description below.

This module gives a high-level overview of FMEA facts: WHAT an FMEA is, WHY they are used, WHEN an FMEA is created, WHO is on the FMEA development team, and HOW the FMEA form is completed. The history of FMEAs, standards, and team responsibilities are also discussed.

A more in-depth on demand option for the FMEA topic is in development. Contact Corporate Learning Solutions to discuss availability and learning options that best fit your need.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.

FMEA for Robust Design: What, Why, When and How Web Seminar

12 Hours
I.D.# WB1422

Failure Modes and Effects Analysis (FMEA) is an integral part of product design activity applicable to any type of product or service. It is a quantitative and qualitative step-by-step approach for identifying and analyzing all actual and potential points of failure in a design, product or service. A successful team-based FMEA activity can use their collective experience with similar products to dramatically improve not only product performance but also reduce manufacturing issues at both a component and system and processing level.

This web seminar introduces the five basic types of FMEAs with emphasis on constructing a Design FMEA. Each column of the FMEA form is clearly explained using a typical FMEA example. This example can be a provided sample or a company sample provided candidate. The course covers various methods for clearly identifying product function at three levels, and associating distinct failure modes, effects and causes related to each function level. Special attention is given to Severity, Occurrence, and Detection and how to develop effective Risk Priority (RPN) strategies and Recommended Actions for significant RPNs.

All material is in conjunction with current industry standards.

Learning Objectives
Upon completion, the participant should be able to:

- State the relationship between Product Development, Voice of the Customer (VOC) and the FMEA process
- Recognize why and when to use the five types of FMEAs, specifically Systems and Design
- Apply the FMEA process as a risk management technique
- Organize an effective FMEA team and conduct FMEA work sessions
- Adapt the steps to generate a FMEA process to your specific company needs
- Develop and manipulate Risk Priority and Detection Strategies and customize Risk Ranking tables
- Assign effective Recommended Actions

Who Should Attend
The course is designed for individuals who are involved in the development of new products and who seek to improve that process. Product development team members including, but not limited to, project and program managers, design and development, process, product, quality, and application engineers will find the course valuable. It is aimed primarily at these managers and engineers who will be facilitating or leading such FMEA activities. Directors, marketing and purchasing personnel will also benefit by understanding why the FMEA process is important to developing a safe and effective product.

Topical Outline
Session 1
- FMEA Introduction
  - Background and History
  - The FMEA Standards - MIL-STD_1629, SAE J1739, AIAG
  - Relationship of Design and Process FMEA in a design & manufacturing environment

Session 2
- Five Types of FMEAs

Session 3
- FMEA and Risk Management
  - Defining Risk Management
  - FMEA and Robust Design
  - FMEA as part of Design to Cost
  - FMEA as Product Liability Protection

Session 4
- Managing the FMEA Process
  - Assembling the FMEA Team
  - Facilitator Role during the FMEA Process
  - Capturing the 6 Levels of Voice of the Customer (VOC)
Introduction to Failure Mode and Effects Analysis for Product and Process

2 Days
I.D.# C1201

Failure Mode and Effects Analysis (FMEA) is a systematic method for preventing failure through the discovery and mitigation of potential failure modes and their cause mechanisms. Actions are developed in a team environment and address each high: severity, occurrence or detection ranking indicated by the analysis. Completed FMEA actions result in improved product performance, reduced warranty and increased product quality. This course assists FMEA team members to apply severity, occurrence and detection rankings consistently and efficiently and explores, in detail, the linkage of the Design FMEA and the Process FMEA through special characteristics development and product and process design collaboration. The relationships between FMEA and other popular tools, including Failure Mode Avoidance (FMA /FPA Failure Prevention Analysis and Control Plans) will also be discussed. Participants can expect dynamic “hands-on” activities with in-class Design and Process FMEA creation, facilitation skill development and risk analysis best practices. Instruction and clarification will be provided for relevant portions of the SAE J1739 standard, Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly (Process FMEA), a copy of which will be included with the course materials.

Learning Objectives

Upon completion of this seminar, participants will be able to:
- List the benefits, requirements, and objectives of an FMEA
- Demonstrate the steps used in developing an FMEA
- Follow the methodology to efficiently create an FMEA
- Describe other tools used in, or related to the FMEA
- Identify corrective actions resulting from proper FMEA development
- Identify and classify the levels of risk requiring corrective action
- Show the links between Design and Process FMEA
- Demonstrate the FMEA’s role in developing Special Characteristics and Design and Process Controls
- Summarize the objectives of the SAE standard J1739

Who Should Attend

This seminar is designed for engineers involved with manufacturing, product design, reliability, testing, quality, development, logistics/support, product assurance/design assurance, materials, and their management or anyone responsible for the design and development of manufacturing, assembly or service processes in the completion of a Design or Process FMEA.

Topical Outline

DAY ONE
- Pretest - Set baseline of knowledge and determine Voice of the Customer (participants) wants needs and desires
- FMEA Process Overview
  - Introductions and course objectives
  - What is risk?
  - The history and purpose of FMEA
  - SAE J1739 introduction
  - FMEA - where it fits in the product development process
  - System/Subsystem/component Design FMEA
  - Manufacturing and Assembly Process FMEA
  - Machinery and Equipment FMEA (Logistics Support)
- FMEA Development Methodology
  - Design FMEA development methodology - the three path model
  - Failure Mode Avoidance FMA /FPA Failure Prevention Analysis
  - Team structure and rules for efficiency - cross functional teams
- The Links between Design and Process FMEA
  - Special characteristics (critical and significant)
  - Collaboration on special characteristics
  - Characteristics as inputs to PFMEA
- Workshop 1: Review product and processes to be performed
- Practical Application of the Design FMEA Technique
ENGINEERING TOOLS & METHODS

• Robustness Tools: Interface Analysis/Boundary (BLOCK) Diagrams; Parameter Diagram (P Diagram)
• Workshop 2: Construct Boundary/Block Diagrams and P Diagrams
• Review of Days Activities and Q&A

DAY TWO
• Methodology and Hands-on Experience
• Path 1
  • Functions/Failure Modes/Effects of Failure/Severity
  • Severity ranking guidelines
  • Actions for high severity (9,10)
• Workshop 3: Path 1 Exercise
• Path 2
  • Causes/prevention controls/occurrence
  • Occurrence ranking guidelines
  • Inputs to FTA (Fault Tree Analysis)
  • Actions to eliminate and/or reduce cause probability
• Workshop 4: Path 2 Exercise
• Path 3
  • Test and verification methods
  • Detection ranking guidelines
  • Links to DVP&R
  • Actions to improve tests and verification techniques
  • RPN - Risk Priority Number
• Workshop 5: Path 3 Exercise
• Fault Tree Analysis Fundamentals
  • When to use FTA instead of or in combination with FMEA
  • Similarities and differences with FMEA
  • Symbols and structure
  • Cut set development
• Workshop 6: FTA Exercise
• Process FMEA Pre-Work
  • Process flow diagrams
  • Characteristics matrix (QFD III)
• Workshop 7: Process FMEA Development (Three Path Model)
  • Keys to Success and Efficient FMEA Development
  • Technology blocks for failure mode/cause mechanism history
  • FMEA legacy matrices (Lean FMEA)
• Other Tools and Techniques Used or Related to FMEA
• Statistical Process Control (SPC) for special characteristics
• Design for Assembly and Manufacturing DFA/M
• 8D - Eight Disciplines of Problem Solving and FMEA Links
• Role of FMEA software
• Reliability and Maintainability (Logistics Support)
• Q&A
• Post Test and VOC Closure

Instructor: Lee D. Dawson
Fee $1445 1.3 CEUs

Fundamentals of Statistical Process Control

2 Days
I.D.# C0553
As competition for market share increases, so does the need to monitor processes and quality to ensure top-notch products. This hands-on seminar will provide you with the skills to apply and maintain statistical process control to assist your organization in the improvement of various processes to achieve higher percentage yield or higher quality products or services. Quality characteristics (process outputs to track), measurement systems, sampling strategies, types of control charts, construction of control charts, and control chart interpretation will be covered. The determination of the key process parameters and controlling them to provide consistent results will improve quality and lower costs, in particular, scrap and rework costs. Statistical theory and depth are kept to a minimum while you learn how to utilize the tools. Attendees will receive a copy of the Statistical Process Control Manual (SPC-3, 2nd Edition) by the Automotive Industries Action Group.

Learning Objectives
By attending this seminar, participants will be able to:
• Describe the purpose and uses of SPC
• Select the best measurement system to use for a specific application
• Identify an appropriate process sampling strategy
• Determine the basic type of control chart to use
• Collect data and construct basic control charts
• Interpret control chart results

Who Should Attend
Quality managers, engineers, and technicians, project engineers, manufacturing engineers, technical specialists and anyone with responsibility for product or process control who want to apply SPC in the workplace should attend this seminar. Individuals seeking to attain the Certified Quality Engineering status within the American Society for Quality will find this course particularly helpful.

Topical Outline
DAY ONE
• Introduction
• Viewpoints and Determinants of Quality
• SPC: Part of a Product Quality System
  • SPC philosophy: prevention versus detection
  • Process control system
  • Causes of variation: common and special
  • Reactions to causes of variation

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• Requirements and specifications
• Control charts: SPC tools
• Benefits of SPC
• SPC implementation process
• Quality Characteristic Determination
  • Everything is a process
  • Process flowchart and functions
  • Quality characteristics generation -- intermediate/final; variable/attribute
  • Critical characteristics determination -- final customer requirements; subsequent process requirements
  • Process example
• Quantification (measurement) of Quality
  • Types of characteristics -- variable; attribute
  • Methods of measurement and measurement systems
  • Measurement system capability
• Sampling Strategy
  • Sample size
  • Sample frequency
  • Sample structure
• Quality Planning Workshop
• Basic Control Chart Types
  • Variable: X and R charts - AIAG example; workshops
  • Attribute
  • np chart - number defective - AIAG example; workshops
  • c chart - number of defects - AIAG example; workshops
• Basic Chart Interpretation
  • Basic decision rules
  • Process responses - jumps, steps, shifts; trends; cycles
• Documented process changes

Instructor: Phillip J. Ross
Fee $1370 1.3 CEUs

Introduction to Design Review Based on Failure Modes (DRBFM) Web Seminar and Web Seminar RePlay

6 Hours
Web Seminar: I.D.# WB1047
Web Seminar RePlay: I.D.# PD331047ON

Design Review Based on Failure Modes (DRBFM) is a methodology focused on change management and continuous improvement. It centers on early prevention and engineering knowledge, eliminating time spent debating ranking systems, waiting for lead engineers to document and list their concerns, identifying what types of concerns are open for discussion and resolution, and brainstorming without any actionable closure.

This web seminar will explain all phases of the DRBFM methodology and provide details on how to accomplish the specific steps. With the Design Review Based on Failure Modes (DRBFM) and Design Review Based on Test Results (DRBTR) Process Guidebook that is bundled with the course, the instructor will provide specific information on each step. Formats, examples, notes and homework slides will be used to illustrate the defined steps of the new SAE J2886 DRBFM Recommended Practice. Similarities in content between DRBFM and FMEA will be discussed, however the focus will be on conducting DRBFM methodology.

This DRBFM web seminar will provide roles and responsibilities of management, design engineers, manufacturing engineers, facilitators and technical experts. Those interested in DRBFM will benefit from understanding the rationale behind this methodology and learn to guide teams through the paradigm shifts and mind set that are needed.

Learning Objectives
By connecting with this web seminar, participants will be able to:
• Outline the fundamental steps of DRBFM methodology, including:
  • DRBFM Plan and analysis requirements
  • Necessary preparation feeding DRBFM analysis
  • The two phases of DRBFM analysis
  • Documentation of design, validation and manufacturing actions
  • Feedback loop into engineering knowledge documents
• Explain the intent and format of the DRBFM worksheets
• Predict what it takes to gain and maintain proficiency and consistent application of the methodology
• Find answers to most DRBFM questions
ENGINEERING TOOLS & METHODS

Who Should Attend
Product engineers, manufacturing engineers, quality engineers, supplier quality engineers, validation and test engineers, and facilitators, trainers and consultants in all industries. This web seminar will benefit beginning engineers, advanced and senior engineers and managers who must participate in FMEA’s and DRBFM.

Topical Outline
Session 1
- DRBFM Procedure, Forms, Planning and Preparation
  - Process Guide and Workbook Overview
  - Scope and Purpose
  - Process Map - General Requirements
  - Planning - Formats, examples, homework
  - Planning Results and Output
  - Preparation - Formats, examples, homework
  - Preparation Results and Linkage with DRBFM Format
  - Definition of Change Section
Session 2
- DRBFM - Forum 1, Design Review, Action Results and Follow Up
  - DRBFM Forum 1 - Engineer analysis
  - Change Point definition
  - Identification of concerns
  - Identification of causes and influences on the vehicle
  - Identification of effects
  - Identification of severity/priority
  - Actions to gain engineering knowledge - evidence
Session 3
- DRBFM - Forum 2, Design Review, Action Results and Follow Up
  - DRBFM Forum 2 - Design Review introduction
  - Change Point overview
  - Identification of additional concerns
  - Identification of additional causes and influences on the product
  - Identification of effects
  - Identification of severity/priority
  - Actions taken to eliminate concerns
  - Design actions to gain engineering knowledge - evidence
  - Validation actions to gain evidence of reliability
  - Manufacturing, assembly, and supplier actions
  - Action results and feedback to design guidelines
  - Roles and responsibilities

Reverese Engineering: Technology of Reinvention
2 Days
I.D.# C0559
During the past decade reverse engineering has become a common and acceptable practice utilized by many original equipment manufacturers and suppliers. This course focuses on the application of modern technologies used to decode the design details and manufacturing processes of an existing part in the absence of the original design data. It emphasizes the real-life practice of reverse engineering in the aerospace industry from both scientific and legal points of view. Attendees will learn the applicability and limitations of reverse engineering through case studies and hands-on exercises.

Various measurement instruments, ranging from traditional micrometers to computer-aided laser probes, will be compared for their merits and shortcomings. The statistics of dimensional measurements and the acceptable tolerance of variations, with emphasis on industrial standards in real-life practice will be discussed. Material identification, manufacturing process verification and the system compatibility of the subject part to be reverse engineered will be covered in substantial detail. In addition, the materials specifications will be exemplified as useful supporting documents for substantiation data.

Note: Participants should bring a calculator for in-class exercises.

Learning Objectives
By attending this seminar, participants will be able to:
- Define the critical elements of reverse engineering
- List the measurements and analyses required to duplicate/reproduce an OEM part by reverse engineering
- Recognize if an OEM part can be duplicated/reproduced by reverse engineering
- Judge if a “duplicated” part will meet the design functionality of the OEM part
- Evaluate the feasibility of a reverse engineering proposal/project
- Describe and implement a process to duplicate/reproduce a part by reverse engineering

Who Should Attend
This seminar is designed to assist individuals in various industries including, but not limited to, automotive, aerospace, off-highway, motorsports and parts brokerage firms. Corporate senior executives, engineering managers, engineers, technicians, government inspectors, sales managers, salespersons, lawyers and legal counselors will find the course relevant and informative.

Instructor: Bill Haughey
Fee $615 .6 CEUs
Robust Design

2 Days
I.D.# C1231

Engineers are taught to create designs that meet customer specifications. When creating these designs, the focus is usually on the nominal values rather than variation. Robustness refers to creating designs that are insensitive to variability in the inputs. Much of the literature on robustness is dedicated to experimental techniques, particularly Taguchi techniques, which advocate using experiments with replications to estimate variation. This course presents mathematical formulas based on derivatives to determine system variation based on input variation and knowledge of the engineering function. If the function is unknown, experimental techniques are presented to efficiently estimate a function.

The concept of designing for both nominal values and variability is expanded to multiple outputs and designing to minimizing costs. Traditionally, if the output variation is too large to meet requirements, the tolerances (variation) of the inputs are reduced. Using the approach presented in this course, the equations presented can be used to identify the contribution of each of the inputs to the output variation. The variation of the components with the largest contribution can be reduced which will reduce output variation. At the same time, the variation of the components contributing the least to the variation of the output can be increased which will reduce costs. A system of equations can be created that will allow an optimization routine to create a design optimized for total cost including the cost of poor quality and component cost.

Participants should bring a laptop computer for in-class exercises.

The book, Probabilistic Design for Optimization and Robustness for Engineers by Bryan Dodson, Patrick Hammett, & Rene Klerx is included in the course materials.

Learning Objectives

By attending this seminar, participants will be able to:

- Create designs that have a minimal sensitivity to input variation
- Reduce design costs
- Determine which design parameters have the largest impact on variation
- Optimize designs with multiple outputs

Who Should Attend

This course is relevant to design and manufacturing engineers, researchers and those interested in cost reduction. This methodology can link manufacturing to engineering design and help design engineering solve manufacturing problems.
Topical Outline

DAY ONE
• Basics of Variation - unique problems facing engineers; small sample sizes and the inability to obtain random samples; techniques for overcoming these problems
• Distributions
  • Normal, Lognormal, and Weibull
• Process Capability
  • Measuring process capability
  • Process capability indices
  • Estimating process capability for design inputs
• Robustness Concept
  • Statistical bias that results from input variation in a non-linear system
  • Modeling output variation
  • Circuit exercise
  • Projectile exercises
• Simulation
  • Determining the variability of the inputs
  • Random number generators
  • Verification & validation
  • Simulation modeling

DAY TWO
• Minimizing the Variance of a Single Output
  • Polynomial exercise
• Identifying Critical Parameters
  • Ranking the contribution to the output variation
  • Identifying parameters that are constrained
  • Pipe flow exercise
• How to Model and Optimize Multiple Outputs
  • Combustion exercise
• Adding Cost to the Design Model
  • Minimizing the total system cost including component, scrap and process costs
  • Electronics exercise

Instructor: Bryan Dodson
Fee $1465 1.3 CEUs

Root Cause Problem Solving: Methods and Tools Web Seminar

8 Hours
Web Seminar: I.D.# WB0931
Similar content is available in an on demand course. Review the course info in the On Demand Courses Resource Guide on pages 199-259.

Tough times require searching for things that we can change and making them better. But so often problems are solved with ‘band-aids’ and not root cause solutions. This approach is getting too expensive and at best only helps companies tread water. To combat these issues and adopt a fresh approach, teams can use the methods and tools of Root Cause Problem Solving to first view problems as opportunities for improvement, identify root causes and implement solutions to prevent recurrence. Benefits include improved quality and customer satisfaction, reduced operation costs, and greater employee knowledge of work processes.

This proven 8-step approach to problem solving will help improve operational and financial performance by identifying causes and implementing solutions to significant or recurring problems. This approach to problem solving is used by many major automotive manufacturers.

Learning Objectives

By connecting with this web seminar, participants will be able to:
• Describe the 8-Step Problem Solving Methodology
• Define the difference between Symptom and Root Cause
• Use tools and techniques to solve problems
• Evaluate effectiveness of problems solving efforts
• Describe the role of problem solving in continuous improvement
• Write an action plan to apply problem solving to a specific concern

Who Should Attend

This course is applicable to those directly working in or responsible for performance improvement of any definable, repetitive process, e.g. manufacturing, design, logistics, purchasing, sales, or distribution, including:
• Manufacturing managers, supervisors and team leaders
• Manufacturing engineers
• Design engineers
• Quality engineers and technicians
• Technical managers
• Project team leaders
• Problem solving and quality improvement facilitators
• Anyone whose role includes problem solving; therefore all supervisors and lead personnel

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Topical Outline

Session 1
• Overview
  • Following a process approach
  • What is a problem?
  • Inhibitors to effective problem solving
  • 8-step problem solving process overview
• Step 1: See the Problem as an Opportunity
  • Framing the problem solving effort
  • Identifying team member; Team roles
• Step 2: Describe the Problem
  • Symptoms vs. Causes
  • Methods for describing the problem
  • Using and charting data
  • Problem Is/Is-Not analysis
Session 2
• Step 3: Implement Containment
  • Protect the Customer
  • Process Control Plan
• Step 4: Recognize Potential Root Causes
  • Identifying possible causes
  • Process Maps
  • Cause-Effect diagrams
  • 5-Why tool
Session 3
• Step 5: Design Solution
  • Solutions that don’t work
  • Process Controls and Error Proofing
  • Standardized Work
• Step 6: Implement Permanent Corrective Actions
  • Plan the work
  • Complete system changes
  • Verify effectiveness
Session 4
• Step 7: Prevent Recurrence
  • Was the problem eliminated?
  • Layered audits
  • Leverage learnings with FMEA
• Step 8: Recognize Efforts
  • Team debrief and lessons learned
  • Evaluate and celebrate success
• Summary
  • Sufficiency checklist for effective problem solving
  • Continuous Improvement

Instructor: Murray Sittsamer
Fee $640 .8 CEUs

Root Cause Problem Solving: Methods and Tools
8 Hours
I.D.# PD530931

Similar content is available in live web seminar - Root Cause Problem Solving: Methods and Tools. See the course description the previous page.

This course introduces the Root Cause Problem Solving approach. It explains how using the Root Cause approach can help improve operational and financial performance by identifying root causes and implementing solutions to significant or reoccurring problems. This problem-solving approach is used by many major automotive manufacturers to improve quality and customer satisfaction, reduce operation costs, and provide greater employee knowledge of work processes.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.

Statistical Methods for Quality Engineering
3 Days
I.D.# C0554

Based on your test data or process data, do you ever wonder if:
• An improved product really performs better?
• A substitute material really processes the same?
• A cheaper material really performs satisfactorily?
• What confidence do you have in the final decision that you make?

This seminar helps individuals responsible for product or process development and testing to statistically assess the variation of the product or process performance and make effective decisions with confidence. Technical personnel are consistently making changes to product and process designs and the resultant performance changes need a statistical basis for moving ahead to the cost assessment and release phases. Various continuous and discrete probability functions are covered with the normal distribution receiving the most emphasis. Other distributions covered include Weibull, Exponential, Binomial, Poisson, Hypergeometric, and non-parametric comparisons. Various confidence intervals and tests of comparison, including Z test, Student’s t tests, Chi-Square test, F test, and ANOVA for the normal distribution for these probability functions are covered.
ENGINEERING TOOLS & METHODS

Learning Objectives
By attending this seminar, participants will be able to:
• Select the proper distribution model
• Determine valid sample sizes
• Design valid tests of comparison
• Make effective decisions at stated confidence levels

Who Should Attend
This course applies to anyone making product or process assessment or changes and will help them to make effective decisions concerning those situations. Product design managers and engineers, process design managers and engineers, and quality managers and engineers will particularly benefit from this course. Individuals seeking to attain the Certified Quality Engineering status within the American Society for Quality will find this course particularly helpful.

Prerequisites
Participants should have at least high school mathematics and graphing skills, a good technical understanding of products and processes in their work environment, and a good technical understanding of testing methods and protocols.

Topical Outline
DAY ONE
• Introduction
  • Training objectives
  • Statistical resources
• Concept of variation
  • Common development questions
  • Histograms
  • Descriptive statistics
• Distribution Models
  • Continuous
  • Discrete
  • Applications
• Model Selection
  • Empirical distribution functions
  • Cumulative distribution functions
  • Normal probability paper
  • Small sample sizes and median ranks
  • Tests for normality
DAY TWO
• Parametric Evaluations and Tests
  • Normal and log-normal data - Z confidence intervals and tests; t confidence intervals and tests; Chi-Square confidence intervals and tests; F tests;

DAY THREE
• Parametric Evaluations and Tests (continued) - analysis of variance
  • Weibull distribution, confidence intervals and tests
  • Exponential distribution tests
  • Poisson distribution applications
  • Binomial distribution applications
  • Hypergeometric applications
• Nonparametric Tests
  • Sign tests
  • Run tests
  • Rank tests

Instructor: Phillip J. Ross
Fee $1745 2.0 CEUs

Vibration Analysis Using Finite Element Analysis (FEA)
12 Hours
I.D.# WB1401
Web Seminar Replay: I.D. PD331401ON

Finite Element Analysis (FEA) has been used by engineers as a design tool in new product development since the early 1990’s. Until recently, most FEA applications have been limited to static analysis due to the cost and complexity of advanced types of analyses. Progress in the commercial FEA software and in computing hardware has now made it practical to use advanced types as an everyday design tool of design engineers. In addition, competitive pressures and quality requirements demand a more in-depth understanding of product behavior under real life loading conditions. This course will enable participants to expand the scope of FEA to vibration analysis to simulate product behavior under those conditions.

This six-session web seminar introduces vibration analysis performed with Finite Element Analysis (FEA). By considering time-dependent loads and inertial and damping effects, vibration analysis allows for a more in-depth product simulation thus reducing product development cost and time. The course reviews basic concepts of vibration analysis and illustrates how they are implemented in FEA to simulate product behavior. The most common types of vibration analysis such as modal, time response, and frequency response will be covered.

All topics are illustrated using FEA software, SolidWorks® Simulation, for which participants will be provided a student license (compatible with 64-bit Windows 7 SP1, 8.1, 10; IE 10,11; MS Excel

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and Word 2010, 2013, 2016) and opportunity to practice skills learned. Acquired skills, however, will not be software specific and no prior exposure to FEA software is required. The eBook, Vibration Analysis with SolidWorks® Simulation by Paul Kurowski, will also be included in the course materials. In-class, hands-on exercises and between-session assignments will provide an opportunity to put what is learned into practice.

**Learning Objectives**

By participating in this web seminar, participants will be able to:
- Evaluate the importance of dynamic effects in product simulation
- Analyze inertial and damping effects in structural response
- Perform modal analysis, time response analysis and frequency response analysis
- Apply proper FEA modeling techniques to model system vibration
- Use vibration analysis as a design tool

**Who Should Attend**

The course will be of interest to design, R&D, project, and product engineers who already use Finite Element Analysis (FEA) as a design tool and would like to explore if and how vibration analysis with FEA may benefit the design process. It builds on participants' experience with static FEA and on knowledge of mechanical vibrations common to any mechanical engineer.

**Prerequisites**

Participants should have a degree in mechanical engineering and have some experience with FEA either by participating in the SAE Finite Element Analysis for Design Engineers web seminar (I.D.# WB1241; page 55) or through equivalent work experience. Familiarity with Windows OS and some CAD is helpful. The textbook, Engineering Analysis with SolidWorks® Simulation by Paul Kurowski, is recommended reading.

**Topical Outline**

**Session 1**
- Structure vs. Mechanism
- Simulation Process with the FEA
- Verification and Validation of FEA Results
- Discrete and Distributed Systems
- Mode of Vibration
- Modal Analysis
- Eigenvalues and eigenvectors
- In-class Exercises/Homework Assignment

**Session 2**
- Modal Analysis
- Convergence of Frequencies
- Rigid Body Modes
- Properties of Lower and Higher Modes
- Modes of Vibration of Single Degree of Freedom Oscillator (1DOF) and Two Degrees of Freedom Oscillator (2DOF)
- In-class Exercises/Homework Assignment

**Session 3**
- Modal Analysis
- Modeling Techniques in Modal Analysis
- Modes Separation
- Modal Analysis as a Tool to Find "Weak Spots"
- Modal Analysis as a Diagnostic Tool
- In-class Exercises/Homework Assignment

**Session 4**
- Modal Analysis with Pre-Stress
- Buckling Analysis
- Analogies between Modal Analysis and Buckling Analysis
- Modes of Vibration
- Modal Superposition Method
- In-class Exercises/Homework Assignment

**Session 5**
- Time Response Analysis
- Load Excitation and Base Excitation
- Impulse Load
- Static vs. Dynamic Response
- Time Response of a 1DOF and 2DOF Systems Time Response of a Distributed System
- In-class Exercises/Homework Assignment

**Session 6**
- Frequency Response Analysis
- Steady State Harmonic Response
- Force and Base Excitation
- Resonance
- Modal Damping
- Frequency Response of a 1DOF and 2DOF Systems
- Frequency Response of a Distributed System
- Linear vs. Non-linear Vibration Analysis
- Summary for Post-Course Learning Assessment

**Instructor:** Paul Kurowski

**Fee:** $870 1.2 CEUs
Weibull-Log Normal Analysis Workshop

3 Days
I.D.# 86034

RMS (Reliability-Maintainability-Safety-Supportability) engineering is emerging as the newest discipline in product development due to new credible, accurate, quantitative methods. Weibull Analysis is foremost among these new tools. New and advanced Weibull techniques are a significant improvement over the original Weibull approach. This workshop, originally developed by Dr. Bob Abernethy, presents special methods developed for these data problems, such as Weibayes, with actual case studies in addition to the latest techniques in SuperSMITH® Weibull for risk forecasts with renewal and optimal component replacement. Class work is used to reinforce key concepts, lectures are based on actual case studies, and personal computers and hands-on experiments are used to analyze dozens of Weibull & Log Normal problems. Students will be fully capable of performing basic and advanced RMS Engineering analysis with their own software on completion of the workshop.


Bonus Introductory Course Included
To accelerate your learning, you may want to complete the SAE On Demand Course, Introduction to Weibull Solution Methods prior to the Workshop. Your registration will give you online access to this highly recommended, 75-minute overview of Weibull Analysis approximately 10 days in advance of the course start date. Access will end the last day of class.

Learning Objectives
By attending this seminar, participants will be able to:
• Analyze design, development, production, and service failures
• Model product lifetime and reliability
• Evaluate calibration and maintainability plans
• Analyze inspection data
• Reduce test substantiation, time and costs

Who Should Attend
An engineering undergraduate degree in any discipline would be beneficial. Engineers responsible for reliability, safety, supportability, maintainability, materials, warranties, life cycle cost, design, structures, instrumentation and logistics will find these Weibull techniques extremely useful.

Topical Outline
DAY ONE - Undergraduate Weibull Analysis
• Background, Development & Introduction - 23-Minute Video Short Course
• How to do Weibull Analysis
• Interpretation of Good Weibulls - 2 & 3 Parameter
• Are two Weibull datasets significantly different?
• Interpretation of Bad Weibulls
• Risk and Failure Forecasting Case Studies
• Weibull Experiments (Wire Rupture, Torsion, LCF, Accelerated Testing), Classwork Problems and Solutions
• Log Normal Analysis
• Optimal Replacement Intervals, Block Replacement

DAY TWO - Postgraduate Weibull Analysis
• Maximum Likelihood Weibull Theory and Application
• WeiBayes Analysis
• Dauser Shift, Warranty Analysis
• Rank Regression vs. Maximum Likelihood
• Extremely Small Samples Analysis
• One Failure Weibull Case Study
• An Introduction to SuperSMITH® Software, Features, Input, Analysis, Output
• Summary of Weibull Methods
• Class Work Problems
• Experimental Wire Data Distribution Analysis
• Playtime With SuperSMITH® Tutorial

DAY THREE - Confidence Intervals and System Models
• Confidence Intervals, “The Good, The Bad and The Complicated”
• Comparing Designs
• The Binomial & Poisson
• Crow-AMSAA Reliability Growth Modeling - Useful Technology for Tracking Development Testing and Any Significant Event to be Managed
• The Exponential Related to the Poisson and the Weibull
• Kaplan-Meier Survival Analysis
• Crow-AMSAA Employed for Analyzing Renewal-Repairable Systems
• System Models
• Classwork
• Complete Playtime With SuperSMITH®
• Ph.D. Oral Examination

Instructor: Wes Fulton
Fee $2275 2.0 CEUs
**Introduction to Weibull Solution Methods**

75 Minutes  
I.D.# PD530946ON

This is an introductory module; more in-depth content is available in the seminar, *Weibull-Log Normal Analysis Workshop*. See the course description above.

The Weibull Solution Methods course is designed for technical personnel and engineers who want to discover the best toolset for continuous improvement at their organization or business. The course will benefit those in any industry including automotive, aerospace, electrical/electronic, transportation, design, manufacturing, test planning, warranty, reliability, quality, liability, value engineering, and management, among others. This course is appropriate for anyone who needs an awareness of Weibull’s basic premises and benefits as well as those who need this foundational knowledge as a prerequisite for additional training toward becoming an expert Weibull practitioner.

*Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.*

*Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.*

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**Tolerance Stack-up Fundamentals Web Seminar and Web Seminar RePlay**

6 Hours  
Web Seminar: I.D.# C0842  
Web Seminar RePlay: I.D.# PD330842ON

Analysis of tolerance stacks varies widely. This web seminar introduces the basic tools to create a common methodology for tolerance stack-ups, and ensure seamless documentation. Participants will create 1-D tolerance stacks for parts and assemblies that use geometric dimensioning and tolerancing using a tolerance stack spreadsheet. This simple, manual spreadsheet method produces an easily interpreted and checked documentation trail, and is easily adaptable to common electronic spreadsheet programs. Multiple examples will be provided to assist engineers in applying tolerance stack-up fundamentals to Y14.5 issues.

**Learning Objectives**

By connecting with this Web Seminar, participants will be able to:
- Perform and develop a tolerance stack-up analysis
- Correctly enter geometric feature control frame data into a tolerance stack
- Apply a common step-by-step methodology to tolerance stack analysis

**Who Should Attend**

Engineers familiar with concepts and practices contained within Y14.5 and who are looking for a fundamental step-by-step process for getting geometric dimensioning and tolerancing (GD&T) into a tolerance stack will benefit from this course. A basic understanding of GD&T symbols and concepts is required.

**Topical Outline**

**Session 1**
- Introduction and review
  - Introduction and tolerancing review
  - Tolerancing strategies
  - Review of GD&T

**Session 2**
- Stack fundamentals
  - How to identify the stack path
  - The two-column stack spreadsheet
  - Entering dimensions into the spreadsheet
  - Examples with coordinate dimensions

**Session 3**
- Factoring GD&T into a Stack
  - Location and runout tolerances
  - Profile tolerances
  - Form and orientation tolerances

**Session 4**
- Bonus and shift tolerance in a stack
  - Overview of bonus and shift tolerance
  - Part vs. assembly stacks
  - Wrap-up

**Instructor:** John-Paul Belanger

Fee $640 .8 CEUs
Fundamentals of Geometric Dimensioning & Tolerancing (GD&T) Web Seminar and Web Seminar RePlay

16 Hours
Web Seminar: I.D.# WB0933
Web Seminar RePlay: PD330933ON

Geometric dimensioning and tolerancing (GD&T) is used as a symbolic way of showing specific tolerances on drawings. GD&T is a valuable tool that effectively communicates the design intent to manufacturing and inspection. It is governed by the technical standard ASME Y14.5M-2009. This course introduces participants to the GD&T system, providing a working knowledge of the correct interpretation and application of each symbol, general rules, the datum system, and ‘bonus’ tolerance and highlighting some of the changes in the updated Y14.5 standard. The material is reinforced with many practice exercises.

Learning Objectives
By connecting with this web seminar, participants will be able to:
• Explain the benefits of geometric tolerancing
• Identify datum features and determine their order of precedence
• Identify and interpret each of the characteristic symbols
• Describe the material condition modifiers and how “bonus” tolerance occurs
• Correctly interpret GD&T feature control frames, and explain the impact on manufacturing and inspection

Who Should Attend
This course is ideal for anyone who has a need to apply or interpret geometric tolerances on a product print. Product engineers, manufacturing engineers, CAD designers, quality inspectors, and other engineering and manufacturing personnel will all benefit from a better understanding of design requirements; improved communication with customers and suppliers; and improving designs by taking advantage of bonus tolerance and other GD&T benefits. Participants should have an understanding of basic blueprint reading. If employees are already applying basic GD&T concepts, consider advanced competency courses Advanced GD&T Competencies: Composite Positioning web seminar (I.D.# WB1321), Advanced GD&T Competencies: Datum Usage web seminar (I.D.# WB1319), and Advanced GD&T Competencies: Profile of a Surface web seminar (I.D.# WB1320). Descriptions on following pages.

Topical Outline
Session 1
• Why Use GD&T?
  • Review of traditional dimensioning
  • Benefits of GD&T
  • Technical standards
  • Definitions
  • Basic dimensions
  • How to read the feature control frame
Session 2
• Rules and the Form Symbols
  • Rule #1: Size controls form
  • Rule #2: Assume RFS
  • Flatness
  • Surface straightness
  • Circularity
  • Cylindricity
Session 3
• Bonus Tolerance
  • GD&T applied to a feature of size
  • Bonus and the MMC modifier
  • Virtual condition
  • Gaging and inspection of GD&T
Session 4
• Datums
  • Datum vs. datum feature
  • The datum reference frame
  • Primary, secondary, and tertiary datums
Session 5
• Profile and Orientation
  • General definition of profile
  • Profile of a line
  • Profile of a surface
  • Use of datums with profile
  • Perpendicularity
  • Angularity
  • Parallelism
Session 6
• Position Tolerance I
  • True position
  • Position tolerance RFS
  • Using MMC or LMC
  • The “boundary” concept
  • The pitch diameter rule
Session 7
• Position Tolerance II
  • Projected tolerance zone
  • Inspecting parts for position
  • Calculating tolerance values
  • Composite position tolerance
Session 8
• Symmetry and Coaxial Controls
• Concentricity
• Symmetry
• Circular runout
• Total runout
• Wrap-up

Instructor: John-Paul Belanger
Fee $995 1.6 CEUs

Advanced GD&T Competencies: Composite Positioning Web Seminar and Web Seminar RePlay
1.5 Hours
Web Seminar: I.D.# WB1321
Web Seminar RePlay: I.D.# PD331321ON

While the basics of position are covered in a standard Geometric Dimensioning & Tolerancing (GD&T) course, and sometimes a lone example of composite position is given, those discussions often overlook the variations allowed that enable more accurate control based on part function. This advanced web seminar will clarify the proper use of “double-decker” position controls in GD&T. There are two distinct types: composite position (one symbol) and two single-segment position controls (two symbols). These are commonly used to locate patterns of features (bolt circles, etc.), but they are rarely taught in any depth. In this course, participants will learn the difference in showing one vs. two position symbols and the importance of the datum references in understanding each meaning, per the ASME Y14.5-2009 standard. Many samples will be shown of the proper tolerancing of patterns of holes and pins that use each method. Examples and exercises will be provided to allow participants to practice several calculations. Learning these advanced techniques will permit better communication of part and assembly requirements between designers and manufacturers.

Learning Objectives
By connecting with this web seminar, participants will be able to:
• Explain composite positioning tolerancing
• Explain two single-segment tolerancing
• Apply the appropriate callout based on functional requirements
• Describe gages for each and calculate gage sizes

Who Should Attend
This advanced-level course is intended for designers, product engineers, manufacturing engineers, manufacturing personnel, and quality/gaging inspectors with a basic knowledge of GD&T concepts. It is a companion to the Advanced GD&T Competencies: Profile of a Surface and Advanced GD&T Competencies: Datum Usage web seminars - immediately following.

Prerequisites
For those new to GD&T, the Fundamentals of Geometric Dimensioning & Tolerancing web seminar is a recommended prerequisite. See course description on page 70.

Topical Outline
• Brief review of position and bonus tolerance
• Explanation of composite tolerancing
• The need to control orientation vs. location
• Adding secondary and tertiary datums to the lower tolerance
• Two single-segment position tolerancing
• Functional gaging and CMM gaging perspectives

Instructor: John-Paul Belanger
Fee $215 .15 CEUs

Advanced GD&T Competencies: Datum Usage Web Seminar and Web Seminar RePlay
1.5 Hours
Web Seminar: I.D.# WB1319
Web Seminar RePlay: I.D.# PD331319ON

While the basics of datums are covered in a standard Geometric Dimensioning & Tolerancing (GD&T) course, those discussions often overlook the variations that enable datums to be used in complex ways. This advanced course will detail the proper use of datums, showing their full potential to make your drawings as effective as possible. Most people who use GD&T are familiar with traditional datums derived from flat surfaces, and have adequate knowledge of the principle of establishing 3-2-1 contact points. In this web seminar, participants will learn to select, identify, simulate, and describe datums and datum features for special uses such as irregular shapes, flexible parts, and datum references that use the maximum material modifier. Also covered are several new modifiers and options given in the ASME Y14.5-2009 standard. Learning these advanced techniques will allow designers to better communicate certain requirements.
ENGINEERING TOOLS & METHODS

Learning Objectives
By connecting with this web seminar, participants will be able to:
• Explain the difference between a datum and a datum feature
• Select appropriate datums for irregularly shaped parts such as body or interior panels
• Properly simulate given datums
• Explain effects of a modified datum on a geometric tolerance
• Interpret new datum tools such as translation and custom degrees of freedom

Who Should Attend
This advanced-level course is intended for designers, product engineers, manufacturing engineers, manufacturing personnel, and quality/gaging inspectors with a basic knowledge of GD&T concepts. It is a companion to the Advanced GD&T Competencies: Composite Positioning and Advanced GD&T Competencies: Profile of a Surface Web Seminars. See course descriptions on previous page.

Prerequisites
For those new to GD&T, the Fundamentals of Geometric Dimensioning & Tolerancing Web Seminar is a recommended prerequisite. See the course description on page 70.

Topical Outline
• Brief review of traditional datum usage
• Selecting datums: surface vs. feature of size
• Use of the MMB modifier (formerly MMC)
• Using a pattern as a single datum
• The new translation modifier
• Applying the “M” modifier to a surface
• Customized degrees of freedom
• Irregular feature of size datums
• Moveable datum targets

Instructor: John-Paul Belanger
Fee $215 .15 CEUs

Advanced GD&T Competencies: Profile of a Surface Web Seminar and Web Seminar RePlay

1.5 Hours
Web Seminar I.D.# WB1320
Web Seminar RePlay: I.D.# PD331320ON

While the topic of profile is covered in a basic Geometric Dimensioning & Tolerancing (GD&T) course, those discussions often ignore the variations allowed with these symbols that enable them to be used in complex ways. This advanced web seminar will clarify the proper use of the profile tolerances in GD&T and uncover the nuances of these two symbols. Since profile of a surface is arguably the most powerful GD&T symbol, its full potential will be explored. It can be used to control size, form, orientation, and location and its relationship to datums can be varied. Learning these advanced techniques will allow designers to better communicate certain requirements. The examples given in this session will also illustrate several of the new options for profile that were introduced in the ASME Y14.5-2009 standard.

Learning Objectives
By connecting with this web seminar, participants will be able to:
• Explain when profile tolerances require a datum reference
• Determine which aspects of GD&T a given profile tolerance controls
• Interpret unilateral, bilateral, and nonuniform tolerances
• Describe how to properly measure profile tolerances

Who Should Attend
This advanced-level course is intended for designers, product engineers, manufacturing engineers, manufacturing personnel, and quality/gaging inspectors with a basic knowledge of GD&T concepts. It is a companion to the Advanced GD&T Competencies: Datum Usage and Advanced GD&T Competencies: Composite Positioning Web Seminars. See course descriptions on previous page.

Prerequisites
For those new to GD&T, the Fundamentals of Geometric Dimensioning & Tolerancing Web Seminar is a recommended prerequisite. See course description on page 70.
ENGINEERING TOOLS & METHODS

Topical Outline

• Review of profile of a surface and profile of a line
• Using profile without datums
• All around and all over
• Locating a profile zone with toleranced dimensions
• Using the MMB modifier with profile
• Composite profile
• The “U” modifier
• Nonuniform tolerancing

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<thead>
<tr>
<th>Instructor:</th>
<th>John-Paul Belanger</th>
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WE ARE PLEASED TO ANNOUNCE GD&T EDUCATION AND TRAINING AND REFERENCE RESOURCES FROM EFFECTIVE TRAINING INC. (ETI), AN SAE INTERNATIONAL COMPANY.

Getting where you need to go in your job.

A seasoned training company founded by globally recognized GD&T expert Alex Krulikowski, ETI offers an array of training products designed to train industry engineers at all levels of GD&T usage. High-quality learning products including classroom and digital courses, text books and reference guides, and job resources all meant to produce the world’s best GD&T practitioners. All ETI instructors are ASME certified and mentored by Alex Krulikowski.

Explore public workshops, on-site training, computer-based training, and other GD&T resources from ETI.

Course titles from ETI include:

- Engineering Drawing Requirements
- ASME Y14.5M-1994-2009 Comparison
- GD&T for Manufacturing (ASME Y14.5-2009)
- Functional Gaging and Measurement
- Critical Concepts of Tolerance Stacks
- Solid Model Tolerancing (ASME Y14.41)
- Introduction to Statistical Tolerance Stacks
- The GD&T Trainer: Fundamentals 2009

For more information or to arrange GD&T training or resources for your whole team, visit etinews.com or contact sales@etinews.com

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**Engineering Drawing Requirements**


1 Day  
I.D.# ET2701

Providing you have a basic understanding of engineering drawings, this course teaches how to correctly interpret engineering drawings. It will improve a student’s understanding of print reading and result in more effective communication on the job.

Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, the course focuses on practical application of print interpretation providing a better understanding of the view representation, dimensions, tolerances, and symbols used.

Each attendee receives a robust collection of learning resources.

**Learning Objectives**

By attending this class, participants will be able to:

- Describe the types of engineering drawings
- Recognize common drawing formats
- Explain line conventions and lettering used on drawings
- Recognize types of drawing views
- Recognize the section views on drawings
- Describe dimensioning and tolerancing practices on drawings
- Explain surface texture standards and symbols
- Describe how weld symbols are used on drawings
- Recognize the symbols and conventions used on electronic diagrams

**Who Should Attend**

This course is valuable for individuals who create or interpret engineering drawings, product and gage designers; process, product, and manufacturing engineers; supplier quality engineers/professionals; CMM operators; buyers/purchasers; checkers; inspectors; technicians; and sales engineers/professionals. Attendees should have a basic understanding of engineering drawings prior to enrollment.
ENGINEERING TOOLS & METHODS

Topical Outline

- Engineering Drawings
  - Engineering drawings
  - CAD
  - The purpose and importance of engineering drawings
  - Standards used on engineering drawings
  - Types of engineering drawings
  - Layout, detail, assembly, control, and diagram drawings
- Drawing Formats
  - Drawing sheet sizes
  - Drawing zones
  - Title and revisions blocks
  - Angle of projection
  - Engineering drawing units
  - Parts lists
  - General, local, and flag notes
  - Drawing scale
  - Multi-sheet drawings
- Line Conventions and Lettering
  - Line types on drawings
  - The functions represented by line types
  - Hierarchy of line types
  - Lettering
- Drawing Views
  - Orthographic projection
  - Projection systems
  - Single view and multiview drawings
  - Detail, auxiliary, and assembly views
- Section Views
  - Section views
  - Eight types of section views
  - Conventional vs. true geometry
  - Revolution of features
  - Sectioning of assemblies
- Dimensioning and Tolerancing
  - Practices for metric and English unit dimensions
  - Expressing tolerance
  - General tolerances
  - Definitions
  - Implied and coaxial relationships
  - General symbols and abbreviations
  - Thread, gear, and spline representation and specifications
  - GD&T standards and symbols
  - Uses of GD&T
- Surface Texture
  - Surface texture standards
  - Definition of surface texture
  - ASME surface texture symbols

- Weld Symbols
  - Weld specifications
  - Common weld types
  - Common weld joints
- Electric and Electronic Diagrams
  - Components on electrical and electronic diagrams
  - Cables and conduits on electrical and electronic diagrams
  - Wiring conventions and terminal conventions
  - The types of electrical and electronic diagrams

Instructor: This course is taught by one of ETI’s approved instructors, each of whom has been vetted and mentored by Alex Krulikowski

Fee: Contact ETI for pricing information

0.7 CEUs are offered for this course

Solid Model Tolerancing (Based on ASME Y14.41)

1 Day
I.D.# ET2501

Providing you have a basic understanding of Y14.5 Dimensioning and Tolerancing practices, this course explains the fundamental definitions, concepts, and methods from the ASME Y14.41 Standard on Digital Product Definition Data Practices.

Utilizing the expertise of world-renowned GD&T expert and former Chairman of the Y14.41 Committee, Alex Krulikowski, the course focuses on understanding the benefits of a math-based product development process.

Each attendee receives a robust collection of learning resources.

Learning Objectives

By attending this class, participants will be able to:
- Explain the benefits of a math-based product development process (PDP)
- Describe the history, basic information, and definitions from the Y14.41 standard
- Explain how to create product definition data sets
- Describe data set requirements
- List drawing model data set requirements
- Explain various requirements that apply to annotated model data sets
- List the requirements when using the annotated model method
- Recognize the gaps, issues, and challenges of implementing a math-based PDP
Who Should Attend

This course is valuable for designers, engineers, and managers who are considering implementation of a math-based product development process. Attendees should have a basic understanding of Y14.45 Dimensioning and Tolerancing practices.

Topical Outline

• The Product Development Process
  • The characteristics of current PDP’s
  • Problems with current PDP’s
  • What a math-based PDP is
  • The benefits of math-based PDP’s
  • The role of standards in implementing math-based PDP’s
• General Information on the ASME Y14.41 Standard
  • The history of the Y14.41 standard
  • Basic information about Y14.41
  • Y14.41 terms
• The Data Set Concept
  • The data set concept explained
  • Two methods in the standard for creating product definition data sets
• Common Requirements for Data Sets
  • Data set and design model requirements that apply to both the annotated model data set and drawing data set
  • Display management requirements
  • Reasons for model value query
  • Requirements for resolved, basic, and size dimensions
• Requirements for the Drawing Data Set Method
  • The data set requirements that apply to the drawing data set method
  • General method requirements for drawing data set method
  • The requirements for work coordinate systems in orthographic and axonometric views
  • The requirements for specifying section views, dimensions in axonometric views, datums, and geometric tolerances
• Requirements for the Annotated Model Method
  • The data requirements that apply to annotated model data sets
  • The design model requirements for the annotated model method
  • The requirements for views, annotation, query, and notes on annotated models
• Tolerancing Using the Annotated Model Method
  • The requirements for plus-minus tolerances
  • The requirements for datum applications
  • The requirements for displaying geometric tolerances
• Gaps, Issues, and Challenges of Implementing a Math-Based Development Process
  • The benefits of the Y14.41 standard
  • The major questions that companies need to answer to implement a math-based development process
  • The gaps and issues when trying to achieve a math-based product development process

Instructor: This course is taught by one of ETI’s approved instructors, each of whom has been vetted and mentored by Alex Krulikowski

Fee Contact ETI for pricing information .7 CEUS are offered for this course

Fundamentals of GD&T (Based on ASME Y14.5M-1994)

3 Days
I.D.# ET2001

This subject is offered in multiple course lengths.

Providing you have a basic understanding of mechanical drawings, this course teaches the terms, rules, symbols, and concepts of GD&T as prescribed in the ASME Y14.5M-1994 Standard. Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, the course offers an in-depth explanation of geometric symbols, including each symbol’s requirements, tolerance zones, and limitations. It also includes a comparison of GD&T to coordinate tolerancing; an explanation of tolerance zones; Rules #1 and #2; form and orientation controls; tolerance of position; runout and profile controls. Newly acquired learning is reinforced throughout the class with more than 300 practice problems.

Each attendee receives a robust collection of learning resources.

Learning Objectives

By attending this class, participants will be able to:
• Describe engineering drawings: importance, drawing conventions, dimensions and tolerances, standards
• Explain why geometric tolerancing is superior to coordinate tolerancing
• Describe the key terms used in geometric tolerancing
• Recognize the modifiers and symbols used in GD&T
• Explain the rules used in GD&T
• Describe the concepts of basic dimensions, worst-case boundary, virtual condition, inner and outer boundary, and bonus tolerance

Instructor: This course is taught by one of ETI’s approved instructors, each of whom has been vetted and mentored by Alex Krulikowski

Fee Contact ETI for pricing information .7 CEUS are offered for this course
• Interpret the various types of tolerances (flatness, straightness, circularity, cylindricity, perpendicularity, angularity, parallelism, position, concentricity, symmetry, runout, and profile)
• Describe the datum system
• Interpret applications of datum targets, feature of size datum specifications (RFS & MMC)
• Describe the fundamental concepts of tolerance of position
• Interpret tolerance of position special applications

Who Should Attend
This course is valuable for individuals who create or interpret engineering drawings, product and gage designers; process, product, and manufacturing engineers; supplier quality engineers/professionals; CMM operators; buyers/purchasers; checkers; inspectors; technicians; and sales engineers/professionals.

Attendees should have completed ETI’s Engineering Drawing Requirements course (I.D.# ET2701; page 74) or equivalent.

Topical Outline
• Introduction
  • Engineering drawings
  • GD&T/coordinate dimensioning comparison
  • Eight key GD&T terms
• Terminology
  • GD&T modifiers and symbols
  • Rule #1 and Rule #2
  • Basic dimensions, virtual condition, bonus tolerance
• Form Controls
  • Flatness
  • Straightness
  • Circularity
  • Cylindricity
• Datums
  • The datum system (planar datums)
  • Interpreting datum targets
  • Feature of size datum specifications (RFS)
  • Feature of size datum specifications (MMC)
• Orientation Controls
  • Perpendicularity
  • Angularity
  • Parallelism
• Tolerance of Position Controls
  • Definitions, conventions, advantages, basic theories
  • RFS and MMC tolerance of position applications
  • Cartoon gages for tolerance of position (MMC) applications
  • Tolerance of position special applications
  • Calculating distances on parts dimensioned with tolerance of position
  • Fixed and floating fastener formulas
• Concentricity / Symmetry Controls
  • Concentricity
  • Symmetry
• Runout Controls
  • Circular runout
  • Total runout
• Profile Controls
  • Profile tolerancing
  • Profile of a surface
  • Profile of a line

Instructor: This course is taught by one of ETI’s approved instructors, each of whom has been vetted and mentored by Alex Krulikowski

Fee Contact ETI for pricing information

2.0 CEUs are offered for this course

Fundamentals of GD&T for Inspectors (ASME Y14.5M-1994, Y14.5.1, and Y14.43 Standards)

2 Days
I.D.# ET2053

Providing you have a basic understanding of geometric dimensioning and tolerancing fundamentals, this course teaches an introduction to how to inspect GD&T requirements.

Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, this course offers an explanation of the geometric symbols, rules, and concepts, the datum system, and how to inspect GD&T requirements using tools from the four categories of inspection tools (CMM; comparison instruments and fixed gages; hand tools and open set up; and production gaging systems). Newly acquired learning is reinforced throughout the class with numerous practice problems. The scope of this course does not include how to use the various inspection tools. For example, the course will discuss how to locate a part for inspection on a CMM, but it will not cover how to program the CMM to gather the data point.

Each attendee receives a robust collection of learning resources.

Learning Objectives
By attending this class, participants will be able to:
• Describe inspection and engineering drawings
• Explain key terms used in GD&T and how they affect interpretation and inspection
• Recognize the modifiers and symbols used in geometric tolerancing
• Interpret and inspect Rule #1, Rule #2, flatness, straightness, circularity, cylindricity, perpendicularity, angularity, parallelism, concentricity, symmetry, circular and total runout
• Explain the concepts of basic dimensions, virtual condition, inner and outer boundary and bonus tolerance and their effects on inspection
• Interpret and simulate planar datums and datum targets for inspection
• Interpret and inspect feature of size datums RFS and MMC
• Explain the fundamental concepts of tolerance of position: definitions, conventions, advantages and interpretations and their effects on inspection
• Interpret and inspect tolerance of position RFS, MMC, and special applications
• Describe functional gages for tolerance of position (MMC) applications
• Explain profile tolerancing
• Interpret and inspect profile of a surface and profile of a line applications

Who Should Attend

This course is valuable for individuals who create or interpret engineering drawings, product and gage designers; process, product, and manufacturing engineers; supplier quality engineers/professionals; CMM operators; buyers/purchasers; checkers; inspectors; technicians; and sales engineers/professionals.

Attendees should have completed ETI’s Engineering Drawing Requirements course (I.D.# ET2701; page 74) or equivalent prior to enrollment.

Topical Outline

• Inspection
  • Quality parts and quality drawings
  • Inspection, importance, components, and the characteristics of an expert inspector
  • Sources of variation
  • Categories of inspection tools
• The Engineering Drawing
  • Engineering drawings, communication, and drawing errors
  • Dimension, tolerance, limit tolerance, plus-minus tolerance
  • Metric unit dimensions on drawings
  • Interpreting dimensional limits
  • ASME Y14.5M-1994 and the fundamental dimensioning rules
• Key Terms and Their Effect on Interpretation and Inspection
  • Feature, feature of size, cylindrical feature of size, planar feature of size
  • Actual local size, actual mating envelope of external and internal feature of size
  • Maximum and least material condition of a feature of size
  • Non-feature of size dimensions and regardless of feature size
• Modifiers and Symbols
  • Modifiers, geometric characteristic symbols, and controls
  • Radius and controlled radius
  • Feature control frame
• Interpreting and Inspecting Rule #1 and Rule #2
  • Rule #1, envelope boundary, size dimension, overriding, and exceptions
  • Rule #1 effects on the interrelationship between features of size
  • Inspecting a feature of size controlled by Rule #1
  • Rule #2
• Basic Concepts
  • Basic dimensions, virtual condition and uses in inspection
  • Inner, outer, worst-case boundary, and virtual condition of a feature of size
  • Geometric tolerance applied to feature or feature of size
  • Bonus tolerance calculations
  • MMC and LMC modifiers and inspection
• Interpreting and Inspecting Flatness
  • Flatness, flatness tolerance zone, location, and inspection
  • Rule #1 as an indirect flatness control
  • Legal flatness specification
  • Establishing a reference plane for flatness
• Interpreting and Inspecting Straightness
  • Straightness, straightness tolerance zone, and Rule #1 as indirect straightness control
  • Legal straightness specification
  • Inspecting straightness applied to a surface
  • Determining if a straightness control is applied to a surface or a feature of size
• Interpreting and Inspecting Cylindricity
  • Cylindricity, cylindricity tolerance zone, and inspection
  • Rule #1 as an indirect cylindricity control
  • Legal cylindricity specification
• Interpreting and Simulating Planar Datums for Inspection
  • True geometric counterpart, datum feature simulator, and simulated datum
  • Datum feature symbol, planar datums, datum reference frame
  • Choosing datum features and what controls their orientation
  • Six degrees of part freedom in space and the 3-2-1 Rule
  • Datum-related and non datum-related dimensions
  • Datum reference frame for a part with inclined datum features
  • Coplanar datum features and simulation for inspection

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Interpreting and Simulating Datum Targets for Inspection
- Datum targets, specification, requirements and the datum target symbol
- Basic dimensions used to locate datum targets
- Point, line, and area datum targets
- Simulated gage for a point, line, and area datum target applications
- Simulating datum targets for inspection

Interpreting and Inspecting Feature of Size Datums (RFS)
- Datum that results from a feature of size datum feature
- Specifying an axis or center plane as a datum
- How feature of size datum references communicate size condition
- Datum feature simulators and coaxial datum features

Interpreting and Inspecting Feature of Size Datums (MMC)
- Specifying an axis or center plane as a datum
- Datum that results from a feature of size datum feature
- How feature of size datum references communicate size condition
- Datum feature simulators and coaxial datum features

Interpreting and Inspecting Tolerance of Position RFS and MMC Applications
- Tolerance of position control, advantages, use of MMC modifier
- Implied basic relationships
- Virtual condition boundary and axis interpretation

Interpreting and Inspecting Perpendicularity
- Perpendicularity tolerance on implied right angles, tolerance zone shapes
- Perpendicularity of a surface and the surface flatness
- Multiple datum references with a perpendicularity control
- Perpendicularity of the axis centerXplane of a feature of size
- Perpendicularity control and worst-case boundary of a feature of size
- Gage for verifying perpendicularity at MMC
- Indirect perpendicularity controls, legal perpendicularity specification; inspection

Interpreting and Inspecting Angularity
- Angularity, tolerance zone, and inspection
- Angularity of a surface and the surface flatness
- Angularity control and the worst-case boundary of a feature of size
- Angularity of the axis centerXplane of a feature of size
- Indirect angularity controls, legal angularity specification

Interpreting and Inspecting Parallelism
- Controlling parallelism when no symbol is shown
- Parallelism, tolerance zone shapes, applied to a surface, and inspection
- Parallelism of a surface and the flatness of the surface
- Controlling the parallelism of the axis centerXplane of a feature of size
- Parallelism control and the worst-case boundary of a feature of size
- Tangent plane modifier with a parallelism control
- Indirect parallelism controls, legal parallelism specification
**Introduction to Statistical Tolerance Stacks**

1 Day  
I.D.# ET2055

Providing you have an understanding of tolerance stacks, this course teaches an introduction to statistical tolerance stacks, a crucial skill in today's competitive workplace. Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, the course includes a brief overview of several terms used in statistical stacks. It explains four methods for applying statistics to tolerance stacks and covers precautions about when and how to use statistics in stacks. Newly acquired learning is reinforced throughout the class with stacks that allow the student to practice applying statistical methods.

Each attendee receives a robust collection of learning resources.

**Learning Objectives**

By attending this class, participants will be able to:

- Define the terminology used with statistical tolerance stacks
- Describe common statistical tolerance stacks methods
- Calculate statistical tolerance stacks using the RSS method
- Calculate statistical tolerance stacks using the realistic method
- Apply the RPL method to statistical tolerance stacks
- Apply the Monte Carlo method to tolerance stacks
- Describe precautions needed when using statistical tolerance stacks

**Who Should Attend**

This course is valuable for individuals who create or interpret engineering drawings, product and gage designers; process, product, and manufacturing engineers; supplier quality engineers/professionals; CMM operators; buyers/purchasers; checkers; inspectors; technicians; and sales engineers/professionals.

Please be aware that this is not an introductory course. Students should have completed ETI's *Tolerance Stacks Using GD&T* course or equivalent prior to enrollment.

**Topical Outline**

- Importance of statistical stacks
  - The three assumptions that apply to Worst-case tolerance stacks
  - The two laws of probability that apply to statistical stacks
  - Two common probability distribution curves used in statistical stacks
  - The probability of an assembly of six parts with uniform distributions reaching extreme limits
  - The probability of an assembly of six parts with normal distributions reaching extreme limits

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**Instructor:** This course is taught by one of ETI’s approved instructors, each of whom has been vetted and mentored by Alex Krulikowski

**Fee**  
Contact ETI for pricing information  
1.3 CEUs are offered for this course
• Statistical stacks terminology
  • Statistics and data
  • Uniform and normal frequency distributions
  • Range, mean, and deviation
  • Variance and standard deviation
  • Specification limits
  • Standard normal curve and the Empirical Rule
  • A Z score and parts per million rejects
  • Control limits
  • How CP and CPK relate to a normal distribution
  • The difference between dependent and independent variables
• Common statistical tolerance stacks methods
  • What a statistical tolerance stack is
  • The Realistic Predicted Limits (RPL) method its assumptions
  • The Root Sum of Squares (RSS) method and its assumptions
  • The Motorola Six Sigma Root Sum of Squares method and its assumptions
  • The Motorola Six Sigma Dynamic Root Sum of Squares (DRSS) method and its assumptions
  • The Monte Carlo Simulation method and its assumptions
  • The formulas for and results of using the different statistical stack methods
  • Three benefits of statistical stacks
  • Two common reasons why statistical stacks are done
• The ETI statistical stack form
  • How to complete the ETI statistical stack form
  • The four stack consequences that must be considered when doing statistical stacks
• The RPL statistical stack method
  • The formula for calculating the RPL factor
  • A qualified dimension used in the RPL method
  • How to do the RPL method using the ETI statistical stacks form
  • The advantages and disadvantages of the RPL method
  • Calculating a statistical stacks using the RPL method
• The Six Sigma DRSS statistical method
  • The derivation of the standard RSS statistical stack formula
  • The seven steps in calculating a RSS statistical stack
  • Calculating a stack using the RSS method with a safety (Bender) factor applied
  • The Motorola Six Sigma RSS formula and its advantages
  • The Dynamic RSS (DRSS) formula and its advantages
  • The eight steps in calculating a DRSS statistical stack
  • How to do a DRSS stack using the ETI statistical stack form
  • How to interpret the stack results shown on the ETI statistical stack form
  • How to adjust a statistical stack to handle dependent variables (bonus & shift)
• Statistical stack results before and after adjusting for dependent variables
• The Monte Carlo statistical simulation method
  • Simulation and Monte Carlo simulation
  • The parameters used in a Monte Carlo simulation
  • List common distributions used in a Monte Carlo simulation stack
  • The minimum number of trials that should be used in a Monte Carlo simulation stack
  • Available software that can perform Monte Carlo simulations
  • How a Monte Carlo simulation works
  • How to do a Monte Carlo simulation using the ETI stack form with RiskAMP plug-in
• Statistical tolerance stacks precautions
  • The guidelines for determining when a statistical stack should be done
  • The seven assumptions of RSS statistical tolerance stacks
  • The four precautions to reduce risk of using statistical tolerance stacks
  • Why the ST symbol from Y14.5 should be used on a drawing that specifies statistical tolerances
  • How the ST is used on a drawing to indicated a tolerance is based on statistical methods
  • The benefits of using the ST symbol on product drawings
• DRSS and RPL statistical stack calculations
  • Calculating statistical tolerance stacks
  • Making adjustments for bonus and shift
  • Calculating a stack using the DRSS and RPL methods
  • Using CPK values in a statistical stack

Instructor: This course is taught by one of ETI’s approved instructors, each of whom has been vetted and mentored by Alex Krulikowski

Fee Contact ETI for pricing information .7 CEUS
Critical Concepts of Tolerance Stacks
(Based on Y14.5M-1994 & Y14.5-2009)

2 Days
I.D.# ETI701

This subject is offered in multiple course lengths.

This two-day course provides an in-depth explanation of how to use tolerance stacks to analyze product designs and how to use geometric tolerances in stacks. You will learn the essential methods and concepts used for creating 1D part and assembly tolerance stacks. The course was developed utilizing the expertise of world-renowned GD&T expert Alex Krulikowski and features numerous practice problems and in-depth coverage of tolerance stacks applications.

In order to understand the course content, students should have a good understanding of GD&T based on the ASME Y14.5-2009 Standard either through work experience or knowledge gained by participating in a course such as the ETI course Fundamentals of GD&T. Find the course information on page 91. Basic GD&T concepts will not be covered in this course.

Each attendee receives a robust collection of learning resources.

Learning Objectives

By attending this class, participants will be able to:
- Describe how virtual condition affects the assembly of parts
- Explain the importance of tolerance stacks and be familiar with stack methods, the stack form and the stack spreadsheet
- Calculate part stacks using coordinate dimensions, runout and concentricity tolerances, equal bilateral and unilateral profile tolerances, multiple geometric tolerances, position tolerances at RFS and MMC with datum references at MMB
- Calculate assembly stacks using coordinate dimensions, runout and concentricity tolerances, equal bilateral and unilateral profile tolerances, multiple geometric tolerances, position tolerances at MMC with datum references at MMB
- Calculate stacks using form and orientation applied to features and features of size

Who Should Attend

This course is valuable for individuals who create or interpret engineering drawings; product and gage designers; process, product, and manufacturing engineers; supplier quality engineers/professionals; CMM operators.

Topical Outline

- Introduction to Tolerance Stacks
  - Stack definition
  - Importance/purpose/benefits of stacks
  - When stacks should be calculated
- Introduction to 1D Stack Methods
  - Definition and stack conventions
  - Effects of rounding
  - Four basic stack steps
  - Virtual condition concepts, calculations, clearance/interference between mating part features
- ETI Stack Form and Spreadsheet
  - Major parts of the stack form
  - Stack abbreviations
  - Use and limitations of the spreadsheet
- Part Stacks Using:
  - Coordinate dimensions
  - Runout tolerances
  - Profile tolerances
  - Position tolerances at RFS
  - Position tolerances at MMC
  - Position tolerances at MMB - basics of datum shift
  - Position tolerances at MMB - datum shift exceptions
  - Multiple geometric tolerances
- Assembly Stacks Using:
  - Coordinate dimensions
  - Runout tolerances
  - Profile tolerances
  - Position tolerances at MMC/MMB
  - Form and orientation tolerances applied to surfaces and features of size
  - Multiple geometric tolerances
- Course Summary
  - The six critical concepts of tolerance stacks
  - Course assessment

Instructor: This course is taught by one of ETI’s approved instructors, each of whom has been vetted and mentored by Alex Krulikowski

Fee Contact ETI for pricing information
1.3 CEUs are offered for this course
GD&T for Manufacturing (ASME Y14.5-2009 Standard)

1 Day
I.D.# ET2726

Providing you have an understanding of GD&T fundamentals, this course teaches an introduction to geometric dimensioning and tolerancing and its impact on the manufacturing process.

Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, the course focuses on the basic requirements of engineering drawings, size dimensions, form tolerances, and the datum system, as well as the impact of tolerancing requirements on production.

Each attendee receives a robust collection of learning resources.

**Learning Objectives**

By attending this class, participants will be able to:

- Understand the basic facts about engineering drawings
- Recognize the types of dimensions and tolerances used on engineering drawings
- Explain the basic concepts and requirements of size dimensions
- Answer five basic questions for interpreting form tolerances
- Describe the basic concepts of the datum system and planar datums
- Describe the basic concepts of datum targets and size datums
- Answer five basic questions for interpreting orientation, position, runout, and profile of a surface tolerances
- Explain the purpose and limitations of in-process inspection methods
- Assess the GD&T on a typical drawing and determine the impact to manufacturing

**Who Should Attend**

This course is designed for product engineers, designers, checkers, and engineering managers, and supplier quality engineers. Attendees should have completed ETI’s *Engineering Drawing Requirements* course (I.D.# ET2701; pg 74) prior to enrollment.

**Topical Outline**

- Engineering Drawings
  - Engineering drawing purposes
  - Relationship between drawings and part function
  - Applicable standards on drawings
  - Why drawings are legal documents
  - Fundamental tolerancing rules
- Dimensions and Tolerances
  - Geometry attributes of a part
  - General dimensioning symbols
  - General notes, flag notes, and local notes
  - The 14 major GD&T symbols
  - The feature control frame
  - Basic dimensions
  - Implied specifications from assumptions
- Size Dimensions
  - Feature and feature of size
  - Maximum material condition (MMC)
  - Regardless of feature size (RFS)
  - Rule #1 and its effect on a size dimension
- Form Tolerances
  - Form deviations
  - Flatness, straightness, and circularity tolerances
  - How bonus tolerances affect part processing
  - Correctly specifying form tolerances
- Datum System and Planar Datums
  - The shortcomings of implied datums
  - The benefits of a datum system
  - Planar datums
- Datum Targets and Size Datums
  - Datum target symbols and applications
  - Datum targets establishing a datum reference frame
  - Terms used with size datums
  - Specifying an axis and a center plane as a datum
  - Recognizing when an MMB exists
  - Differences between MMB and RMB datum applications
- Orientation Tolerances
  - Interpreting perpendicularity and parallelism tolerances
  - Bonus tolerance effects on part processing
  - Correct specification of an orientation tolerance
- Position Tolerances
  - Interpreting a position tolerance of a feature of size
  - Recognizing when a bonus tolerance exists
  - Correct specification of position tolerance
- Runout Tolerances
  - Effects of a runout tolerance
  - Circular runout tolerance interpretation
  - Correct specification of a runout tolerance
- Profile of a Surface Tolerances
  - Effects of a profile of a surface tolerance
  - Basic requirements of a profile of surface tolerance
  - Profile of surface tolerance interpretation
  - Correct specification of a profile of a surface tolerance
- In-Process Inspection
  - The purpose of in-process and final inspection and their differences
  - Categories of inspection tools
  - Common in-process inspection tools
  - Limitations of in-process inspection
  - Tools capable of verifying certain applications
ENGINEERING TOOLS & METHODS

• Assessing GD&T on Your Drawings
  • Identifying and understanding items on a drawing:
  • Applicable standards
  • Names of geometric tolerances
  • Which symbols apply to a feature or a feature of size
  • MMC for each feature of size
  • Size of the Rule #1 boundary for the features of size
  • Datums indicated
  • Amount of bonus tolerance for the position tolerance
  • Which dimensions are related to a datum reference frame
  • If geometric tolerances are specified correctly
  • Answers to the five basic questions for interpreting geometric tolerances
  • In-process inspection methods that could be used

Learning Objectives
By attending this class, participants learn how to do a design functional analysis on an assembly and use this information to assign dimensions and tolerances. They will also learn how to select datum features and how to fully define component surfaces using GD&T. Establishing tolerance values is not covered. Small groups (8-12) are most effective in this workshop. The students will work in teams and actually create GD&T tolerance mark-ups of their company parts in the workshop.

By attending this class, participants will be able to:
• Describe the importance of technically correct drawings
• List three major areas that affect the creation and interpretation of technically correct drawings
• Explain the common approaches to part tolerancing
• Identify and specify datum features based on the fit and functional requirements of the part
• Use GD&T to communicate functional requirements of a component
• Describe how to specify nonfunctional dimensions
• Explain the five-step approach to functionally dimensioning a component
• Apply the five-step method to functionally dimensioning a component to your company product

Instructor:
This course is taught by one of ETI’s approved instructors, each of whom has been vetted and mentored by Alex Krulikowski

Fee
Contact ETI for pricing information
0.7 CEUs are offered for this course

Applications of GD&T (Based on ASME Y14.5M-1994 & Y14.5-2009)

2 Days
I.D.# ET2512

Providing you have an understanding of GD&T fundamentals, this course teaches the thought processes involved in assigning GD&T to components. It will change the way many engineers think about part tolerancing.

Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, the course focuses on what constitutes good and poor drawing practices, common dimensioning methods used in industry, using GD&T to communicate system functions on component dimensions, and the logic of how to apply GD&T to components. Newly acquired learning is reinforced when students perform a design function analysis on a part assembly provided by your company, then specify GD&T on assembly components during the course. (This is optional in case of concerns over drawings and privacy.)

Newly acquired learning is reinforced when students perform a design function analysis on a part assembly provided by your company, then specify GD&T on assembly components during the workshop. (This is optional in case of concerns over drawings and privacy.)

Attendees will receive a robust collection of learning resources.

Who Should Attend
This course is for product engineers, designers, checkers, and engineering managers, and supplier quality engineers.

Please be aware that this is not an introductory course. Attendees should have completed 16 hours of formalized classroom training in GD&T or ETI’s Fundamentals of GD&T course (I.D.# ET1150, page 91) experience interpreting or applying GD&T in an industrial setting, and working knowledge of the ASME Y14.5M-1994 Standard or ASME Y14.5-2009 Standard.

Topical Outline
• Importance of Technically Correct Drawings
  • Engineering drawings
  • Purpose of drawings
  • Three common paradigms about drawings
  • Effects of a poor drawing
  • Benefits of a technically correct drawing
• Three Areas that Affect the Creation and Interpretation of Engineering Drawings
  • Importance of standards
  • Three methods for creating drawings
  • How drawing creation affects interpretation
  • The six principles of dimensioning
• Four Common Approaches to Part Tolerancing
  • Pros and cons of each dimensioning approach
  • Dimensioning approach to be used in this class
• Selecting Datums
  • Why datum feature selection is controversial
  • Selecting datum features based on the functional approach
  • Mounting and performing datum features
  • Qualifying datum features
• Using GD&T to Communicate Functional Requirements
  • Where to use a linear or geometric tolerance
  • Customer robust and customer sensitive dimensions
  • Where to use MMC, LMC, and RFS
  • Converting functional requirements into GD&T specifications
• Specifying Nonfunctional Dimensions
  • What a nonfunctional dimension is
  • Risks of not tolerancing nonfunctional dimensions and using restrictive general tolerances
  • When to apply general or local tolerances
  • General tolerancing practices
  • Application requirements of general geometrical tolerances
  • Interpreting general tolerances
• Understand the 5-Step Method to Functionally Dimension a Component
  • The functional dimensioning design philosophy
  • Advantages of functional dimensioning
  • How functional dimensioning supports the PDP
  • The principles of dimensioning and technically correct drawings
• Applying the 5-Step Method to Functionally Dimension Components of a Customer’s Products
  • Review the functional dimensioning process and 5-step method
  • Review the DFA
  • Review when dimensioning compromises should be considered

| Instructor: | This course is taught by one of ETI's approved instructors, each of whom has been vetted and mentored by Alex Krulikowski |
| Fee | Contact ETI for pricing information |

1.3 CEUs are offered for this course

Functional Gaging and Measurement (ASME Y14.43, Y14.5, Y14.5.1, B89.3.1, B89.7.2, and B89.7.3 Standards)

2 Days  
I.D.# ET8200

Providing you have a basic understanding of geometric dimensioning and tolerancing fundamentals, this course is an introduction to functional gaging design and teaches how to verify part dimensional requirements using functional gages and other measurement methods.

Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, this course offers an explanation of metrology, the roles of the metrologist and inspector, measurement uncertainty, inspection tools, functional gages, inspection planning and reporting, and simulating datums.

The scope of this course does not include measurement systems analysis or sampling strategies.

Each attendee receives a robust collection of learning resources.

**Learning Objectives**

By attending this class, participants will be able to:
• Describe the functions of inspection in an organization
• Define what measurement uncertainty is.
• Explain the basic operating principles, strengths, and weaknesses of the three major categories of inspection tools
• List the types, uses, and tolerance methods for attribute gages
• Explain attribute gage design fundamentals
• Develop a measurement / inspection plan
• Describe the purpose and content of an inspection report
• Inspect and report size dimensions
• Describe the basic concepts of datums related to inspection
• Understand how to simulate datums for inspection
• Verify flatness, straightness, circularity, cylindricity, orientation, position, runout, profile of a surface, and profile of a line tolerance requirements

**Who Should Attend**

This course is a valuable tool for individuals who inspect parts, create inspection plans, or approve inspection methods. Typical attendees include CMM operators, inspectors, gage designers, manufacturing engineers, technicians, supplier quality engineers.
Prerequisites
Please be aware that this is not an introductory course. In order to understand the course content, you should have:
1. Completed 16 hours of formalized classroom training in GD&T
2. Experience interpreting or applying GD&T in an industrial setting
3. Have a working knowledge of the ASME Y14.5-2009 Standard
   A certificate from the GD&T Trainer: Fundamentals 2009 (page 96) or ETI’s
   Fundamentals of GD&T (I.D.# ET2001, page 76 ) course is acceptable.

Topical Outline
• Inspection in an Organization
  • Quality, the purpose and contents of a quality manual
  • Metrology and the roles of a metrologist
  • Importance and types of inspection, roles of inspector
• Introduction to Measurement Uncertainty
  • Terms, importance, and major contributors
  • Using calipers for size measurements
  • Type A, type B, combined, and expanded uncertainties
  • Measurement uncertainty standards and major contributors
  • Decision rule, requirements, and factors that affect the choice of a decision rule
  • Guard band, simple acceptance, and simple rejection
  • Pros and cons of measurement uncertainty decision rules
  • Uncertainty calculator software
• Three Major Categories of Inspection Equipment
  • Three categories, types, and pros and cons of inspection tools
  • Attribute and variables gages and data, operating principles
  • Common sources of attribute and variables gage errors
  • Operating principles of algorithmic measurement
  • Common sources of CMM errors
• Attribute Gaging Concepts
  • Supporting Y14.5 concepts, common types, uses
  • Basic concept of functional gages
  • Options for gaging tolerance policies
  • Y14.43 recommendations and cost effects
  • The five gagemakers’ tolerance classess
• Attribute Gaging Design Fundamentals
  • Design constraints of functional gages
  • Considerations for workpiece distortion during gaging
  • In-process, final acceptance, and referee gages
  • Calculating gage pin size using absolute, tolerant, and optimistic tolerancing policies
  • Gage tolerance accumulation
  • How RMB datum references affect gage design
• Benefits of RMB Datum Feature Simulation
• Permitted departure from MMC and LMC principles of a gage design
• Measurement / Inspection Plan
• Dimensional measurement plan (DMP) purposes, contents, and importance
• Eight inputs to a DMP
• Classification of dimensional characteristics
• Seven steps to creating a DMP
• Inspection Reporting
  • Inspection reports, requirements, standards for reporting
  • Common methods for indicating inspection numbers
  • Mark up a drawing to number the dimensions for inspection
  • Non-conformance report and contents
• Inspecting and Reporting Size Dimensions
  • Y14.5 requirements for a feature of size
  • Relationship between Rule #1 and a size dimension
  • Inspecting MMC size limits
  • Minimum CMM probe points
  • Rule #1 MMC boundary, actual local size inspection
  • Reporting MMC & LMC size inspection results
• Datums Related to Inspection
  • Y14.5 requirements
  • Effects of datum sequence on inspection
  • Y14.5.1 candidate datum set concept
• Simulating Datums for Inspection
  • Simulate datum planes using a fixture, datum reference frame with a functional fixture
  • Effects of datum reference frame simulation with a fixture on inspection
  • Simulating datum planes and a datum reference frame using a CMM
  • Simulating a datum axis (RMB) on a functional fixture and using a CMM
  • Simulating a datum axis (MMB) on a fixture
  • How a functional gage accounts for datum shift
  • How a CMM simulates datum shift (MMB)
• Verifying Flatness Tolerance Requirements
  • Y14.5 requirements
  • Applied to a surface: verification using variable and algorithmic measurement
  • At MMC: verification with attribute measurement
  • Dimensional measurement planning and inspection reporting
• Verifying Straightness Tolerance Requirements
  • Y14.5 requirements
  • Applied to a surface using variable and algorithmic measurement
  • Applied to a feature of size at MMC with attribute and variable measurement
  • Dimensional measurement planning and inspection
Advanced Concepts of GD&T (Based on ASME Y14.5M-1994)

3 days
I.D.# ET2011

This course is offered in a 2-day, 20-hour, and 3-day format.

Providing you have a basic understanding of geometric dimensioning and tolerancing fundamentals, this course teaches the advanced concepts of GD&T as prescribed in the ASME Y14.5M-1994 Standard.

Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, this course offers an in-depth explanation of advanced GD&T topics like composite tolerancing, tolerance analysis, datum selection, non-rigid part dimensioning, and many more key dimensioning topics, including the system approach for part dimensioning.

Each attendee receives a robust collection of learning resources.

Learning Objectives

By attending this class, participants will be able to:
• Explain the importance of product design and functional dimensioning
• Define the terms “feature” and “feature of size”
• Recognize which dimensioning standards apply to an engineering drawing
• Explain the fundamentals of drawing interpretation and how to handle substandard drawings
• Recognize the difference between a rigid and a flexible (non-rigid) part
• State the requirements for tolerancing parts measured in the restrained state
• Identify the two special considerations for datum usage on restrained (non-rigid parts
• Calculate advanced applications of form controls
• Describe uses, advantages, misconceptions, and common errors of the datum system
• List nine common datum feature types
• Describe advanced datum target concepts
• Explain how to specify / interpret specialized datum feature applications
• Describe modifier usage in tolerance of position applications
• Describe the effects of simultaneous and separate requirements with tolerance of position
• Explain composite position tolerancing and multiple single-segment position tolerancing

Instructor:
This course is taught by one of ETI’s approved instructors, each of whom has been vetted and mentored by Alex Krulikowski

Fee
Contact ETI for pricing information
1.3 CEUs are offered for this course

Catalog Key Classroom Live, Online On Demand Certificate ACTAR approved
ENGINEERING TOOLS & METHODS

- Interpret tolerance of position applications with a conical tolerance zone
- Explain composite profile tolerancing and multiple single-segment profile tolerancing
- Describe profile applications

Who Should Attend
This course is valuable for individuals who create or interpret engineering drawings, product and gage designers; process, product, and manufacturing engineers; supplier quality engineers/professionals; CMM operators; buyers/purchasers; checkers; inspectors; technicians; and sales engineers/professionals.

Please be aware that this is not an introductory course. In order to understand the course content, attendees should have completed ETI’s GD&T Fundamentals course (I.D.# ET2001, page 76) or equivalent.

Topical Outline (3-day format)
- GD&T Fundamentals Review
  - GD&T skills survey
  - GD&T fundamentals for further study
- Importance of Product Design
  - Product design effects on costs
  - Consequences of drawing errors
  - Advantages of GD&T
- Functional Dimensioning
  - The purpose of tolerances
  - The importance of specifying proper tolerances
  - The importance of a common tolerancing approach
  - Tolerancing principles and benefits
- Interpretation of Feature
  - The terms “element,” “gap,” and “interruption”
  - Y14.5 definition of feature and types
  - Regular, element, complex, and interrupted feature; sub-feature
- Interpretation of Feature of Size
  - The terms “opposed,” “fully opposed,” “partially opposed, “size dimension,” and “cylindrical”
  - Importance of distinguishing between a feature and feature of size
  - The definition of feature of size from Y14.5
  - Requirements and categories of a feature of size
  - Identifying and interpreting a complete, interrupted, partial, and bounded feature of size
- Applicable Drawing Standards
  - Determining on which standards an engineering drawing is based
  - Clarifying a drawing when no dimensioning standard is referenced
  - Reducing confusion on dimensioning standards
- Drawing Interpretation
  - Interpreting an engineering drawing
  - Drawing title block, revision column, general drawing notes
  - Fundamental rules that affect drawing interpretation
  - Surface coating and heat treat
  - Geometric controls and a valid datum system
  - Misconceptions on measuring parts that use the datum system
  - Controlling characteristics for each part feature
  - Proper uses for coordinate tolerancing
  - Specification / interpretation
- Using Substandard Drawings
  - Categories of substandard drawing specifications
  - Steps for dealing with substandard drawings
  - Things not to do when using a substandard drawing
- Rigid/Non-Rigid Parts Definitions
  - Free state
  - Restrained state
  - Rigid part
  - Non-rigid part and part feature
- Tolerancing Non-Rigid Parts
  - Tolerancing a non-rigid (restrained) part
  - Roles of a restraint note
  - Determining restraining conditions on non-rigid parts
  - Requirements that need to be addressed in a restraint note
  - The difference between a general note and a local restraint note
  - When a free state symbol should be used
  - Areas that need special attention when inspecting a non-rigid part
- Restrained Part Datum Usage
  - How to use datum targets to support, orient, and locate a restrained part in the datum reference frame
  - How datum shift occurs on a restrained part
- Form Controls
  - Calculating the flatness tolerance value for a gasketed joint application
  - Calculating the cylindricity tolerance value in a support application
  - Calculating the straightness tolerance value in an assembly application
  - Overriding Rule #1 to limit flatness on a thin part
- The Datum System
  - When to use the datum system
  - Advantages of the datum system
  - Common misconceptions about the datum system
  - Common errors in datum usage
- Datum Feature Types
  - Common datum feature types
  - When each datum feature type is typically used
  - Degrees of freedom restrained when each datum feature type is used
• The datum feature simulator for the datum features referenced in a geometric tolerance
• Datum Targets
  • Reducing the impact that using datum targets has on functional dimensioning
  • Application requirements
  • Applications where datum targets should be used
  • Specifying fixed and movable datum targets
  • Special datum target types
  • Dimensioning a simulated gage for datum target applications
• Specialized Datum Applications
  • Specifying a screw thread as a datum feature and interpreting application
  • Specifying a gear or spline feature as a datum feature and interpreting application
  • Temporary and permanent datum features
  • Major disadvantage of temporary datum features
• Tolerance of Position Usage
  • When to use a tolerance of position control
  • Loss function curve, customer robust dimension, and customer sensitive dimension
  • Tolerance of position control and material condition used
• Simultaneous and Separate Requirements
  • Simultaneous and separate requirements, effects and where they apply
  • Tolerance of position at MMC simultaneous requirement
  • Tolerance of position controls as separate requirements
  • One exception to the simultaneous requirement
• Composite Position Tolerancing
  • Rules, advantages, and when to use it
  • “FRITZ” and “PLTZF”
  • Tolerance of position composite application
• Multiple Single-Segment Tolerance of Position Tolerancing
  • Rules, advantages, and when to use it
  • Tolerance of position vs. composite tolerance of position
• Conical Tolerance Zones
  • A conical tolerance zone and advantage of use
  • Specifying a conical tolerance zone in a tolerance of position application
  • When to use tolerance of position with a conical tolerance zone
• Profile Tolerances
  • Myths about profile controls
  • When to use a profile control
  • The four characteristics profile can control
  • Converting coordinate tolerances into profile callouts
  • The profile datum rule
• Profile and Simultaneous Requirements
  • Simultaneous requirement applied to profile
  • Profile controls with separate requirements

ISO Geometrical Tolerancing (Based on ISO 1101:2004 and related standards)

3 Days
I.D.# ET7100

This subject is offered in a 2, 3, or 4-day format. Contact ETI to determine which course length best suits your specific need.

Providing you have a basic understanding of mechanical drawings, this course teaches how to use engineering drawings that use the International Standards Organization (ISO) standards. Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, this course teaches proper recognition of requirements for standard-compliant drawings and geometrical tolerances based on the ISO standards. The course combines information from dozens of ISO standards into a logical understandable topic.

Each attendee receives a robust collection of learning resources.

Learning Objectives

By attending this class, participants will be able to:
• Describe the ISO standards system on technical drawings
• Recognize ISO drawing practices
• Explain the structure of GPS and the domains of features
• Recognize the symbols used in geometrical tolerancing
• Describe linear size and size conditions
• Explain the principle of independency and the envelope requirement
• Explain geometrical tolerancing concepts: MMR, LMR, RPR, virtual conditions, and collective requirements
• Describe the ISO 286 system of limits and fits
• Describe the datum system (planar datums)
• Interpret datum target and size datum specifications
ENGINEERING TOOLS & METHODS

- Interpret the flatness, straightness, roundness, cylindricity, perpendicularity, angularity, and parallelism tolerances
- Explain the fundamental concepts of position tolerances
- Interpret the position tolerance at MMR and special applications
- Interpret the coaxiality, concentricity, symmetry, circular and total run-out tolerances
- Interpret the profile any surface and profile any line tolerances
- Explain the ISO system for general tolerances
- Interpret work piece edge specifications
- Interpret surface texture and surface imperfection requirements

Who Should Attend
This course is valuable for individuals who create or interpret engineering drawings, product and gage designers; process, product, and manufacturing engineers; supplier quality engineers/professionals; CMM operators; buyers/purchasers; checkers; inspectors; technicians; and sales engineers/professionals.

Attendees should have completed ETI’s Engineering Drawing Requirements course (I.D.# ET2701; page 74) or equivalent prior to enrollment.

Topical Outline
- ISO Standards and Drawing Conventions
  - The ISO standards system used on technical drawings
  - ISO drawing practices
- GPS Basics
  - Modifiers and symbols used in geometrical tolerancing
  - Fundamental ISO geometrical tolerancing concepts
  - Feature types and levels
  - Linear size and material conditions
  - Independence and envelope principles
  - Key geometrical tolerancing concepts: maximum, least, and reciprocity requirement; virtual condition; bonus tolerance
- Limits and Fits
  - The ISO 286 system of limits and fits
- The Datum System
  - The datum system (planar datums)
  - Datum target specifications
  - Datum specifications
- Form Controls
  - Flatness
  - Straightness
  - Roundness
  - Cylindricity
- Orientation Controls
  - Perpendicularity
  - Angularity
  - Parallelism
- Location Controls
  - Position
  - Position tolerance RFS, MMR, and LMR
  - Concentricity
  - Symmetry
- Location Controls
  - Circular run-out
  - Total run-out
  - Profile tolerance
  - Profile any surface tolerance
  - Profile any line tolerance
- General Tolerances
  - ISO system for general tolerances for linear and angular dimensions
  - ISO system for general tolerances for geometrical tolerances (ISO 2768-2)
- Workpiece Edges
  - Interpret workpiece edge specifications
- Surface Texture and Surface Imperfections
  - Surface texture and surface imperfection requirements
- ISO/ASME Comparison
  - Major differences between the tolerancing standards

Instructor: This course is taught by one of ETI’s approved instructors, each of whom has been vetted and mentored by Alex Krulikowski

Fee Contact ETI for pricing information
CEUs vary based on course length

ASME Y14.5 1994-2009 Comparison
1 Day
I.D.# ET8000

Providing you have a basic understanding of geometric dimensioning and tolerancing fundamentals, this course teaches the significant revisions, additions, and deletions prescribed in the new ASME Y14.5-2009 Standard. Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, the course offers an in-depth cross-examination and comparison of features in the 2009 and 1994 ASME Standards.

The one-day ASME Y14.5 1994-2009 Comparison course will teach you about the pertinent changes made to the Y14.5 standard. You’ll learn how the subject matter has been reorganized, and about new sections that have been created for profile, orientation, and form.
Newly acquired learning is reinforced throughout the class with numerous practice problems, and a set of comprehensive comparison charts that highlight itemized changes in the standard are included in the course price. Each attendee receives a robust collection of learning resources.

**Learning Objectives**
By attending this class, participants will be able to:
- Recognize forty new or revised terms
- Explain the revisions and additions to the fundamental rules
- Describe twelve new or revised modifying symbols
- Recognize the revisions and new symbols for datum specifications
- Describe new geometric symbols and specifications
- Describe the revisions and new additions to 3D digital data sets
- Summarize the major changes in the standard
- Describe considerations for implementing the new standard

**Who Should Attend**
This course is valuable for individuals who create or interpret engineering drawings, product and gage designers; process, product, and manufacturing engineers; supplier quality engineers/professionals; CMM operators; buyers/purchasers; checkers; inspectors; technicians; and sales engineers/professionals. Attendees must have a basic understanding of Y14.5M-1994 Dimensioning and Tolerancing practices.

**Topical Outline**
- 24 revised terms in ASME Y14.5-2009
- 16 new terms in ASME Y14.5-2009
- Revised and new modifying symbols
- The datum system
- Revisions to geometric symbols
- 3-D digital data sets
- Summary of major changes
- Implementing a new standard

**Fundamentals of GD&T (Based on ASME Y14.5-2009)**

2 Days  
I.D.# ET1150

This course is offered in multiple length formats. Contact Effective Training Inc to determine which course length best suits your specific need.

Providing you have a basic understanding of mechanical drawings, this course teaches the terms, rules, symbols, and concepts of GD&T as prescribed in the ASME Y14.5-2009 Standard.

Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, Fundamentals of GD&T offers an in-depth explanation of geometric tolerancing symbols, their tolerance zones, applicable modifiers, common applications, and limitations.

The class includes a comparison of GD&T to coordinate tolerancing; Rules #1 and #2; form and orientation controls; tolerance of position; runout and profile controls.

**Learning Objectives**
By attending this class, participants will be able to:
- Explain the importance of standards on engineering drawings
- Describe the types of dimensions, tolerances, and notes
- Explain why geometric tolerancing is superior to coordinate tolerancing
- Interpret the general dimensioning symbols
- Define the key terms used in GD&T
- Recognize the symbols and modifiers used in GD&T
- Explain the rules used in GD&T
- Describe the concepts of worst-case boundary, virtual condition, and bonus tolerance
- Interpret the various types of tolerance (flatness, circularity, cylindricity, straightness, perpendicularity, parallelism, angularity, position, runout, and profile)
- Describe the datum system
- Interpret applications of datum targets, size datum features (RMB), and size datum features (MMB)

**Who Should Attend**
This course is valuable for individuals who create or interpret engineering drawings, product and gage designers; process, product, and manufacturing engineers; supplier quality engineers/professionals; CMM operators; buyers/purchasers; checkers; inspectors; technicians; and sales engineers/professionals. Attendees should have completed ETI’s Engineering Drawing Requirements course (I.D.# ET2701; page 74) or equivalent prior to enrollment.
ENGINEERING TOOLS & METHODS

Topical Outline

• Introduction
  • GD&T importance, six components
  • CARE test and Significant Seven test
  • Real-world applications

• Dimensions, Tolerances, & Notes Used on Drawings
  • Metric unit conventions
  • Dimensions, tolerances, basic dimensions
  • Interpreting dimensional limits

• Key Terms Used in GD&T
  • Size and actual local size
  • Feature, feature of size, regular and irregular features of size
  • Least and maximum material condition
  • Related and unrelated actual mating envelope
  • MMC, LMC, RFS
  • Specifying a pattern on a drawing

• GD&T Symbols & Modifiers
  • Geometric characteristic symbols
  • Five categories, five geometric attributes, twenty-one geometric modifying symbols
  • Feature control frame and placement
  • Continuous feature modifier effects on a feature and feature of size

• GD&T Rules
  • Sixteen fundamental dimensioning rules
  • Rule #1, applied to a feature of size, exceptions, overriding, inspecting
  • Independence concept, Rule #2, GO/NOGO gage

• GD&T Concepts
  • Virtual condition, calculations, and worst-case boundary
  • Bonus tolerance concept and calculations
  • Verification principles for a virtual condition boundary

• Flatness Tolerance
  • Derived median plane, tolerance zones
  • Rule #1 as a flatness control
  • Applied to a planar surface and feature of size
  • Bonus tolerance (at MMC)
  • Interpreting flatness tolerances using the Significant Seven Questions
  • Real-world applications, CARE test

• Straightness Tolerance
  • Derived median line, tolerance zones
  • Rule #1 effects
  • Standard-compliant specification
  • Applied to a surface and a feature of size
  • Bonus tolerance (at MMC)
  • Interpreting straightness tolerances using the Significant Seven Questions
  • Real-world applications, CARE test

• Circularity Tolerance
  • Tolerance zones
  • Rule #1 effects
  • Standard-compliant specification
  • Interpreting circularity tolerances using the Significant Seven Questions
  • Real-world applications, CARE test

• The Datum System
  • Implied datums, benefits, terminology
  • Datum reference frame and symbol
  • Six degrees of freedom
  • Coplanar datum features
  • Multiple datum reference frames
  • Datum-related dimensions

• Datum Targets
  • The datum target symbols, usage, requirements
  • Point datum target, line datum target, datum target simulators, movable datum targets
  • Datum target applications

• Size Datum Features: RMB
  • Terms, methods to specify a feature of size as a datum feature
  • Effects of a datum feature (RMB)
  • Coaxial datum features of size, datum feature simulator for coaxial datum features of size (RMB)

• Size Datum Features: MMB
  • Maximum material boundary (MMB) and effects
  • Datum shift, datum sequence, datum feature simulators
  • Using a hole pattern as a datum feature

• Perpendicularity Tolerance
  • Implied 90° angles
  • Perpendicularity and perpendicularity tolerance
  • Common tolerance zones
  • Indirect perpendicularity tolerances
  • Modifiers used with perpendicularity tolerance
  • Interpreting a perpendicularity tolerance using the Significant Seven Questions
  • Real-world applications, inspection methods, CARE test

• Parallelism Tolerance
  • Implied parallel relationships
  • Parallelism and common tolerance zones, indirect parallelism controls
  • Modifiers used with parallelism tolerances
  • Interpreting a parallelism tolerance using the Significant Seven Questions,
  • Real-world applications, CARE test

• Position Tolerance Introduction
  • True position and common tolerance zones
  • Implied relationships and advantages
  • Surface and axis interpretations
  • Real-world applications, CARE test

3 ways to get a no-obligation price quote to bring a course to your company • Call SAE Corporate Learning at +1.724.772.8529
• Fill out the online quote request at sae.org/corplearning • Email us at Corplearn@sae.org

1 Day
I.D.# ET2025

Providing you have a basic understanding of Y14.5 Dimensioning and Tolerancing practices, this course explains the major differences between the ASME and ISO standards in a concise, easily understood manner. Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, the course focuses on how the standards compare when dealing with symbols, feature control frames, tolerances, form controls, datums, and more. Newly acquired learning is reinforced throughout the class with numerous practice problems.

Each attendee receives a robust collection of learning resources.

Learning Objectives
By attending this class, participants will be able to:
• Explain how ASME and ISO standards are developed
• Recognize the advantages and cautions of using ASME and ISO standards
• List the major differences in technical drawing presentation
• Recognize the major differences between ASME and ISO geometric tolerancing terms and symbols
• Recognize the major differences between ASME and ISO datum systems
• Identify the differences in ASME and ISO drawings

Who Should Attend
This course is valuable for individuals who work with ISO standards on drawings, designers, engineers, inspectors, and machinists. All attendees should have a basic understanding of Y14.5 Dimensioning and Tolerancing practices prior to enrolling in this course.

Topical Outline
• Standards and Technical Drawings
  • Importance of standards
  • ASME and ISO organizations
  • Stages of standard development
  • Major differences in scope of standards
• Advantages and Cautions
  • Why each standard should be used
  • ISO GPS concept
  • Three domains of ISO specifications
  • Comparing ASME and ISO GPS systems
  • Five cautions when using ASME standards
  • Six cautions when using ISO standards
• Technical Drawing Presentation Differences
  • Technical drawing standards
  • Items that are the same in both standards
  • View projection methods
  • Dimensioning termination and presentation methods
  • Dimensioning symbols
  • Angular tolerance interpretation
  • Workpiece edge requirements and general tolerance specification
  • Size dimensions and limits and fits expressions
  • Surface texture is specification
• Tolerancing Term Differences
  • Feature and feature of size
  • Envelope requirement and independency principle
  • Eight major terms
  • Bonus tolerance and collective requirement
• Datum System Differences
  • Datum specifications
  • Datum interpretations
  • Candidate and single solution datums
  • Datum target specifications
• Geometric Tolerancing Symbol Differences
  • Specification / use for each geometric tolerance symbol
  • Interpretation for each geometrical tolerance
  • Specification / use for modifiers and symbols
ENGINEERING TOOLS & METHODS

• ASME and ISO Drawing Differences
  • Applicable standards
  • Drawing symbol differences
  • Geometrical tolerance specification and interpretation differences

Instructor: This course is taught by one of ETI’s approved instructors, each of whom has been vetted and mentored by Alex Krulikowski

Fee Contact ETI for pricing information .7 CEUs are offered for this course

TOPICS INCLUDE:
• Form
• Orientation
• Runout, Concentricity, Symmetry
• Key GD&T Terms, Rules, & Concepts
• Datum System
• Position
• Profile
• Position, profile, and datums

THIS BOOK IS A VALUABLE TOOL FOR:
• Designers
• Product, Manufacturing, and Quality Engineers
• CMM Operators
• Checkers

SKILL LEVEL
A basic understanding of engineering drawings is required.

ISBN: 978-1111129828
448 pp.
Paperbound 2013
$133.00 List
Product Code PD021101

Fundamentals of Geometric Dimensioning and Tolerancing Using Critical Thinking Skills
(based on ASME Y14.5-2009)
3rd Edition
By Alex Krulikowski

A unique book that meets the needs of readers studying industrial technology, CAD, engineering technology, or manufacturing technology. This book clearly organizes geometric dimensioning and tolerancing fundamentals into small, logical units for step-by-step understanding. Measurable performance objectives help readers assess their progress. Discussion questions promote interaction and higher-order thinking, and practice problems ensure thorough understanding of the concepts presented. Fundamentals of Geometric Dimensioning and Tolerancing (2009) 3rd Edition defines and fully encompasses the ASME Y14.5-2009 Standard to keep readers current on these important industry standards.

Fundamentals of Geometric Dimensioning and Tolerancing
(based on ASME Y14.5M-1994)
2nd Edition
By Alex Krulikowski

CHAPTER GOALS INCLUDE:

• Understand why geometric tolerancing is superior to coordinate tolerancing
• Understand eight key terms and how they affect the interpretation of a drawing
• Understand the modifiers and symbols used in geometric tolerancing
• Understand Rule #1 and Rule #2
• Understand the concepts of basic dimensions, virtual condition, inner and outer boundary, worst-case boundary, and bonus tolerance
• Interpret: flatness; straightness; circularity; & cylindricity
• Understand the datum system (planar datums)
• Interpret datum targets
• Interpret feature of size datum specifications (RFS)
• Interpret feature of size datum specifications (MMC)
• Interpret the perpendicularity control
• Understand the concepts of basic dimensions, virtual condition, inner and outer boundary, worst-case boundary, and bonus tolerance
• Interpret flatness; straightness; circularity; & cylindricity
• Understand the datum system (planar datums)
• Interpret datum targets
• Interpret feature of size datum specifications (RFS)
• Interpret feature of size datum specifications (MMC)
• Interpret the perpendicularity control
• Understand the fundamental concepts of tolerance of position: the definition and conventions, the advantages, and the basic theories
• Interpret RFS and MMC tolerance of position applications
• Draw cartoon gages for tolerance of position (MMC) applications
• Interpret tolerance of position special applications
• Calculate distances on a part dimensioned with tolerance of position
• Calculate tolerance of position tolerance values using the fixed and floating fastener formulas
• Interpret the: concentricity control; symmetry control; circular runout control; total runout control
• Understand profile tolerancing
• Interpret the profile of a surface control & line control

THIS BOOK IS A VALUABLE TOOL FOR:

• Designers
• Product, Manufacturing, and Quality Engineers
• CMM Operators
• Checkers

SKILL LEVEL
A basic understanding of engineering drawings is required.

Critical Concepts of Tolerance Stacks
Material Set
(Applicable to ASME Y14.5-2009 and ASME Y14.5M-1994 Standards)

Proficiency in tolerance accumulation studies (also referred to as stacks) separates the exceptional engineers from the rest. More than simply the study of dimensional relationships within assemblies, tolerance stacks are the key to creating robust, efficient, and successful designs. Use stacks to create designs that maximize fit, function, and return on investment. Optimize part tolerances for design function and manufacturing processes.

MATERIALS SET INCLUDES*:

• A copy of Critical Concepts of Tolerance Stacks Course Book (applicable to ASME Y14.5-2009 and ASME Y14.5M-1994 Standards)
• Tolerance Stacks Exercise Workbook
• A Tolerance Stacks Drawing Package
• A Tolerance Stacks Summary Charts (ASME Y14.5-2009 and ASME Y14.5M-1994)
• An Excel tolerance stack spreadsheet template – electronic delivery

*Materials in this set are not available for individual sale.

MATERIALS ADDRESS:

• Step-by-step approach to a 1D two-column stack methodology
  • Over 60 performance objectives
  • Applicable to both part and assembly stacks
  • Mathematically based to account for all tolerance variation
  • Correctly apply
    • Coordinate tolerances
    • Geometric tolerances
    • Bonus tolerancing
    • Datum feature shift
  • Exercises to test your knowledge
    • Over 35 stack exercises

SKILL LEVEL
Students must have a good understanding of GD&T based on the ASME Y14.5-2009 or ASME Y14.5M-1994 Standards either through work experience or knowledge gained by participating in a course such as the ETI Fundamentals of GD&T 3-Day Workshop. Basic GD&T concepts are not covered in the material.

$175.00 List
Product Code PD021701
Advanced Concepts of Geometric Dimensioning and Tolerancing
(based on ASME Y14.5M-1994)
2nd Edition
By Alex Krulikowski

This reference book stresses the application of GD&T in today’s industrial workplace, and it’s the perfect resource to expand and deepen your understanding of GD&T. Advanced Concepts of Geometric Dimensioning and Tolerancing includes examples and explanations of tolerancing concepts that are often problematic in real world applications. This must-have text features 26 chapters that cover a broad range of tolerancing practices common in industry, but not well documented in national standards. The text includes 50 exercises with over 250 problems designed to reinforce the material.

TOPICS INCLUDE:
• Tolerancing non-rigid parts
• Position, profile, and datums
• Functional dimensioning
• Drawing interpretation
• Advantages and misconceptions of the datum system
• Relating tolerance applications to a loss function curve
• Tolerancing of threaded holes
• Composite position tolerancing
• Profile applications

THIS BOOK IS A VALUABLE TOOL FOR:
• Designers
• Product, Manufacturing, and Quality Engineers
• CMM Operators
• Checkers

SKILL LEVEL
It is intended for those who have mastered the fundamental concepts of GD&T and are ready to take this knowledge into a more applications-oriented setting.

ISBN: 0-924520-25-6
360 pp.
Spiral Bound 2007
$83.50 List
Product Code PD024016

The GD&T Trainer: Fundamentals 2009
(based on ASME Y14.5-2009) Computer-Based Training

The GD&T Trainer: Fundamentals 2009 is a comprehensive training program consisting of 29 lessons covering basic rules, definitions, and concepts of GD&T. This software package contains newly updated course administration tools with enhanced student progress tracking capabilities as well as:
• Student/course records storage
• Learning assessments
• 2,000 student maximum capacity
• Simultaneous record access for multiple administrators
• Report generator to track student and course progression
• Password protection for student records
• And much more.

The GD&T Trainer can be used as:
• A complete course in GD&T, with quizzes, final exam, and certificate of completion
• A geometric tolerancing seminar
• A supplement or review for live training
• An internal GD&T certification
• An on-the-job reference

SKILL LEVEL
Users should have completed ETI’s Engineering Drawing Requirements course or use drawings regularly on the job.

VERSIONS
This course is available in various platforms to team member or the entire team:
• Corporate—unlimited learners in multiple locations
• Single Site—preset number of learners or unlimited learners in a single location
• Multi-user or Single-user on a stand-alone PC

SYSTEM REQUIREMENTS
• Pentium 4-based computer with a 2GHz or higher CPU
• 512 MB RAM minimum, 1024 MB or higher recommended
• 500 MB or more of free hard drive space
• Sound card with speakers
• Video card capable of displaying 24-bit color at a resolution of 1024x768
• Windows 7/8
• Adobe Flash Player 13.0 or higher
• Visual Basic 6 Runtime (Admin and Reporter only)
• .NET Framework 2.0

Contact ETI to determine the version that best fits your training need.
Product Code PD021249
The GD&T Trainer: Fundamentals 1994  
*(based on ASME Y14.5M-1994) Computer-Based Training*

The GD&T Trainer: Fundamentals 1994 is a comprehensive training program consisting of 28 lessons covering basic rules, definitions, and concepts of GD&T. This software package features newly updated administration tools for tracking student progress as well as:

- Student course record storage
- Learning assessments
- Up to 2,000 student capacity
- Simultaneous records access for multiple administrators
- Report generator and database access to track student progress
- Password protection for student records
- And much more.

The GD&T Trainer can be used as:

- A complete course in GD&T, with quizzes, final exam, and certificate of completion
- A geometric tolerancing seminar
- A supplement or review for live training
- An internal GD&T certification
- An on-the-job reference

**SKILL LEVEL**

Users should have completed ETI’s Engineering Drawing Requirements course or use drawings regularly on the job.

**VERSIONS**

This course is available in various platforms to team member or the entire team:

- Corporate—unlimited learners in multiple locations
- Single Site—preset number of learners or unlimited learners in a single location
- Multi-user or Single-user on a stand-alone PC

**SYSTEM REQUIREMENTS**

- Pentium III-based computer with a 1GHz or higher CPU
- 256 MB RAM minimum/512 MB or higher recommended
- 1 GB minimum of free hard drive space
- Sound card with speakers
- Video card capable of displaying 24-bit color at a resolution of 1024x768
- Windows XP (SP2)/XP/64-bit/Vista/7
- Adobe Flash Player 10.0 or higher

- Visual Basic 6 Runtime (Admin and Reporter only)
- .NET Framework 2.0
- NOTE: Windows 3.x/98/ME/2000 are not supported

**ISO GPS Quick Reference**  

The ISO GPS Quick Reference software is a valuable on-the-job resource for locating technical drawing information without navigating through multiple standards. The ISO GPS Quick Reference software covers more than 250 related topics with full-color drawings and illustrations, and user-friendly navigation for easy transition between topics. The software covers the most common aspects of product design. It was created by GD&T expert Alex Krulikowski, member of ISO/TC 213-US Technical Advisory Group.

The program is based on four major ISO GPS standards:

- ISO 8015:1985
- ISO 1101: 2004
- ISO 2768-1: 1989
- plus more than 40 related standards.

**REFERENCE HIGHLIGHTS**

- Explanations of more than 250 topics cover all aspects of ISO GPS standards
- “Hotwords” in topics link to a glossary of more than 250 terms and definitions
- Detailed graphics with full explanations of concepts
- Interactive charts defining symbols and abbreviations
- Topics are cross-referenced with the ISO standards
- Help screens provide a quick explanation of its features
- The subject index organizes subjects and topics
- Search subjects, topics, and terms in the glossary with ease
- Navigation between topics is quick and easy

The ISO GPS Quick Reference software is a valuable tool for anyone who creates or interprets engineering drawings.

Site and corporate licenses are available.
**ENGINEERING TOOLS & METHODS**

**COURSE FORMATS**
- A complete course in GD&T including quizzes, final exam, and certificate of completion
- A geometric tolerancing seminar
- A supplement or review for live training
- Post training content review
- An internal GD&T certification
- An on-the-job reference

**SKILL LEVEL**
Users should have completed ETI’s Engineering Drawing Requirements course or use drawings regularly on the job.

**VERSIONS**
- LAN 2-seat (up to 10 seats)
- Corporate

**SYSTEM REQUIREMENTS**
- Pentium 4-based computer with a 2GHz or higher CPU
- 512 MB RAM minimum/1024 MB or higher recommended
- 4 GB minimum of free hard drive space
- Video card capable of displaying 24-bit color at a resolution of 1024x768
- Windows XP (SP2)/XP/Professional 64-bit/Vista/7
- Adobe Flash Player 10.0 or higher

**Starting at $1200.00 List**
Contact ETI to determine the version that best suits your need.
Product Code PD027201

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**The ETI eLearning System**
*(Based on ASME Y14.5M-1994 & Y14.5-2009 Standards)*

ETI’s eLearning System gives those responsible for GD&T skill development a comprehensive solution for fundamentals training in both standards, comparison instruction to understand the differences, and access to powerful GD&T dictionary, quick reference, and skill survey tools.

The ETI eLearning System is the ideal software package for anyone considering or currently operating in a multi-standard environment.

Users will receive all the same benefits as each of our individual GD&T trainer packages as well as:
- Three fully interactive, narrated courses
  - Fundamentals of GD&T (2009)
  - Fundamentals of GD&T (1994)
  - ASME Y14.5 Standard Comparison
- Over 60 significant revisions, additions, and deletions
- Student/course record storage
- Digital Design Dictionary
- A copy of the Ultimate GD&T Pocket Guide:

**COURSE FORMATS**
- A complete course in GD&T including quizzes, final exam, and certificate of completion
- A geometric tolerancing seminar
- A supplement or review for live training
- Post training content review
- An internal GD&T certification
- An on-the-job reference

**SKILL LEVEL**
Users should have completed ETI’s Engineering Drawing Requirements course or use drawings regularly on the job.

**VERSIONS**
- LAN 2-seat (up to 10 seats)
- Corporate

**SYSTEM REQUIREMENTS**
- Pentium 4-based computer with a 2GHz or higher CPU
- 512 MB RAM minimum/1024 MB or higher recommended
- 4 GB or more of free hard drive space
- Sound card with speakers
- Video card capable of displaying 24-bit color at a resolution of 1024x768
- Windows XP/XP Professional/64-bit/Vista/7
- Adobe Flash Player 10.0 or higher
- Visual Basic 6 Runtime (Admin and Reporter only)
- NET Framework 2.0

Contact ETI for pricing
Product Code PD021201

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Fundamentals of Geometric Dimensioning and Tolerancing Video Training Program – Video Workbook
*(based on ASME Y14.5M-1994)*

By Alex Krulikowski

This unique self-study course is designed as a supplement to the Fundamentals of GD&T Video Training Package (ask your ETI sales representative for details). The GD&T Video Workbook contains 30 exercises and over 300 questions on the fundamentals of geometric tolerancing. Diagrams, tips, charts, and key points...
ENGINEERING TOOLS & METHODS

correspond to its companion video to provide reinforcement of concepts learned in each section. Users can gauge their comprehension through assessments included at the conclusion of each lesson. The GD&T Video Workbook can be used as an ongoing practice and reference guide well after the initial training is complete.

THIS BOOK IS A VALUABLE TOOL FOR:
• Designers
• Product, Manufacturing, and Quality Engineers
• CMM Operators
• Checkers

SKILL LEVEL
Basic blueprint reading skills is required; must have also completed courses in GD&T fundamentals and advanced concepts.

Spiral Binder
Starting at $64.00 List
Product Code PD024051

GD&T Workbook with Engineering Drawings
(based on ASME Y14.5M-1994)
By Alex Krulikowski

The GD&T Workbook enhances student skills through instruction and exercises on topics learned via ETI’s training practicum. A perfect companion to the Fundamentals of GD&T textbook, the GD&T Workbook can be used in the classroom as reinforcement to the ETI Fundamentals of GD&T training course, and as an ongoing practice guide after classroom training is complete. For instructors, the Workbook is designed for use with the Fundamentals of GD&T Digital Instructor’s Kit to complement lesson plans and teaching aids. Users will gain practical experience from the GD&T Workbook with typical industrial engineering drawings through insightful questions and examples covering key terms, concepts, and interpretations. Learning goals and objectives are clearly outlined making the GD&T Workbook the perfect supplement to your live or e-learning GD&T training.

TOPICS INCLUDE:
• Interpreting Engineering Drawings
• Understanding Why GD&T is Superior to Coordinate Tolerancing
• Recognizing Key Terms
• Identifying Modifiers and Symbols Used in GD&T
• Understanding Rules #1 and #2
• Recognizing GD&T Concepts
• Interpreting Flatness, Straightness, Circularity, and Cylindricity
• Specifying and Interpreting Planar Datums, Datum Targets, and Size Datums (RFS and MMC)
• Interpreting Perpendicularity, Angularity, Parallelism, and Position (RFS/MMC/LMC)
• Drawing Cartoon Gages
• Interpreting Tolerance of Position Special Applications
• Calculating Part Distances and Fastener Formulas
• Interpreting Concentricity, Symmetry, Circular Runout, Total Runout
• Interpreting Profile Tolerancing, Profile of a Surface, and Profile of a Liner

THIS BOOK IS A VALUABLE TOOL FOR:
• Designers
• Product, Manufacturing, and Quality Engineers
• CMM Operators
• Checkers

SKILL LEVEL
Student should have taken ETI’s Engineering Drawing Requirements course or have a basic understanding of engineering drawings.

204 pp.
Spiral Bound
$36.00 List
Product Code PD024030

Fundamentals of GD&T Self-Study Workbook
(based on ASME Y14.5-1994)
2nd Edition
By Alex Krulikowski

also available
Fundamentals of GD&T Self-Study Workbook
Spanish Edition

The Fundamentals of GD&T Self-Study Workbook is a popular cost-effective option for learning GD&T at your own pace. Practical examples incorporating real world applications separate this workbook from all competitors. The Fundamentals Self-Study Workbook’s versatility goes beyond self-study and can be multi-purposed for team learning. Users will find useful charts, diagrams, innumerable tips and suggestions, assessments, and other learning resources to maximize your learning objectives.
The Fundamentals of GD&T Self-Study Workbook package also comes complete with 30 targeted lessons, self-study flash cards, and pre- and post tests to measure and track learning goals.

Product highlights: The GD&T Self-Study Workbook is packed with examples, charts, logic diagrams, on-the-job guidelines, and over 500 practice problems with solutions.

Each lesson begins with a pre-inventory test to assess your current skill level. The lesson continues with illustrated, step-by-step training in each concept and provides problems to allow you to practice those concepts. Each lesson ends with a summary quiz and a post-inventory, giving you immediate feedback on your progress. Includes a send-in final exam.

**This Book Is A Valuable Tool For:**
- Designers
- Product, Manufacturing, and Quality Engineers
- Technicians
- Purchasers
- Checkers

**Skill Level**
A basic understanding of engineering drawings is required.

**ISBN:** 09245420-01-9, Part 4002
570 pp.
Spiral Bound
**Starting at $170.00 List**
Product Code PD024002
Product Code (Spanish Language Edition) PD024004

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**Tolerance Stacks Self Study Course**
By Alex Krulikowski

This unique all-in-one self-study course comes delivered in a multi-volume package and is intended as a course in geometrical tolerancing. Each volume stresses applications found on-the-job in real-world industrial situations. Practice tools replicate actual drawings to maximize knowledge transfer from the training room to the jobsite.

Volume 1 formally outlines the importance of stacks as it relates to product design, the course format, and also offers useful tips on setting personal goals to maximize user’s learning habits.

Volume 2 contains 25 practice stacks based on the ETI Drawing Package (included), progress charts, helpful tips, and solutions to gauge user’s learning progression.

Product highlights: Stresses applications that are found on the job in real-life industrial situations. The practice stacks are from actual drawings that are provided in a separate Drawing Package. It includes a skills assessment tool and exercises at the end of each chapter to practice the concepts.

Additional package items include a Stacks Summary Chart and blank stacks forms for use in documenting practice content.

**This Book Is A Valuable Tool For:**
- Designers
- Product, Manufacturing, and Quality Engineers
- Inspectors
- Machine Builders

**Skill Level**
Basic blueprint reading skills is required; must have also completed courses in GD&T fundamentals and advanced concepts.

**ISBN:** 0-924520-03-5
Part 1005
Multiple Packaging
**Starting at $210.00 List**
Product Code PD021005

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**Alex Krulikowski’s ISO Geometrical Tolerancing Reference Guide**
By Alex Krulikowski

The ISO Geometrical Tolerancing Reference Guide clarifies interpreting standard-compliant technical drawings that use ISO 1101:2004 and its companion published standards. It guides the user as to which ISO standards should be referenced on a drawing and what the standards cover. The book includes several features to help the reader find information quickly:
- A visual index inside the front cover
- Individual table of contents for each section
- Indexed page edges for each section
- Numerous cross-references
- A comprehensive alphabetical index
- A glossary of more than 100 terms
- More than 250 endnotes that reference ISO standards with clauses that support concepts
- Numerous authors’ comments that provide insights about concepts
• Hidden spiral binding allows it to lay flat
• Comprehensive reference charts and drawings inside the foldout covers

**TOPICS INCLUDE:**
• ISO drawing conventions
• GPS basics
• Size and boundary conditions
• Limits and fits
• The datum-system
• Form tolerances
• Orientation tolerances
• Location tolerances
• Run-out tolerances
• Profile tolerances
• General tolerances
• Workpiece edges
• Surface texture
• ISO/ASME comparison
• Non-rigid parts
• Restraint specifications

**THIS BOOK IS A VALUABLE TOOL FOR:**
• Engineers
• Designers
• Inspectors
• Machinists

**ASME Y14.5M-1994 Reference Chart**

Compare features of ANSI and ASME Standards, and Tolerance Stacks quickly and easily with these handy comparison sets. Each chart contains a fully illustrated breakdown of changes in the standard for quick, on-the-job drawing interpretation. These easy-to-read charts are the ideal tools for the working designer, engineer and design manager. Order one or multiple copies for your home, office and/or remote jobsite.

• Defines and illustrates important GD&T terms, modifiers, and symbols.
• Shows examples of each tolerance with facts about datums, MMC/RFS, bonus tolerances, and tolerance zone boundaries.
• Explains the new datum system.

**The Ultimate GD&T Pocket Guide**

The Ultimate GD&T Pocket Guides are the perfect on-the-job reference tools for anyone who uses GD&T on the job or in the classroom. Each guide delivers a wealth of concise practical information on current ASME Standards and GD&T topics through helpful tips, charts and detailed illustrations for easy reference. Use The Ultimate GD&T Pocket Guides to reference datum applications, conversion charts, formulas, tolerancing, and much more.
ENGINEERING TOOLS & METHODS

PRODUCT HIGHLIGHTS INCLUDE:
• Over 100 detailed drawings to illustrate concepts
• More than 40 charts for quick reference
• Explanation of each GD&T symbol and modifier
• Examples of datum application
• Sections on surface texture and composite tolerancing
• A conversion chart for coordinate measurement to diameter tolerance zone
• Full definitions of major concepts
• Clarification of important rules and topics
• Definitions of fixed and floating fastener formulas
• Handy inch/millimeter conversion charts

The Ultimate GD&T Pocket Guide
(based on ASME Y14.5M-1994)
The Ultimate GD&T Pocket Guides are the perfect on-the-job reference tools for anyone who uses GD&T on the job or in the classroom. Each guide delivers a wealth of concise practical information on current ASME Standards and GD&T topics through helpful tips, charts and detailed illustrations for easy reference. Use The Ultimate GD&T Pocket Guides to reference datum applications, conversion charts, formulas, tolerancing, and much more.

PRODUCT HIGHLIGHTS INCLUDE:
• Over 50 detailed drawings to illustrate concepts
• Explanation of each GD&T symbol and modifier
• Examples of datum application
• Sections on surface texture and composite tolerancing
• A handy inch/millimeter conversion chart
• A conversion chart for coordinate measurement to diameter tolerance zone
• Full definitions of major concepts
• Clarification of important rules and topics
• Definitions of fixed and floating fastener formulas

2nd Edition
Spiral Bound
122 pp.
$20.00 List
Product Code PD024070

Kindle Edition (e-book)
$9.99 List

RELATED TRAINING SOLUTIONS
Some of our courses apply to more than one technology category. Consider these related courses described in other sections of this resource guide.

Creating and Managing a Product Compliance Program
You will learn best practices in creating a compliance program for your products and markets, and how to use this program at all stages of product development and production. Read more about this course on page 116.

Materials Selection Process for Engineering Designs
This course covers the engineering process for selecting materials to use for components and joints within a product. Applying the process enables selection of materials that optimize product performance, reliability and cost, while helping keep projects on schedule. Read more about this course on page 135.

Risk Management Throughout the Automotive Development Process
This discusses the attributes that portend high probability of failure, as well as ways to assess the strategies associated with the project to improve the probability of success. It also demonstrates the processes and steps required for effective project risk management. Read more about this course on page 122.

3 ways to get a no-obligation price quote to bring a course to your company • Call SAE Corporate Learning at +1.724.772.8529
• Fill out the online quote request at sae.org/corplearning • Email us at Corplearn@sae.org
The ISO GPS Ultimate GD&T Pocket Guide


More than 15 standards were directly reviewed and more than 30 standards indirectly used in creating the book. One entire section is devoted to a quick comparison of ASME and ISO standards. Author’s comments throughout the text provide insights about concepts and how to apply or interpret geometrical tolerancing in a cost-effective manner.

TOPICS INCLUDE:
- GPS basics
- View projection options
- Linear size
- Non-size dimensions
- Datum systems
- Geometrical tolerances
- General tolerances
- Non-rigid workpieces
- Workpiece edges
- ASME/ISO comparison

ISBN: 978-0-7680-8258-6
Spiral Bound
$39.95 List
Product Code PD027104

eBook Edition
$39.95 List
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MANAGEMENT: LEADERSHIP, PRODUCT DEVELOPMENT & QUALITY ASSURANCE

Includes: strategic leadership, team building, principles of cost and finance, effective decision making, project and program management, and quality assurance

MANAGEMENT AND LEADERSHIP

The Art of Leadership Presence
40 Minutes

We all experience surprises. What if you could meet these surprises with ease and confidence? And what if you could create, through your own personal presence, space for more positive, collaborative engagements between people?
You can when you adopt the mindset of an improv actor! This means learning and practicing how to show up and be ready – ready to lead, to influence, and to contribute whether things go the way you expected or not. And to have leadership presence: something that builds the trust we need to work together through good times and bad.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Doing the Right Things Right
30 Minutes

Based on the book by bestselling author and award-winning speaker Laura Stack, Doing the Right Things Right: How the Effective Executive Spends Time, this course focuses on how today’s leaders and managers can obtain profitable, productive results by managing the intersection of two critical values: effectiveness and efficiency.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Effective Decision-Making: A Methodology Approach
1 Day
I.D.# C1354

Effective decision making is critical to maximizing profit/minimizing expenses, return on capital spending, and operational efficiency. To understand the impact of decisions that affect the enterprise, professionals at every level must secure and integrate relevant cross-functional information. Register for this seminar and learn skills needed to base decision making on solid
business knowledge and sound financial principles instead of on emotion or “your gut.” The instructor walks you through the tenets of structured decision-making and teaches a step-by-step approach to make practical, effective decisions. Participants are requested to bring a scientific calculator capable of doing exponential calculations for class analyses.

Learning Objectives
By attending this seminar, participants will be able to:
• Define the decision boundaries and expectations for decision outcomes
• Select the optimal methodology for decision making
• Select the best decision-making criteria in making project decisions and allocating capital budgets
• Determine the lowest enterprise costs in raising capital through debt and equity offerings
• Analyze make-buy, buy-lease, replacement and other alternative enterprise decisions based on the best financial strategies
• Articulate the financial sensitivity of project decisions and the use of decision tools for integrating cross-functional business requirements
• Develop an effective decision-making structure for your unique specific project criteria and your organization

Who Should Attend
This seminar will benefit individuals having responsibilities in engineering, business, finance, marketing, purchasing, manufacturing, research, and program management. In addition, local government leaders and individuals in non-profits may benefit from these decision-making case studies in determining business decisions including which projects and grants should be supported. A group from the same organization may find it advantageous to attend together.

Topical Outline
• Decision Boundaries and Expectations
  • Region & Functions Impacted
  • Time Frame of Decision
  • Outcomes
  • Plan B
• Decision-Making Principles
  • Evolution
  • Terminology
  • Types
  • Stages
• Financial Principles
  • Time Value of Money, Interest & Inflation
  • Worth (Present Value, Future Value, etc.)
  • Financial Decision Methods (NPV, IRR, Payback Period, etc.)
  • Case Studies

• Decision-Making Criteria
  • Market Demographics
  • Product or Service Position/Leadership, Parity
  • Financials & Price/Margin/Cost Reduction
  • Quality/Customer Satisfaction
  • Change in Business Direction/Vision
  • Personnel/Job Creation
• Cost Impact & Enterprise Decisions
  • Cost of Capital: Equity & Debt, Revenue Sources
  • Cost of Ownership: Depreciation, Accelerated Cost Recovery
  • Influence of Tax Obligations
  • Case Studies
• Alternative Financial Decisions for the Enterprise (Principles & Case Studies)
  • Make/Buy
  • Buy/Lease
  • Replace/Repair
  • Investments of Unequal Life
• Sensitivity & Scenario Analysis & Decisions (Case Studies)
• Decision-Making Methodology
  • Matrix Priority Rating System
  • Case Study by Attendees

Instructor: James Masiak
Fee $810 .7 CEUs

SAE GENERAL MANAGEMENT AND LEADERSHIP CERTIFICATE PROGRAM
Watch for the certificate icon to indicate course titles that are part of an SAE multi-course certificate program.

This program focuses on four core management and leadership competencies: management capability, team leadership, project management, and finance providing a basis for growth into a leadership or management role. View the list of required and elective courses and more information on enrolling in this SAE certificate program: training.sae.org/certificate/management_leadership
Effective Writing for Engineering and Technical Professionals

2 Days  
I.D.# C1605

The ability to write concise and unambiguous reports, proposals, manuals, or other technical documents is a key skill for any high-functioning engineer or technical staff person in the mobility industries. Through a combination of class discussions, interactive workshop activities, assignments, checker teams (review teams) and job aids, this course delivers real-life technical writing techniques and tools that can be immediately applied. Attendees discover the importance of knowing their audiences and how to communicate technical information in a “user-friendly” style.

During the conclusion of the final session, participants will also share their action plans and learn more about available resources (books, online courses, tools, etc.) to enrich their learning experiences.

To enhance social learning, participants will organize into “Checker Teams” to support each other with developing and critiquing session assignments. Review checklists will be provided to support Checker Team activities.

Because this course is highly interactive, participants are required to bring samples of their own writing projects (past, present, or future ideas) to analyze and develop during class. There may be some sharing of documents among participants on Day Two, so please bring non-proprietary document samples for some class activities. If proprietary documents are to be reviewed, the instructor is available to provide confidential, one-on-one coaching for each participant during the end of Day Two.

A critical resource included as part of this course is Hacker, D. & Sommers, N. (2014), *Pocket Style Manual: Updated With MLA’s Guidelines and Internet Resources 7th Edition*.

Learning Objectives

By attending this seminar, participants will be able to:

- Describe basic technical writing techniques
- Interpret documentation including procedures, work instructions, specifications, and reports
- Apply your technical writing knowledge to documentation and projects

Who Should Attend

This course is valuable for anyone motivated to enhance his or her writing skills in the technical environment. Job roles that may benefit from this workshop include engineering, testing/validation, procurement, marketing, quality management, and management.

Topical Outline

- Technical communication and how to identify the good from the bad
- Complete a self-assessment to identify personal technical writing goals
- Form Checker Teams for workshop activities
- Objectives and purposes of various forms of technical documentation
- Identifying audience needs using audience analysis job aid
- Strategies for gathering, organizing, and developing content effectively, focusing on: “Readability”, “usability” and “accuracy”
- Principles of proper grammar, mechanics, and spelling using the Hacker Pocket Style Manual
- Principles of graphically representing text and data
- Formatting techniques to enhance readability
- Other “unwritten rules” and considerations
- Exercise: writing and editing your own documentation
- Exercise: personal goals based on the self-assessment
- Exercise: personal success plan refinement
- Instructor coaching on writing

Instructor: Norina L. Columbaro

Fee $1400   .1.3 CEUs

Leading High Performance Teams

2 Days  
I.D.# C0410

Product development is organizationally a complex undertaking that requires effective coordination within a company and between companies. During product development, teams are confronted with a number of ongoing organizational challenges and there is a high potential for conflict between participants in the process.

This course addresses teamwork and other “soft-side” factors that largely determine whether product development programs are successfully completed on schedule. The content is relevant for both OEMs and suppliers.
MANAGEMENT

Learning Objectives
By attending this seminar, participants will be able to:
• Explain the importance of effectively managing 'soft-side' issues that cause problems and delays during product development programs
• Employ successful practices of chartering and launching teams
• Implement techniques to successfully lead and facilitate effective teams
• Effectively troubleshoot problems on a team and employ techniques to remain productive
• Implement proven tips for conducting effective team meetings

Who Should Attend
Engineers and business people involved in various product development team activities will find the subject matter practical and useful. The content is of particular value to professionals from engineering, manufacturing, purchasing, quality, marketing, and finance functions in ground vehicle OEMs and suppliers.

Topical Outline
• Designing High Performance Team
  • Characteristics of effective teams
  • Systems aspects of team design
  • Addressing systemic variables
  • Identifying key stakeholders
  • Establishing the team’s charter
• Leadership and Group Dynamics
  • Responsibilities of the team leader
  • Understanding human behavior in groups
  • Motivating team members
  • Establishing a productive team culture
  • Developing team support
  • Productive and destructive team roles
  • Effective communications
  • Influence of personality styles
• Launching the Team
  • Stages of team development
  • Pre-meeting considerations
  • Selecting the team
  • Common reasons meetings fail
  • Managing the first team interface
  • Establishing group norms
  • Structuring the agenda
• Making Sound Decisions
  • Situational analysis: problems, decisions and polarities
  • Common errors in decision making
  • Essential steps in the decision process
  • Quality and acceptance factors in decision making
  • When to use and avoid group consensus
• Identifying the decision makers
• Facilitating consensus decisions
• Flawless Facilitation
  • Recognizing and defusing common group problems
  • Managing conflict and providing feedback
  • Mind mapping, story boarding and other techniques
  • Making work assignments
  • Assessing group performance
  • Concluding the meeting

Instructor: Joseph Doyle
Fee $1370 1.3 CEUs

Managing Engineering & Technical Professionals
3 Days
I.D.# C0608

In the fast paced and competitive environment of today’s global economy, the work of technical professionals is often the difference between success and failure in an organization. Providing leadership for engineers is uniquely challenging, and the transition from working engineer to first-line technical supervisor is one of the most difficult career challenges that an engineer may face. First-time engineering supervisors and mid-level managers who wish to sharpen their skills and learn new techniques for guiding, coaching, and motivating working engineers, technicians, and designers will find this seminar valuable. A mix of lecture and attention-grabbing exercises are used to develop intense and lasting learning results.

Learning Objectives
By attending this seminar, participants will be able to:
• Describe the basic value proposition of management: what managers bring to an organization that makes them worthwhile
• Avoid the most common errors that supervisors and managers make
• Describe the evolution of management thought, and utilize the latest proven concepts for improving the performance of people in complex organizations
• Explain the issues that drive the psychology of effective leadership and develop greater emotional intelligence
• Implement strategies to enhance your skills in meeting management, coaching, and performance review that are essential in today’s professional workplace
**Who Should Attend**

Engineers and technical professionals who are either recently promoted into a management position, or have some experience as a manager but would like to learn how to become more effective will benefit from attending this workshop. The concepts and skills developed during this interactive experience will be of interest to those involved in product development, manufacturing, service, or quality engineering, and all related technical activities in automotive, aerospace, manufacturing, and off-highway industries.

**Topical Outline**

**DAY ONE**
- The Management Perspective - How Managers Earn Their Keep
  - The value proposition of management
  - The “Peter Principle” and how to avoid this trap
  - Understanding the most important errors that managers commonly make - and how to steer clear of major supervisory pitfalls
  - Why people usually struggle to cooperate, and how you can reduce this
- What You Need to Know about Today’s Workforce
  - The evolution of leadership thought, and why recent events have significantly changed effective leadership methods
  - Understanding what leadership is really about
  - Why teamwork and cooperation are necessary in modern corporate structures
  - How you can generate consistent focus and daily commitment among technical and engineering professionals
  - Playing “The Tower Game” - applying focus and commitment
- The Psychology of Successful Modern Leadership
  - Process centered leadership: getting sustained results
  - Task and relationship balances
  - Why “Output Leadership” is ineffective and counter-productive
  - Different kinds of team models - and which is most effective
  - How to reduce the influence of “bad” politics in an organization through constructive decision making processes

**DAY TWO**
- The Psychology of Change
  - Why change is often stressful
  - Five stages of change
  - How to make change exciting and interesting
- Emotional Intelligence: Building an Effective Leadership Style
  - Why “emotional intelligence” is important - the research results
  - The five elements of emotional leadership
  - How to practice and develop greater emotional intelligence
  - Solving typical meeting problems with emotional intelligence
  - Coaching in Supervision
    - Building trust
    - Coaching roles
    - Improving communication for constructive coaching
  - Using Meeting Time Effectively
    - Five key issues for successful meetings
    - How teamwork breaks down in meetings, and how to correct this

**DAY THREE**
- Dealing with Practical Issues
  - Dealing with difficult people
  - Learning how to delegate effectively
- Basic Negotiation Principles
  - Soft & hard negotiating approaches
  - Win-win negotiation
  - Positions, interests, & goals
- How to Make Performance Reviews Constructive
  - Legal requirements
  - Style issues
  - 360 reviews

**Instructor:** Eric Timmis  
**Fee:** $1895 2.0 CEUs

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**The Pillars of Leadership**  
65 Minutes

This exciting new series focuses on the extensive research, CEO interviews and corporate engagements of Jason Jennings and Laurence Houghton. Their team has observed and documented the lives of successful leaders. Now these ideas, and valuable practices, have been converted to high-impact elearning as a “Front Row Seat” for managers and leaders – especially new managers and leaders who have great knowledge and technical ability but have not had the opportunity to learn “first hand” from the best in the world.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.
Patent Litigation in the U.S.: What You Need to Know

4 Hours
Web Seminar: I.D.# WB0940

In today’s economic environment, patents have become an increasingly important asset for both individuals and corporations. More and more, individuals and corporations, including those in the automotive and aerospace industries, are recognizing the economic importance of patent rights, whether those rights consist of a single patent, a family of patents or an entire portfolio. Indeed, some companies do not make or sell products; their entire revenue is derived from the licensing of their patents. Suffice it to say, licensing revenue has become a significant source of value in the global intellectual property economy.

This web seminar focuses on the intricacies of patents, patent infringement litigation, and patent licensing. Participants will explore the important subjects of obtaining U.S. and foreign patents, maintaining U.S. and foreign patent rights, enforcing patent rights, defending against patent rights asserted by competitors, and licensing patent rights for revenue. After this course, you will effectively understand patents and ways to protect and monetize your company’s valuable inventions. Your new knowledge will help your company maintain and enhance its position in the an increasingly competitive marketplace.

Learning Objectives
By connecting with this web seminar, participants will be able to:
• Explain U.S. patent rights, including how patents are obtained and maintained
• Provide an overview of U.S. patent litigation, including recent changes under the The Leahy-Smith America Invents Act (AIA)
• Anticipate the scope of discovery in and avoid the potential business disruption arising from a U.S. patent case
• Explain the basic legal principles for liability and damages in patent cases
• Describe how patent disputes are resolved
• Predict the fees and expenses associated with bringing and/or defending a patent case in the U.S.
• Peek into the future of potential patent law reform

Who Should Attend
This course is geared toward executives, in-house counsel, in-house patent agents, and senior managers across industries, including automotive and aerospace. Participants may be both U.S. and non-U.S. -- anyone who needs help in understanding what to expect and what the practical realities are should they become involved in U.S. patent litigation.

This course complements the Patent Litigation Risk Management Toolkit web seminar (#WB1525, page 119), which provides practical guidance to help keep businesses out of patent infringement litigation.

Topical Outline
Session 1
• Overview of Patent Litigation
  • Recent headlines
  • Scope of patent protection
  • Issues the patent-owner has to prove
  • Issues the accused infringer has to prove
• What is the Scope of Discovery?
  • Documents, including e-documents
  • Depositions
  • Third parties (e.g. customers, suppliers)
  • Confidentiality of discovery materials
• Who Decides Liability and Damages?
  • Jury
  • Judge
  • Mediator/Arbitrator

Session 2
• How Long Does it Take from Filing to Trial?
  • District Courts
  • ITC
• How Much Does it Cost?
  • Fees and expenses
  • Contingency fees
  • Recovery of fees and expenses
• Practical Issues in Patent Licensing
  • Exclusivity considerations
  • Other permissible limitations
  • Royalty calculations
• What Changes are on the Horizon?
  • Supreme Court
  • Patent law reform

Instructor: William Cory Spence
Fee $425 .4 CEUs
Immersive training covering core engineering topics. Cost-effective and time-efficient educational programs taught by experts dedicated to helping the industry.

- Engineering Management
- Diesel Engine Technology
- Vehicle Noise Control
- Hybrid and Electric Vehicle
- Gasoline Engine Calibration
- Transmission

training.sae.org/academies
Patent Law for Engineers

1 Day
I.D.# 88007

This information-packed seminar focuses on the intricacies of patents, patent infringement litigation and patent licensing. Attendees will explore the important subjects of obtaining U.S. and foreign patents, maintaining U.S. and foreign patent rights, enforcing patent rights, defending against patent rights asserted by competitors, and licensing patent rights for revenue. After this seminar, participants will effectively understand patents and ways to protect your company’s valuable inventions. Knowledge gained will help the company maintain and enhance its position in the marketplace.

Learning Objectives
By attending this seminar, participants will be able to:
• Obtain an overview of U.S. patent litigation
• Understand the basic legal principles for liability and damages in patent cases
• Gain insights into how patent disputes are resolved
• Predict the fees and expenses associated with bringing and/or defending a patent case in the U.S.
• Anticipate the scope of discovery in, and/or business disruption arising from, a U.S. patent case
• Peek into the future of potential patent law reform

Who Should Attend
Participants should have a mid- to upper-level managerial role. Research and development, in-house legal staff members such as in-house lawyers, patent agents, or patent liaisons will especially benefit.

Topical Outline
• Overview of Patent Litigation
  • Issues the Patent-Owner Has to Prove
  • Issues the Accused Infringer Has to Prove
• Who Decides Liability and Damages
  • Jury
  • Judge
  • Mediator/Arbitrator
• How Long Does it Take From Filing to Trial
  • District Courts
  • ITC
• How Much Does It Cost
  • Fees and expenses
  • Contingency Fees
  • Recovery of fees and expenses
• What is the Scope of Discovery
  • Documents, including e-documents
  • Depositions

Principled Negotiation

1 Day
I.D.# C1602

This highly interactive workshop focuses training on negotiation strategy and skills. This is not the manipulative, win-lose negotiation approach frequently taught today, where the “winner” eventually spends time and effort protecting his negotiated advantage against erosion, while the “loser” continually exploits loopholes and shortcuts to recover lost ground. Traditional negotiation is a wary dance based on mistrust, the true cost of which is lost in quality and brain fatigue – usually for someone other than the negotiator – over the life of the agreement.

Successful negotiations occur when all parties want the agreement to stay in force and when everyone has a vested interest in making things work. There is no desire to find loopholes or shortcuts, there is little time given to supervising the agreement, and both product and relationship quality is enhanced. When the Principled Negotiation guidelines are followed, negotiated outcomes simply cost less.

Learning Objectives
By attending this seminar, participants will be able to:
• Assess your current approach to negotiation
• Utilize a principled approach when preparing for negotiations
• Practice principled negotiation techniques
• Develop a personal action plan for change

Who Should Attend
This course is particularly useful for front-line employees in manufacturing, design, and customer liaison – those who manage daily human interactions with both suppliers and customers. It also easily applies to procurement, estimating, sales, testing, and business development.

Topical Outline
• Principled Negotiation Overview
  • Setting the stage
  • Exploring where we are today
MANAGEMENT

• Principles, Guidelines, and Techniques
• Negotiation: Operational Definition
• Three General Negotiation Approaches – Soft, Hard, “Win-Win”
• Personal Goals and Expectations
• Paradigm Stretcher
• Key Elements of Principled Negotiation
  • Interests
  • Options
  • Standards
  • People
  • Alternatives
• Emotional Intelligence (E.I.) - the Pre-requisite 21st Century Leadership Skill set for Principled Negotiation
• Explore Practical Ways to Enhance the E.I. Skills You Will Need
  • Self-Awareness
  • Self-Regulation
  • Self-Motivation
  • Empathy
  • Social skill
• Positional Bargaining vs. Principled Negotiation
  • Using role play scenarios to assess and select strategies for each key element that fits your particular situation
• Action Planning – Using a Proven 10 Step Approach
  • Putting it to work for you
  • What do you want to do better, stop doing or do differently?

Instructor: Eric Timmis
Fee $810 .7 CEUs

Principles of Cost and Finance for Engineers

3 Days
I.D.# C0828

In today’s corporate environment of shrinking budgets, required structural cost reductions, sharing of global designs/services, and pricing pressures, it is critical that engineers possess a working knowledge of engineering economics principles. To fully understand the economic viability of engineering decisions, engineers need to find the appropriate balance between design alternatives, resulting costs, and impact on their enterprise. This seminar introduces participants to the cost, finance and economic concepts and their applications to products and services. This three-day course provides you with practical information normally obtained through university level economics and business management courses and will help you to maximize efficiencies from both an engineering and business perspective.

Note: Attendees are requested to bring with them a business or scientific calculator capable of doing exponential calculations.

Learning Objectives
By attending this seminar, participants will be able to:
• Understand the hierarchy of economics, finance and cost in making financial decisions
• Review financial statements and ratios in assessing the financial state of a business
• Select the best decision-making criteria in making project decisions and allocating capital
• Implement a benchmarking plan to establish a competitive market position
• Determine the enterprise costs of raising capital through debt and equity offerings
• Analyze make-buy and buy-lease options and other alternative decisions based on the best financial strategies
• Understand the financial sensitivity of project decisions and the use of decision tools for integrating business requirements
• Determine and optimize all costs in the production process
• Select the optimum cost accounting strategy and inventory plan
• Identify the appropriate cost estimation methodology for metallic, electronic & plastic components
• Select cost control alternatives from marketing, engineering, commercial & geographic options

Who Should Attend
This seminar will benefit engineers having responsibilities in manufacturing, maintenance, research, design, product and process development, program and project management, troubleshooting, and materials management. Additionally, individuals in non-engineering disciplines, including marketing and general management, will benefit from an introduction to the engineering perspective.

Topical Outline
DAY ONE - Principles of Economics & Finance
• Process & Responsibility for Determining Cost
• Economics, Finance & Cost Principles
  • Macroeconomics and Growth
  • Microeconomics, Supply & Demand
  • International Economics & Comparative Advantage
• Finance & Accounting: Corporate
• Finance
  • Financial Statements & GAAP
  • Financial Analysis & Ratios, Case Analysis
  • Capital Sources & Allocation
• Time Value of Money and Decision Making
  • Interest: simple and compounded
  • Inflation
  • Worth: present and future values
Strategic Leadership

3 Days
I.D.# C0620

As a strategic leader, it is your responsibility to ensure that your organization is moving in the right direction. Executives and high-level managers must have the practical insight necessary to address competitive business challenges. Each segment of this three day course is designed to impart simple, but powerful lessons that will equip participants to more fully engage in strategic discussions, ask pertinent questions, facilitate critical decisions and shape high performing organizations. In addition, the course provides students with a personal leadership profile that illustrates their strengths and potential limitations. Participative exercises assist emerging executives with practical and effective methods of gaining organizational credibility and avoiding common errors in strategic leadership.

Learning Objectives
By attending this seminar, participants will be able to:
• Describe the role and responsibilities of strategic leadership
• Manage the critical factors that drive the success and failure of business strategies
• Anticipate the longer term impact of strategic initiatives
• Attain credibility and support as you assume the helm of a new operation
• Avoid common errors made by leaders in transitioning to higher levels of responsibility
• Select the most effective approaches when framing strategic decisions
• Think strategically and systemically as you plan organizational change
• Influence the emergence of a more positive and functional corporate culture
• Eliminate turf battles, dropped balls and organizational duplication of effort
• Analyze and correct dysfunctional organizational dynamics
• Manage the strengths and limitations of your personal leadership style

Who Should Attend
This seminar is designed for executives, senior level managers, and engineering managers or technical specialists who are called upon to formulate or provide input into strategic decisions and business strategies.

Topical Outline
• Introduction to Strategic Leadership
  • What exactly do we mean by leadership?
  • Who is and is not a leader?
At what point do we become leaders?
Critical elements of leadership support
Managing versus leading - is there really a difference?
Critical factors in assessing leadership performance
The relationship between leadership, strategy, human behavior, decision-making and organizational systems
Understanding the Human Dimension
Similarities between animal behavior and human behavior
Influence of brain structure on human behavior
Creating long term employee motivation
Rules of thumb for predicting human behavior in organizations
Recognizing the symptoms of pathological leadership
Managing and defusing dysfunctional behavior
Assuming the Helm
Managing the transition to a new workgroup
Common and avoidable errors of leadership
Developing and maintaining the support of your workgroup
Simple, but effective steps to improve workgroup performance
Shaping Corporate Culture
Understanding the critical components of corporate culture
Forming productive organizational norms
How leaders contribute to dysfunctional cultures
Establishing a high performance work environment
Creating Organizations that Work
Creating an organizational charter
Selecting an effective management team
Thinking systemically
Importance of managing image and expectations
Creating meaningful performance indicators
Eliminating turf battles and duplication
Limitations on the application of common systems
Facilitating Strategic Decisions
Critical distinctions between problems, decisions and polarities
How to properly frame a decision
Selecting the decision makers
Common errors in decision making process
Essential elements of effective decision making process
Knowing when the decision has been made
The Leader's Role in Creating Effective Strategies
What exactly is a strategy?
Why business strategies fail
Internal and external considerations
What constitutes effective strategy?
Anticipating the impact of adaptive responses
Framing strategic initiatives
Barriers to strategy implementation
Leading Strategic Change
Planning a change initiative
Critical variables in organizational change
The leader's role in fostering change
Anticipating and dealing with resistance
Culture as a barrier to change
Political Reality versus Dysfunctional Idealism
Gaining credibility in executive circles
Sources of leadership power
How power is gained and lost
The importance of building networks and relationships
How to avoid getting derailed
Lessons of History for Strategic Leaders
Developing a Leadership Profile
Charting your personal leadership profile
Identifying your leadership assets and liabilities
Creating a plan of action

Success Strategies for Women in Industry and Business

1 Day
I.D.# C1202

It is a well-known fact that the number of women in science, engineering and business fields is growing, yet men continue to outnumber women, especially at the upper levels of these professions. Many women appear to encounter a series of challenges at early or midcareer stages that contribute to them leaving their careers prematurely due to feelings of isolation, an unsupportive work environment, extreme work schedules, and unclear rules about advancement and success.

This program serves as a unique opportunity to obtain both formal and informal mentoring tips from a successful woman engineer who spent over 25 years in the petrochemical/specialty chemical industry. She has seen and has experienced significant changes in the number of professional women active in the technical/scientific field and is convinced that more positive change can happen in the future. This seminar will provide detailed guidance, based on real life examples, on how female professionals can become proactive in creating career opportunities via self-assessment, self-motivation, an objective view of one's own abilities, and continuous steps in self-improvement. The program will take participants beyond theory to case studies and real life examples exemplifying potential for immediate use.
Learning Objectives
By attending this seminar, participants will be able to:
• Identify obstacles and common challenges that hold you back in your career
• Develop and utilize critical communication skills
• Develop focused and well defined criteria for professional progress
• Define your professional relationships with clear boundaries and respect
• Create a flexible career plan
• Handle criticism and difficult situations with composure

Who Should Attend
This seminar will benefit professional women who want to positively impact their careers. Recent engineering graduates, as well as experienced female engineers and/or scientists will learn skills to help them navigate these male-dominated fields. Additionally, individuals working in non-engineering disciplines, including general management, human resources, academia, business, and law as well as current engineering students, will benefit from this unique perspective.

Topical Outline
• Course Motivation: Why are you here?
• Historical Perspective - Women in Engineering and Scientific Professions
  • Dr. Ewa Bardasz - personal story
  • Survey data - status of women professionals: tenure, promotions, salary trends, recognitions, etc
• Case Study #1: What holds you back in your career?
• Common Challenges
• Case Study #2: Career Goals: Success Defining Questions
• Work Climate Changes
• Definition of Professional Success
  • Technical know-how
  • Leadership skills
• Refining Critical Verbal Communication Skills
  • Presentations/ public speaking
  • Negotiations/ conflict communications
  • Getting your points across
  • How to speak up without coming across as to aggressive
  • How to find balance between “being too nice” and “coming on too strong”
  • How you can say “no” without feeling guilty
• Case Study #3: How can you successfully negotiate with a group of aggressive men?
• Refining Critical Written Communication Skills
  • Reports, technical papers
  • Email, social media
• Networking
• Behaviors and Relationships
  • Handling emotions at work
  • Mentors/Advisors - pros and cons
• Work-Life Balance
• Key Resources
  • Professional organizations
  • Community activities
• Reflections and Final Thoughts
• Take Away Message
• Case Study #4: What will I do next?

Instructor: Ewa Bardasz
Fee $610 .7 CEUs

MANAGING PRODUCT DEVELOPMENT & QUALITY ASSURANCE

Creating and Managing a Product Compliance Program
2 Days
I.D.# C1213

Around the world, and more often than not, government bodies require formal certification of products. As product developers expand into new markets, they will be confronted with new standards, regulations, and customer expectations that may require new compliance processes. A properly run compliance program improves your product’s quality and safety, broadens your product’s market, ensures compliance with regulations and laws, and helps provide protection from future product liability issues.

This two-day seminar presents a process development methodology that can be used repeatedly as new compliance requirements emerge. Participants will learn best practices in creating a compliance program for your products and markets, and how to use this program at all stages of product development and production. Sample spreadsheets will be used to demonstrate tailoring the program to your product, your markets, and your organization. A properly managed compliance program simplifies the certification or approval of your product, and ensures that you regularly apply and document good engineering practices for product safety and reliability.
Learning Objectives
By attending this training program, participants will be able to:
• Summarize how a formal compliance program adds value to your goods and services
• Develop a compliance checklist
• Identify effective strategies for researching compliance requirements
• Describe how to manage the ongoing compliance process
• Explain the importance of documenting compliance and retaining records

Who Should Attend
This seminar is designed for managers with implementation authority for product safety and compliance; product development engineers, designers and managers; new business development managers; risk managers and compliance or certification managers. Companies considering expanding or modifying their product line, or attempting to enter new export markets, will especially benefit. Suppliers who are involved in product development and compliance, regulatory agency representatives, industry safety organization representatives, and corporate compliance lawyers will also benefit.

Topical Outline
DAY ONE
• Introduction to Compliance
  • What do we mean by compliance
  • The 3 basic forms of compliance
  • Why we need to show compliance: Legal requirements in different countries; Commercial advantages; Product liability risks
  • What is a formal compliance program
• Creating a compliance checklist - getting started
  • An introduction to the compliance process
  • Defining your markets in terms of compliance requirements
  • Finding applicable regulations, standards, and guidelines
  • Documenting best practices in the compliance checklist

DAY TWO
• Completing the compliance checklist
  • Extracting relevant requirements from the regulations, standards and guidelines
  • Selecting methods of compliance
  • Sorting and presenting the blank checklist
• Applying the checklist to a development project
  • Introducing the checklist within your organization: Integrating the checklist process into existing policies and procedures; Identifying key players, and getting them on your side
  • When and how to start the product specific checklist
  • Sidebar: discoverable documents and document retention
• Managing the compliance program over a product’s life
  • Storing and sharing the final checklist
  • Using the checklist as the product grows and develops
  • How the checklist gives your product a unique identity: Learning from the checklist for your next project; the checklist as “corporate memory”; identifying and retaining best practices beyond minimum compliance requirements
  • The standards development process

Instructor: R.W. (Bill) Walker
Fee $1370 1.3 CEUs

Engineering Project Management
2 Days
I.D.# 99003

Project Management and Advanced Product Quality Planning (APQP) are two critical techniques used in product development in the mobility industry today. This seminar will bring these techniques together in an easy to understand format that goes beyond the typical concept of constructing timelines and project planning, by exploring not only the AIAG APQP process, but also specific aspects of PM processes. Participants will gain a solid foundation in the essential principles of Project Management and APQP.

Participants will immediately apply learned skills by taking a sample project through all phases of the Project Plan using actual industry documents. Realistic issues, problems and time constraints are introduced throughout the exercise to stimulate actual project concerns. Each workshop exercise uses documents specific to the particular areas of study such as Statement of Requirements and Statement of Work, Timeline development and reacting to changing situations such as time crash. Discussion of the major milestones of typical OEM APQP processes, to include PPAP. The workshop is structured so that students must operate in teams and the time constraints allow students to see firsthand the effects of improper delegation of work assignments.


Learning Objectives
By attending this seminar, participants will be able to:
• Define the importance of each of the ten (10) Bodies of Project Management Knowledge and the essential components of APQP by Phase
• Recognize the minimum essential elements of a Robust Project Plan
MANAGEMENT

- Properly evaluate and differentiate between Statement of Requirement, Statement of Work and Work Breakdown structures
- Understand the application of different timeline methodologies: Milestone, Gantt, Network (PERT) and Critical Path
- Utilize different types of meeting and conflict resolution strategies, formulate an effective meeting summary and action list, and conduct an actual Design Review
- Recognize the pitfalls common to most mobility projects due to Voice of the Customer (VOC) collection, current U.S. and international legislation and directives, improper application of limited resources, and others.
- Beyond the Checklist! - Advanced techniques for Risk Management

Who Should Attend
Account Managers and those requiring refresher training or desiring to learn how to properly apply more advanced project management techniques. Other individuals who are involved with projects such as functional managers and support staff will benefit by attending.

Topical Outline
- The Project Management Process
  - Project constraints
  - The ten (10) bodies of Project Management Knowledge
  - Project Management and ISO
- Project Plan Life Cycle
  - Three types of life cycles: Product, Project, Project Management
  - Differentiating between project management and the APQP process
  - Major elements of each APQP phase
- Project Management Techniques
  - Principles of Integration Management
  - Managing project Stakeholders and Sponsors
  - Defining, constructing, and recognizing the differences between Letter of Intent, Statement of Requirements, Statement of Work and Work Breakdown structures
  - Developing scope of work for conceptual-based (R&D) customers
  - Defining and Developing a task-based Work Breakdown Structures (WBS)
  - Various types of WBS structures and Levels
  - Structure of effective Phase and Design Reviews
  - Beyond lessons learned - Project Best Practices and the TGR/TGW database
  - Documentation requirements necessary to support the PM/APQP/PPAP processes
- Resource Planning
  - Choosing an organizational structure to support effective Project Management
  - Roles and responsibility matrix (RASIC)
  - Tangible versus Intangible resources
  - Developing and managing an effective Staffing and Resource Plan
  - Surviving as the “multi-hatted” project leader
  - Special considerations for small projects
- Sequence Planning
  - Milestone Charts
  - Gantt Charts
  - Network Diagrams and Critical Path Method (CPM)
  - Understanding and applying float/slack time
  - Techniques to address Fast Tracking and Crashing
- Project Costing and Tracking
  - Project cost analysis methods and estimating methods
  - Recognizing and dealing with Scope Creep
  - Control techniques - Requirements for an effective Change Management System; Negotiating the difference between Phase and Design Reviews; Earned Value Analysis (EVA); Effective meeting techniques; Forming and leading project teams; Structure of effective Phase and Design Reviews; Recognizing and resolving internal and external conflict
- Project Risk Management
  - Components and construction of an effective Risk Management Plan
  - Addressing product liability using the FMEA and HAZOP
  - Risk qualification quantification techniques - Developing effective checklists; Risk Register/Quadrant Mapping, Expected Values Matrix; Probability and Impact Matrix;
- Procurement Management
  - Understanding partner supplier relationships
  - Suppliers rating techniques
  - Suppliers skill requirements

Instructor: Angelo E. Mago or Curt Pawloski
Fee $1595 1.3 CEUs

Managing Programs and Associated Risks
2 Days
I.D.# C0409

This course presents a proven eight-step method for program planning and control, including: definition of customers’ requirements, roles of the program team, determination and flowcharting of program tasks, scheduling and costing, quality aspects of critical tasks, and risk management. Easy to grasp, each of the eight steps evolve from common-sense questions that should be answered for any program, regardless of size or complexity.
With shortened development cycles and greater reliance on information in programs, this course emphasizes the value of communication within a program team, between the team and functional areas, and between the team and the program customer. Since the appropriateness of communication vehicles vary depending on purpose and audience, alternative modes of communication and change control are discussed.

**Learning Objectives**
By attending this seminar, participants will be able to:
- Explain the eight-step method for program planning and control
- Implement the eight-step method to improve program outcomes as measured by cost, schedule and quality
- Make plans and progress visible to team members and to the program customer

**Who Should Attend**
Engineers and business people involved in various product development team activities will find the subject matter practical and useful. The content is of particular value to professionals from engineering, manufacturing, purchasing, quality, marketing, and finance functions in ground vehicle OEMs and suppliers.

**Topical Outline**
- Program and risk management overview
  - Process approach to planning programs
  - Competition drives us to perform better
  - Why programs sometimes fail
  - Reference materials and website
- Defining program outcomes and measurables
  - Building quality and performance targets into program planning
  - Financial impact of poor planning
  - Roles and responsibilities of project team members
  - Design reviews
  - Product performance measurement
  - Program/project metrics
- Team formation and task planning
  - Team development
  - Roles and responsibilities
  - Matrix management
  - Meeting management
- Scheduling work
  - Critical Path calculation
  - Fast tracking
  - Developing a baseline schedule
  - Gantt chart creation
  - Software tools for scheduling & program management
- Resource planning
  - Resource planning (quantity, skills, resource conflicts, anticipating needs)
  - Adding contingencies
  - Constraint management
  - Risk Management
    - Proactive assessment and mitigation of risks
    - Types of risk
    - Failure mode and effects analysis applied to programs/projects
  - Optimizing work performance
    - Spheres of influence and control
    - Cause-effect diagrams
    - Assessing critical information flows
    - Managing human performance
    - Responsibility matrix (RASIC)
- Project initiation
  - Establishing a war room
  - Authorization to begin
  - Meeting management
  - Tracking program performance

**Patent Litigation Risk Management Toolkit**
4 Hours
I.D.# WB1525

In recent years, total annual United States patent grants have increased to over 300,000, while patent infringement lawsuit filings have exceeded 6,000 per year. Only a small fraction of granted patents ever end up in litigation. Of the many causes for the disparity is the growing awareness and sensitivity of companies to patent infringement risk management practices. This course addresses a number of those practices (and tools for implementing the practices), placing them into context, and providing a practical overview for how to implement them to help reduce the prospect of patent infringement litigation.

Participants will receive a basic working knowledge of various common, but most misunderstood, practices for reducing the risk of patent infringement litigation. The course will teach the role and significance of patent claims, address pragmatic record keeping practices, reveal ways to monitor competitive patent filings, explain common practical pitfalls in analyzing a patent landscape, and illustrate alternative ways that risk can be managed (e.g., by use of contracts).
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**Learning Objectives**

By participating in this web seminar, participants will be able to:

- Identify causes why many companies end up in litigation
- Discover ways to help avoid poor patent litigation outcomes
- Expand existing practices to help avoid the risk of litigation in the first place

**Who Should Attend**

Small to mid-size company CFO’s, as well as technology officers, engineering managers, patent liaisons, and in-house counsel for companies of all sizes will benefit from this course. These people will typically have at least five years of industry experience, and some may have two or three decades of experience.

This course complements the *Patent Litigation in the U.S.: What You Need to Know* web seminar (#WB0940, page 110), which focuses on what engineers and business managers need to know to effectively manage patent procurement, patent infringement litigation, and patent licensing.

**Topical Outline**

Session 1
- Infringement: The Theme that Brings Us Together?
  - Patent statistics
  - Glossary of terms
  - Infringement and its consequences
- Hypothetical Case: Fact Review
  - The market generally
  - The patent landscape for the market
  - The product sought for market entry
  - Perspective
- The Tools in the Kit: For the Market Entrant and Existing Participants
  - Internal policies and practices
  - Prior art
  - Contracts
  - Patent applications/patents
  - Design arounds
- Internal Policies and Practices
  - Intellectual property policy of company
  - Confidentiality obligations
  - IP Ownership obligations
  - Invention disclosures
  - Patent searches and competitive patent watches
  - Product clearance
  - Archiving internal activities
  - Sending and receiving accusations of infringement
- The Role of Prior Art in Defining Boundaries in the World of Patents
  - Patents and non-patent literature
  - First inventor to file

Session 2
- Contracts
  - Employment agreements
  - Nondisclosure agreements
  - Joint development agreements
  - License agreements
- Patent Applications/Patents
  - Overview of patents
  - Utilitarian features
  - Ornamental features
  - International filings
  - Continuation/Divisional/Broadening Reissue Applications
- Design Arous
  - Lawful
  - Precautions
- Toolkit Laboratories
  - The marketplace
  - Patent Offices
  - The Courts
  - Comparison of proceedings in Patent Offices and Courts

**Instructor:** Eric M. Dobrusin

**Fee** $425 .4 CEUs

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**Product Liability and The Engineer**

1.5 Days
I.D.# 82001

In the past few decades, product liability law has dramatically changed the manufacturer’s outlook in the design and manufacture of product. The concept of safety and reliability has been altered from a purely engineering/manufacturing concept to a legal/manufacturing approach. This new approach requires an understanding of legal concepts as related to the manufacturing and design process. The engineer’s role has shifted to include a safety audit analysis to minimize the existence of a product defect and/or to defend the product in a way that is responsive to the legal concerns. An overnight assignment will be made by the instructor. It will consist of problems drawn from actual cases and a group project that examines the design, instructions, and warnings of a product.

**Learning Objectives**

By attending this seminar, participants will be able to:

- Relate legal concepts as they apply to the manufacturing/design process
• Use safety audit analysis techniques to minimize or eliminate product defects during design, thus reducing product liability
• Discuss defense of product from a legal perspective
• Recognize the importance of potential liability as it relates to the manufacturer

Who Should Attend
Persons responsible for product design, including managers and designers; corporate risk managers; persons responsible for developing and approving product instructions and warnings; marketing personnel; production and quality assurance managers and personnel; personnel responsible for product safety and those persons, including lawyers, who oversee and manage product liability issues.

Topical Outline
• Legal Concepts
  • Negligence: elements, defenses
  • Strict liability: section 402A (elements, defenses)
  • Warranties: express, implied
• Analysis of Defect
  • Meaning of unreasonable danger
  • Production defect
  • Design defect
  • Defect by words
• Designing for Reasonable Safety
  • Products’ use, users & environment
  • Product safety audit
• The Role of Standards in Design
• Warnings
  • Guidelines for design & warnings
  • Functions & use
• Problem Analysis by Participants
• Review of a Product Design by Participants

Instructor: Charles F. Seyboldt
Fee $1370  1.0 CEUs

The Role of the Expert Witness in Product Liability Litigation
1.5 Days
I.D.# 92054

According to the Federal Rules of Evidence, an expert witness is anyone who can assist the trier of fact (the jury) in understanding any issue in dispute at trial. The witness’ ability to give this assistance can be derived from any specialized training, education, background, or experience. To be effective in providing this assistance, however, requires that the expert witness understand the true role that he or she is to play both before and at the trial.

This seminar will address the critical issues that every person who may be, has been, or is, an expert witness must understand to assist both the attorney and the product manufacturer, regardless of which side the expert serves.

Learning Objectives
By attending this seminar, participants will be able to:
• Employ the risk/utility balancing process necessary for effectively addressing the issue of design defect
• Recognize the critical elements that govern the interaction between human behavior and product behavior
• Apply the technical/legal elements that will enhance your effectiveness as an expert witness

Who Should Attend
This seminar is intended for anyone who is or may become an expert witness in product liability litigation. In-house experts typically have engineering, engineering management or field technician responsibilities. In addition, insurers, risk managers, corporate product safety personnel, attorneys and those who manage product liability litigation will benefit from insight into selecting and using expert services and witnesses more effectively and efficiently.

Topical Outline
(Day two ends at 1:00 p.m.)
• The Legal Framework of Negligence and Strict Liability
• The Relationship Between the Attorney and the Potential Expert Witness
• Investigation of an Accident Years After an Occurrence
• Developing the Background Necessary to Understand the Product and its Environment
• Understanding How to Alleg or Refute the Existence of a Product Defect
• Analyzing the Role of Human Behavior and its Relationship to the Cause of an Accident
• Guidelines for Effective Presentation Before Trial and on the Witness Stand
• The seminar will also include overnight problem assignments and a demonstration of direct and cross-examination of an expert witness.

Instructor: Charles F. Seyboldt
Fee $1370  1.0 CEUs
Risk Management Throughout the Automotive Development Process Web Seminar

12 Hours
Web Seminar: I.D.# WB1629

Automotive projects continue to grow in complexity. Studies provide a glimpse into the attributes of product development projects that have a high likelihood of failure. Knowing these attributes, the approach to the project can be structured to reduce the risks. For example, the scope of the project may already place the project at risk. Understanding the risks associated with the scope enables you to either reconsider the scope or work out strategies that will eliminate or at least mitigate the risks. In addition, your approach or strategy selected to meet the project demands will have significant impact on the results. Also, distribution of talent means you have to ensure your project manager and team know what risk is and the specific risk management process for this project.

This six session course will discuss the attributes that portend high probability of failure, as well as ways to assess the strategies associated with the project to improve the probability of success. It will also demonstrate the processes and steps that are required for effective project risk management. Participants will recognize the signs that a project is at risk even before starting the work and can proactively make the necessary adjustments with the sponsors and stakeholders to reduce those risks. Additionally, participants will learn how to maximize the contribution from the team in regard to identifying, eliminating and remediating risks. This will ensure that greater awareness and attention is given to this area of the project beyond the project manager. In addition to being able to apply the techniques of risk management, participants will receive insight into the typical phases of automotive product development (Product Development, Process Development, Product and Process Validation, and Launch) and risks associated with these phases.

Learning Objectives
By connecting with this web seminar, participants will be able to:
- Identify the risks to project success based upon the structure and scope making it possible to create plans to address and mitigate the risk
- Calculate the probability of connected events and identify the probability of the chain of events
- Evaluate various proposed solutions through demonstrated techniques and project strategies and differentiate the least risky solution
- Diagram the risk management process
- Differentiate quantitative and qualitative risk evaluation techniques
- Explain the need for specific metrics associated with project and product risk
- Identify key metrics associated with risks and explain the needs for metrics
- Identify the monitoring process and then describe an effective monitoring scheme and the connection to metrics
- Define and calculate contingency budgets
- Build a risk register and debate / justify the severity and probability

Who Should Attend
This course addresses the needs of aspiring project managers, project managers, project engineers, manufacturing engineers and managers in the engineering, manufacturing, product testing and supplier quality assurance fields. It is helpful to be working in the automotive industry as a OEM or a tier 1 or tier 2 supplier as the risk discussion spans the gamut of the product development cycle for these industries.

Topical Outline
Session 1
- Overview of Risks to Vehicle Projects
  - What is risk
  - Risk and scope and strategy
  - Overview of statistics
- Identification of Risk for Vehicle Projects
  - Team’s role in discovering risks
  - Brainstorming methods
  - Role of historical records
  - Association of metrics to the risk and prediction (trends)

Session 2
- Assessing the Risk to the Product Developed for the Vehicle
  - Qualitative techniques
  - Quantitative techniques
  - Contingency budgets

Session 3
- Monitoring and Control Risks
  - Importance of metrics
  - Monitoring and responsibility
  - Invoking mitigation or abatement actions

Session 4
- Risk and Voice of Customer
  - What typically goes wrong with scope and requirements in automotive projects
  - Metrics that predict failure in the requirements and scope of the vehicle project
  - Techniques that can reduce the requirements / scope risk
- Risk Associated with Developing the Product for the Vehicle
  - What typically goes wrong while developing the product for the vehicle
  - Metrics associated with developing the product for the vehicle that improve success
  - Techniques that can reduce the development risk
Quality Function Deployment - A Tool for Generating Customer Excitement

2 Day
I.D.# C1509

Quality Function Deployment (QFD) is a cross functional, team based methodology recognized as a key technique in improving new product/service design and development. It is especially useful to translate both spoken and unspoken customer needs into a prioritized set of customer product or service characteristics in a language understandable to an organization’s engineering design group. And, by using a cascading approach, it ensures that the design intent is maintained throughout the production planning process and that the design intent is traceable both up and down the product/process planning effort. QFD establishes a correlation between the different phases of the design effort from concept to full scale production by identifying and prioritizing critical product characteristics and then deploying them into process characteristics, and lastly creating a corresponding set of process controls to ensure the design intent is preserved in the production process. With the ability to provide a clear and traceable path from Voice of the Customer to Manufacturing Process, the QFD helps to reduce Product Development Cycle Time by reducing unnecessary engineering changes. Throughout the class, participants will be involved in exercises/actual projects that demonstrate and incorporate direct application of learned principles.

Learning Objectives

By attending this seminar, participants will be able to:

- Recognize and describe the benefits of QFD to the product/process design and development phase
- Establish the various Voice of the Customer needs and priorities
- Describe the four phases of QFD
- Use QFD to identify product and process special characteristics
- Plan and organize a QFD project
- Prioritize technical risk to optimize product design
- Evaluate opportunities for improving processes, tooling and equipment

Who Should Attend

This seminar is designed for individuals who have key roles in product development and understanding and deploying the Voice of the Customer. This includes project managers, design engineering, quality assurance, manufacturing, testing, marketing, customer field service reps, and other product support personnel.

Topical Outline

DAY ONE

- Introduction
  - What is QFD and Why is it Used
  - QFD and Advanced Product Quality Planning (APQP)
  - Basic QFD - The Four Phases
- Establishing the QFD Environment and Team Selection
  - Planning and Organizing a QFD Project
  - Team Selection and Management Support
  - Creating the Required QFD Databases
  - Issues with the QFD process
- Understanding the QFD Deployment Process
  - The Flow-Down of Product Development Activities
  - Deploying to a Special Characteristics Matrix-- Critical, Significant, and Appearance
  - Theme Selection and Product Benchmarking
  - Exercise 1: Designing the Ultimate Coffee Travel Mug
- Voice of the Customer (VOC)
  - Establishing Customer Needs and Priorities
  - Methods for Capturing and Organizing VOC
  - Exercise 2: Develop & Select Product Concepts
- Reliability Prediction Using Fault Tree/Success Tree Analysis

DAY TWO

- Product Planning
  - Developing the Product Planning Matrix Based on Voice of the Customer
  - Competitive Assessment & Product Strategy
MANAGEMENT

- Developing Technical Characteristics for New Product & Establishing a Correlation Matrix
- Assessing Technical Difficulty and Project Risks
- Exercise 3: Determine PRODUCT Level Special Characteristics
- Understanding Risks Ratings
- Analyzing the Product Planning Matrix and Developing Target Values
- Exercise 4: Establish Ratings & Target Values for PRODUCT
- Process and Production Planning
  - Deployment of Product Characteristics to Process Characteristics
  - Evaluating the Process Approach and Material Selection Criteria
  - Determine Critical Process Parameters and Process Control Plan
  - Exercise 5: Develop & Select Process Concept, Determine Process Special Characteristics
  - Exercise 6: Establish Ratings & Target Values
  - Evaluating Opportunities for Improving Processes, Tooling and Equipment
  - Establish Target Values for Process Control, Test, and Maintenance Parameters

<table>
<thead>
<tr>
<th>Instructor:</th>
<th>Angelo E. Mago</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fee $1370</td>
<td>1.3 CEUs</td>
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Introduction to Advanced Product Quality Planning (APQP)

1 Hour
I.D.# PD530908ON

To become a preferred supplier in the automotive industry, organizations must demonstrate high-level engineering and organizational capabilities that will meet customers’ needs today and tomorrow. Because the outcome of a product development project may determine whether or not an organization procures a purchase order or contract from a global automotive customer, Introduction to Advanced Product Quality Planning provides an overview of the best practices / methodologies for planning and managing the successful launch of a new product.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.

Global 8D - Ford On-Demand Course

12 Hours
I.D.# PD111012ON

Global 8D (G8D) is a disciplined process developed by Ford Motor Company to help product development and manufacturing engineers identify and solve problems. Solving problems results in efficient, as well as effective, resolution to ‘root causes’ of customer satisfaction issues, and helps reduce warranty costs. With this 12-hour on-demand course, participants will learn the methods and tools used to complete each step in the Ford Global 8D find-and-fix problem-solving process, including steps to define the problem, verify the root cause and escape point, and prevent occurrence.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.
Good Laboratory Practices (GLP) Training – CALISO On-Demand Course

8 Hours
I.D.# GLP

GLP refers to a Quality Systems of management controls for laboratories and research organizations to ensure the consistency and reliability and reproducibility of results. The original regulatory enforcement was first published by FDA and then a few years later by EPA. It is also outlined in the Organization for Economic Co-operation and Development (OECD) Principles of GLP in 1992 and has since been added to many national regulations. Your company, and all who partake in the daily activities of running a laboratory or a research and testing center, will benefit from this course. This 8-hour GLP (.8 CEU) overview is particularly adapted for training all levels of an organization on the requirements of this standard.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantitiy discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.

ISO 9001:2008 Training – CALISO Online Course

8 Hours
I.D.# ISO9001TRAINING

ISO 9001 is a quality management standard developed by the International Organization for Standardization (ISO). Your company and all who partake in the daily activities of running the business will benefit from taking ISO 9001 training. This eight-hour ISO 9001 (.8 CEU) overview is particularly adapted for training all levels of an organization on the requirements of this standard.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantitiy discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.
ISO 9001:2008 Auditor Training – CALISO
On-Demand Course

8 Hours
I.D.# ISO9001AUDITOR

ISO 9001 is a quality management standard developed by the International Organization for Standardization (ISO). Your company and all who partake in the daily activities of running the business will benefit from taking ISO 9001 training. The eight-hour (.8 CEU) ISO 9001 Auditor course provides training on the standard itself and on how to lead or conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantitiy discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.

ISO 9001:2008 Lead Auditor – CALISO
On-Demand Course

22 Hours
I.D.# ISO9001LEADAUDITOR

As described in the previous ISO 9001 Overview description, ISO 9001 is a quality management standard developed by the International Organization for Standardization (ISO). Your company and all who partake in planning, leading and conducting the audit activities of running the business will benefit from taking ISO 14001 Auditor training. The 22-hour (2.2 CEU) ISO 9001 Auditor course provides training on the standard itself and on how to lead or conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantitiy discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.

ISO 9001:2015 Overview – CALISO
On-Demand Course

4 Hours
I.D.# ISO-9001-2015-OVERVIEW

ISO 9001:2015 is a quality management standard developed by the International Organization for Standardization (ISO). The ISO 9001:2015 standard is generic and can be used for any organization, whether it provides physical products or services. The requirements must be carefully interpreted to make sense within a particular organization. Developing automotive products is not like producing food products or offering consulting services; yet the ISO 9001:2015 standard, because it is business and management oriented can be applied to any activity. It is the most widely used quality management standard in the world. Your company and all who partake in the daily business activities will benefit from taking ISO 9001:2015 training. This 4-hour ISO 9001:2015 overview is particularly adapted for training top management on the high level requirements of this standard.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantitiy discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.
ISO 9001:2015 Training – CALISO
On-Demand Course

10 Hours
I.D. # ISO9001TRAINING

ISO 9001:2015 is a quality management standard developed by the International Organization for Standardization (ISO). The ISO 9001:2015 standard is generic and can be used for any organization, whether it provides physical products or services. The requirements must be carefully interpreted to make sense within a particular organization. Developing automotive products is not like producing food products or offering consulting services; yet the ISO 9001:2015 standard, because it is business and management oriented can be applied to any activity. It is the most widely used quality management standard in the world. Your company and all who partake in the daily activities of running the business will benefit from taking ISO 9001:2015 training. This 10-hour ISO 9001:2015 course is particularly adapted for training all levels of an organization on the requirements of this standard.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

ISO 9001:2015 Lead Auditor – CALISO
On-Demand Course

32 Hours
I.D. # ISO 9001-2015-LEAD-AUDITOR

Your company and all who partake in planning, leading and conducting the audit activities of running the business will benefit from taking ISO 9001 Lead Auditor training. The 32-hour ISO 9001:2015 Auditor course is the most comprehensive training on the subject. It provides training on the standard itself but also on how to lead or conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.

ISO 9001:2015 Auditor Training – CALISO
On-Demand Course

1.8 Hours
I.D. # ISO-9001-2015-AUDITOR

Your company and all who partake in the daily activities of running the business will benefit from taking ISO 9001:2015 auditor training. The 18-hour Auditor online course is the most effective training on the subject. It provides training on how to conduct internal audits and supplier audits using ISO 19011, the guideline on how to audit management systems, and covers auditing all the requirements of the standard through various case studies.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.

ISO 14001:2004 Training – CALISO
On-Demand Course

8 Hours
I.D.# ISO14001

Your company and all who partake in the daily activities of running the business will benefit from taking ISO 14001 training. This eight-hour ISO 14001 (.8 CEU) overview is particularly adapted for all members of the organization.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.
ISO 14001:2004 Auditor Training – CALISO On-Demand Course
8 Hours
I.D.#ISO14001AUDITOR
ISO 14001 is an environmental management standard (EMS) developed by the International Organization for Standardization (ISO). The ISO 14001 standard is generic and can be used for any organization, whether it provides physical products or services. The requirements must be carefully interpreted to make sense within a particular organization. Developing automotive products and the environmental impact of this activity is not like producing food products or offering consulting services; yet the ISO 14001 standard, because it is business and management oriented can be applied to any activity. It is the most widely used EMS standard in the world. Your company and all who partake in the daily activities of running the business will benefit from taking ISO 14001 training. This eight-hour (.8 CEU) ISO 14001 Auditor course provides training on the standards and how to conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

ISO 14001:2004 Lead Auditor – CALISO On-Demand Course
22 Hours
I.D.#ISO14001LEADAUDITOR
As described in the previous ISO 14001 course description, ISO 14001 is an environmental management standard (EMS) developed by the International Organization for Standardization (ISO). Your company and all who partake in planning, leading and conducting the EMS audit activities of your business and managing its environmental program will benefit from taking ISO 14001 training. The 22-hour (2.2 CEU) ISO 14001 Lead Auditor course is the most comprehensive training on the subject. It provides training on the standard itself but also on how to lead or conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

ISO 14001:2004 Auditor Training – CALISO On-Demand Course
8 Hours
I.D.#ISO14001AUDITOR
ISO 14001 is an environmental management standard (EMS) developed by the International Organization for Standardization (ISO). The ISO 14001 standard is generic and can be used for any organization, whether it provides physical products or services. The requirements must be carefully interpreted to make sense within a particular organization. Developing automotive products and the environmental impact of this activity is not like producing food products or offering consulting services; yet the ISO 14001 standard, because it is business and management oriented can be applied to any activity. It is the most widely used EMS standard in the world. Your company and all who partake in the daily activities of running the business will benefit from taking ISO 14001 training. This eight-hour (.8 CEU) ISO 14001 Auditor course provides training on the standards and how to conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

ISO 14001:2015 Overview – CALISO On-Demand Course
4 Hours
I.D.#ISO-14001-2015-OVERVIEW
Your company and all who partake in the daily business activities will benefit from taking ISO 14001:2015 training. This overview course is particularly adapted for training top management on the high level requirements of this standard.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

ISO 14001:2015 Training – CALISO On-Demand Course
10 Hours
I.D.#ISO14001TRAINING
ISO 14001:2015 is an environmental management standard (EMS) developed by the International Organization for Standardization (ISO). The ISO 14001 standard is generic and can be used for any organization, whether it provides physical products or services. The requirements must be carefully interpreted to make sense within a particular organization. Developing automotive products and the environmental impact of this activity is not like producing food products or offering consulting services; yet the ISO 14001 standard, because it is business and management oriented can be applied to any activity. It is the most widely used EMS standard in the world.

Your company and all who partake in the daily activities of running the business will benefit from taking ISO 14001 training. This course is particularly adapted for all members of the organization.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.

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ISO 14001:2015 Auditor Training – CALISO On-Demand Course

12 Hours
I.D.# ISO-14001-2015-AUDITOR

Your company and all who partake in the audit activities of your business and managing its environmental program will benefit from taking ISO 14001 training. The ISO 14001 Auditor course is the most comprehensive training on the subject. It provides training on the standard itself but also on how to conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

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ISO 14001:2015 Lead Auditor – CALISO On-Demand Course

32 Hours
I.D.# ISO 14001-2015-LEAD-AUDITOR-TRAINING

Your company and all who partake in planning, leading and conducting the EMS audit activities of your business and managing its environmental program will benefit from taking ISO 14001 training. The ISO 14001 Lead Auditor course is the most comprehensive training on the subject. It provides training on the standard itself but also on how to lead or conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.

ISO/TS 16949:2009 Training – CALISO On-Demand Course

8 Hours
I.D.# ISO16949

Your company and all who partake in the daily activities of running the business will benefit from taking ISO/TS 16949 training. This eight-hour ISO/TS 16949 (.8 CEU) overview is particularly adapted for training all levels of an organization on the requirements of this standard.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.

ISO/TS 16949:2009 Auditor Training – CALISO On-Demand Course

8 Hours
I.D.# ISO16949AUDITOR

Your company and all who partake in the QMS and supplier audit activities will benefit from taking ISO/TS 16949 training. The eight-hour (.8 CEU) ISO/TS 16949 Auditor course is the most comprehensive training on the subject. It provides training on the standard itself but also on how to lead or conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.
ISO/TS 16949:2009 Lead Auditor Training – CALISO On-Demand Course

22 Hours
I.D.# TS16949LEADAUDITOR

This lead auditor course provides management representatives, QA managers or supervisors and others not only the information needed to conduct an audit for ISO/TS 16949, but also to organize, implement and lead it. All audit teams need a leader, and the body of knowledge of this course covers all of the lead auditing aspects.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantitiy discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.

ISO 19011:2011 Auditor Training – CALISO On-Demand Course

4 Hours
I.D.#ISO19

Your company and all who partake in the daily activities of running the business will benefit from taking ISO 19011 training for its auditing activities. The four-hour (.4 CEU) ISO 19011 course is the most comprehensive training on the subject. It provides training on the standard itself but also on how to lead or conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantitiy discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.

Six Sigma Overview – CALISO On-Demand Course

8 Hours
I.D.#SIGMA

Six-Sigma is a systematic way to improve a product, process and/or service. This is the ideal course for employees or managers who want to get a basic training on Six-Sigma concepts, methodology and techniques.

Six-Sigma methodology can be used for any size organization, whether it provides physical products (i.e. hardware or software) or services. Developing and maintaining profitable products and services require continuous improvement in numerous key areas such as quality, performance and efficiency. Six-Sigma techniques can help any company achieve these goals.

This is the ideal course for individuals who you want improve their résumé and career opportunities in Six-Sigma, by adding this industry-wide recognized course to the education or training section of your CV.

The course covers Six-Sigma process improvement techniques; it is a stepping stone for Six Sigma Green and Black-belt certifications.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantitiy discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.
MATERIALS AND MANUFACTURING

Includes manufacturing, parts and components, and assembly; as well as materials including plastics, alloys, and metals.

MANUFACTURING

Design for Additive Manufacturing: Towards End-Part Production Web Seminar

10 Hours
I.D.# WB1705

Additive manufacturing (AM), with origins in the 1980s, has only more recently emerged as a manufacturing process of choice for functional part production, adding to the suite of choices a designer has available when designing a part for manufacturing. Like other traditional processes like casting and machining, AM has its set of constraints. An added layer of complexity comes from the fact that there are several different AM processes, and some of the design constraints are process-specific. On the other hand, AM offers a range of opportunities in design freedom and mass customization as well as in cost and lead time reduction in some cases. Today, it is essential for designers to embrace AM as a possible manufacturing method to ensure their products are competitive and also to unlock the design innovation that AM enables.

The goal of this 10-hour course is to give designers the information needed to start designing for AM at all levels – identifying and justifying use of AM technology for a particular part, selecting the right process and material for the application and ensuring it is designed with the advantages and considerations of AM in mind. The course is not intended to serve as a software-training class or as a deep dive into any specific AM process, but rather to draw connections between design and AM from a designer’s perspective.

Learning Objectives

By connecting to this web seminar, participants will be able to:

• List the different polymer and metal AM process technologies and materials and identify which of these are being used for functional part production
• Select the optimum AM material and process for a particular application
• Predict how design decisions impact manufacturability for the selected AM process and apply design rules and guidelines to your design process
• Quantify the expected properties of the AM parts you are designing
• Discover how topology optimization, cellular structures and other disruptive design techniques can be leveraged with AM and associated software tools
• Identify the different drivers for adopting AM for a particular part, with regard to cost, lead time, supply chain and performance risks
• Relate to the challenges and ongoing research efforts to be able to move forward with AM implementation in the presence of rapid change in the field
• Develop a comprehensive strategy to bring AM for functional part production into your organization that addresses both the benefits and impacts
**MATERIALS AND MANUFACTURING**

**Who Should Attend**
This training is relevant to and needed by designers that work in aerospace and automotive companies and are chartered with either designing next generation solutions, or even with designing for cost, replacement parts or tooling used in the manufacturing process. Designers that can use existing design tools but need to learn enough about AM so they can use these tools to design parts suitable for these manufacturing processes will especially benefit from this course.

**Topical Outline**

**Session 1: Additive Manufacturing Process**
- Polymer AM
  - Fused Deposition Modeling (FDM)
  - Selective Laser Sintering (SLS)
  - Other processes and trends
  - Functional parts case studies
- Metal AM
  - Powder Bed Fusion (PBF): laser and electron beam
  - Directed Energy Deposition (DED)
  - Other processes and trends
  - Functional parts case studies
- Material Options and Selection
- Key Process Concepts
  - Build sizes
  - Part orientation
  - Support management
  - Post processing

**Session 2: Introduction to Design for AM**
- The Need for New Design Thinking with AM
- Four Levels of AM Design
  - Prototypes and tooling
  - Direct part replacement
  - Part consolidation
  - Design for AM optimized
- Introduction to Software Tools for AM
  - Solid modeling (CAD)
  - Topology optimization
  - Lattice materials design
  - Build preparation
  - Process simulation
- Support Fundamentals
  - Purpose of supports
  - Process dependence
  - Self-supporting design concepts
  - The importance of orientation
- Build Preparation SW Demos
  - Demo with Insight (FDM)
  - Demo with Magics (Metal)

**Session 3: Topology Optimization**
- Motivation: The Case for Sustainable Design
- Case Studies with AM
- Introduction to Optimization Concepts
- Material Models
  - Problem setup
  - Optimization
  - Smoothing
  - Validation
- Manufacturability

**Session 4: Lattice Materials Design**
- Biometric Underpinnings
- Classification of Cellular Materials
  - Volume/space-filling
  - Surface
- Functions and Performance Gains
  - Structural
  - Transport
  - Case Studies with AM
  - Modeling Approaches
  - Demo with nTopology
  - Manufacturability

**Session 5: Implementing AM - A Practical Guide for Designers**
- Part Selection for AM
  - Purdue scorecard for part evaluation for AM
  - Cost considerations
- Challenges and Open Questions
  - Environment, health and safety
  - Process, supplier, equipment selection
  - Material properties and modeling
  - Process variation: repeatability, reproducibility and tool-to-tool matching
  - Design software choices
  - Data handling & traceability
  - Standards
- Successful AM Adoption Transition Strategies
  - Polymer to metal
  - Prototype to end-use part
  - Outsourcing to in-house
- Resources

**Instructor:** Dhruv Bate

**Fee:** $720 1.0 CEUs
Metal Forming

2 Days
I.D.# 85012

This seminar covers metal forming and related manufacturing processes, emphasizing practical applications. From forged or P/M connecting rods to tailor-welded blank forming, metal parts are integral to the automotive industry. As a high value adding category of manufacturing, metal forming is increasingly important to the core competency of automobile manufacturers and suppliers. A thorough survey of metal forming processes and metal forming mechanics will be performed, including bulk deformation, sheet-metal, and powder metallurgy operations. Design considerations are fully integrated into the course and are presented with every process. A large number of real-world case studies are presented to the attendees to emphasize course content. Attendees will receive a copy of the book *Manufacturing Engineering Technology*, co-written by instructor Steven R. Schmid.

Learning Objectives

By attending this seminar, participants will be able to:

- Identify the unique characteristics of metals that lead to plastic deformation as a processing strategy
- Explain the processes involved in metal forming mechanics, materials, and tribology
- Analyze the interrelationships between various factors that influence the quality of manufactured products
- Describe sheet metal characteristics and forming
- Describe the wide variety of processes used to shape and deform metals, including forging, rolling and extrusion; sheet metal forming, shearing and stamping; powder metallurgy processes and assorted other processes

Who Should Attend

This course is designed for engineers who are involved in metal forming and other related manufacturing processes.

Topical Outline

DAY ONE

- Overview of Solid Mechanics and Materials Science Topics of Importance to Metal Forming
- Tribology of Metal Forming: Friction, Lubrication and Wear
- Bulk Deformation Processes
  - Forging: open die and closed-die (impression) forging; machinery description and capabilities; forging process layout and die design; heading, coining, piercing and upsetting operations; swaging
  - Rolling: flat rolling process, including Orowan model; control of product quality including surface finish and gage control; rolling equipment and capabilities; shape rolling; ring rolling
  - Extrusion and drawing: direct, indirect and hydrostatic extrusion; cold and hot extrusion; die design; defects in extrusion; drawing equipment and mechanics; limiting drawing ratio

DAY TWO

- Sheet Metal Forming Processes
  - Sheet metal shearing: mechanics of shearing, burr formation, blanking operations, fine blanking
  - Sheet metal bending: types of bending operations and equipment; springback calculation and control; tube bending
  - Sheet forming operations: deep drawing and ironing; stretch forming; bulging, rubber forming and hydroforming; roll forming of sheet; spinning; incremental forming; explosive, peen and other specialty forming processes; stamping operations and die design
  - Sheet metal formability: limiting drawing ratio for deep drawing; sheet metal formability; forming-limit diagrams
- Powder Metallurgy Processes
  - Compaction through pressing, cold and hot isostatic pressing and metal injection molding; sintering mechanics and processes; coining and finishing

Instructor: Steven R. Schmid
Fee $1370 1.3 CEUs
Automotive Plastics: Principles of Materials & Process Selection

2 Days  
I.D.# C0135

Plastic - any class of synthetically-produced organic compounds capable of being molded and hardened into a specific shape or form. This course is designed to offer a basic understanding of plastics and plastic processing. Using plastics can be simple, but there is much more behind producing high performance plastic parts. This seminar will walk you through the molding process, provide a comprehensive look at the variables in the manufacturing mix, and review characteristics of typical automotive plastics such as PP, PVC, ABS, and more. This seminar will also cover troubleshooting molding mistakes and alternative processes, and review the selection of an application’s appropriate plastic material. Material presented is both an excellent foundation for further development and an extensive update for those already working in the field.

Learning Objectives

At the completion of this seminar, attendees will be able to:
- Demonstrate an understanding of typical automotive plastics and primary and application-specific plastics processing methods
- Recognize key plastics terminology and parameters related to plastics
- Explain alternative molding processes
- Prevent or reduce molding mistakes
- Understand the molding cycle
- Troubleshoot the processing operation

Who Should Attend

This seminar is designed for those new to automotive plastics and those with some experience. The program will benefit product designers, process, project, manufacturing, and material engineers, purchasing agents, and sales and marketing professionals.

Topical Outline

DAY ONE
- Introduction to Injection Molding
  - Process description
  - Product description
  - Business overview
- The Injection Molding Machine
  - Clamp systems
  - Plastication unit
  - Screw
  - Controls
- The Molding Cycle
  - Pressure in process
  - Velocity generation, including mold filling, mold packing, cooling, ejection, material melting and material handling.

DAY TWO
- Typical Injection Molding Mistakes
  - Melt temperature
  - Material drying
  - Contamination
  - Over packing
  - Incomplete fill
  - Oversized machines
  - Undersized machines
  - Temperature control
- Mold(s)
- Function
  - Forming
  - Cooling
- Basic Design Requirements
  - Clamp slots
  - Ejection “hole”
  - Support
  - “Seal-off”

Instructor: Robert G. Speirs
Fee $1370 1.3 CEUs
Introduction to Advanced High Strength Steel Applications and Manufacturing

2 Days
I.D.# C1416

Advanced High Strength Steels (AHSS) are now commonly used in automotive body structural applications. The high strength of this grade classification is attractive to help reduce mass in the automotive body through reduction in thickness. Strength also supports improvements in safety requirements so that mass increases are minimized. In some specific grades of AHSS, energy absorption is possible in addition to the high strength. This course will review the definition and properties of AHSS and cover several common applications in automotive body structures. In addition, key manufacturing areas including stamping and welding will be addressed to demonstrate the increased challenges as compared to lower strength steel grades. Troubleshooting of typical engineering and production problems will round out the seminar leaving attendees with tools to help design more robust engineering solutions to AHSS applications.

Learning Objectives
By attending this seminar, participants will be able to:
• Define AHSS grades and describe general properties of AHSS
• Identify potential applications for AHSS
• Describe key manufacturing processing issues
• Assimilate tools for trouble shooting part issues

Who Should Attend
This course is designed for Automotive Body Engineers, Die Engineers, Designers, Manufacturing Plant Personnel, New Hires in the Steel Industry, Supervisors, Planners, and others who would like to decrease vehicle weight through the use of AHSS.

Topical Outline
DAY 1
• Background/Overview of AHSS
  • Definition
  • Types of AHSS
  • Typical chemistry and properties
  • Comparison to High Strength Low Alloy (HSLA) Steels
  • Thermo-mechanical processing
  • Coatings
  • Material call-outs
  • Availability of grades/gauges/coatings/coil widths
• Product Applications and Design Considerations
  • Typical automotive body and chassis applications
  • Crash performance advantages
  • Design for manufacturability

Day Two
• Stamping Tooling
  • Formability
  • Springback
  • Effect of material variation
  • Press tonnage
  • Edge fracture
  • Lubrication
• Die design standards
• Die materials and surface treatments
• Die maintenance
• Die Try-Out
  • Proof tooling
  • Trouble shooting
  • Lessons learned
• Hot Stamping Overview
• Roll Forming
• Welding / Joining
  • Other assembly considerations
• Types of Welding
  • Key elements of resistance welding
  • Weld Quality Testing
  • Difference in RSW of AHSS versus Mild Steels
• Other automotive assembly joining
• Case Studies

Instructor: Jody N. Hall
Fee $1370 1.3 CEUs

Materials Selection Process for Engineering Designs Web Seminar

8 Hours
Web Seminar: I.D.# WB1520

Any product is a collection of materials that have been manipulated into various shapes to form the components and joints used within the product. In fact, up to 70% of the cost to make a product is due to its materials. Therefore, getting the materials right will have a big impact on the success of a product. However, many organizations have difficulties getting the materials right and end up facing problems such as repeating product verification tests because sub-optimum materials fail, product failures associated with materials that degrade too fast, components that cost too much or are difficult to manufacture, suppliers incapable of providing materials and components that consistently meet requirements, and low manufacturing yields. These problems result in increased costs, missed schedules, and
unhappy customers. A major reason for these problems is that design teams do not use a methodical approach for selecting materials.

This eight-hour web seminar covers the engineering process for selecting materials to use for components and joints within a product. Applying the process enables selection of materials that optimize product performance, reliability and cost, while helping keep projects on schedule. The topics covered include identifying materials selection criteria, selecting candidate materials, and evaluating materials to determine their suitability. Considerations include design for reliability and design for manufacturability. Case studies will be used to reinforce the concepts taught.

Note: Because this content is focused on product design, discussion of the science of specific materials is outside the scope of this course. Examples used will be based on input from participants about products on which they are actively working or have developed in the past.

**Learning Objectives**

By connecting with this web seminar, students will be able to:
- Explain the steps for the materials selection process
- Describe the categories of product design requirements that must be considered for materials selection
- Identify materials selection criteria based on the product design requirements
- Explain how to identify potential materials to use for a component or joint
- Identify the evaluations needed to determine whether materials are suitable for an application

**Who Should Attend**

This course will be beneficial to design engineers (mechanical and electrical) of all levels who select materials to use in products and to program engineers who have to plan product development schedules. This includes engineers within any industry supported by SAE. The information will enable design teams to more quickly assess risks to meeting development schedules and budget and improve the probability of developing products that meet performance, reliability, and cost requirements. The course will also be beneficial to engineering managers, program managers, and manufacturing engineers.

**Topical Outline**

Session 1
- Materials Selection Process Steps
- Iterative Process and Trade-offs
- Design Hierarchy Between Component Physical Construction and Materials
- Design Requirements Categories
- Identify Product, Sub-assembly, and Component Requirements for the Different Design Requirements Categories
- Identify Component Materials Selection Criteria
- Session 2
- Identify Potential Materials
- Risk Management
- Session 3
- Identify and Perform Tests to Evaluate the Materials
  - Properties, microstructure, composition, manufacturing defects
  - Performance
  - Reliability
  - Ease of use in manufacturing and assembly processes
- Session 4
- Determining Whether Materials Satisfy Selection Criteria
- Making the Final Choice

Instructor: Michael Pfeifer
Fee $640 .8 CEUs

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**Materials Degradation in Mechanical Design: Wear, Corrosion, Fatigue and their Interactions Web Seminar**

10 Hours
Web Seminar: I.D.# WB1722

Materials degradation from environmental conditions is a common factor that will often occur in mechanical equipment used in every type of environment. These processes can frequently materialize in unpredicted and harmful ways, especially when they interact and lead to early component damage or failure.

This five-session course will summarize the mechanisms that cause materials and mechanical components to degrade in service through exposure to deleterious mechanical and environmental conditions. The course is designed to develop knowledge of issues of material degradation in service and the effect upon the performance and reliability in the process of mechanical design. These processes include wear, corrosion, fatigue, and their interactions. The instructor will take a practical approach to the topics to allow participants to cite the causes of performance reduction. Potential solutions will be covered including material selection and material or design modifications that would improve component life and performance in a range of harmful environments or operating conditions. The review of each mechanism will include a presentation of the fundamental basis for these failure mechanisms, followed by practical examples of how they occur in reality.
Learning Objectives
By connecting with this web seminar, students will be able to:
• Cite the typical wear mechanisms that occur in mechanical equipment and their causes
• Cite the basic corrosion mechanisms and their causes
• Identify the interactions that occur between wear, corrosion and fatigue
• Suggest practical material or design solutions to those damage mechanisms

Who Should Attend
Engineers who design and process mechanical equipment; applications engineers involved in equipment or component design specific to an industrial application; materials, process and equipment development engineers; plant engineers; test engineers responsible for product or component testing and analysis of failed mechanisms; and quality engineers who establish methods and procedures for component reliability and analysis of failed components will benefit most from this course.

Topical Outline
Session 1: Corrosion
• Electrochemical cell
• Galvanic series
• Corrosion mechanisms:
  • Galvanic corrosion
  • Uniform attack
Session 2: Corrosion (cont.)
• Corrosion mechanisms (cont.)
  • Crevice corrosion/pitting
  • Stress corrosion cracking
• Effects of corrosion on component life
• Corrosion solutions and prevention
Session 3: Wear
• Adhesion
• Abrasion
Session 4: Wear (cont.)
• Fretting
• Tribo-corrosion
• Fatigue wear
• Erosion
Session 5: Lubrication
• Theory and application and the effects on friction and wear

Instructor: Michael Kim
Fee $720 1.0 CEU

Material Selection and Testing for Plastics
2 Days
I.D.# C0134
Today’s necessity for quickly delivering products to market limits product development time and leaves less room for error and ‘re-dos.’ With so many plastic materials available, it is crucial that those involved in product design understand resin properties and how they affect part design and manufacturability. To help you make the best plastic choices the first time, this seminar provides an overview of polymer chemistry, explains the methods for testing properties of plastics and presents a method of systematic selection that will optimize your plastics material selection process.

Learning Objectives
At the conclusion of this seminar, attendees will be able to:
• Understand the properties of plastic materials
• Know what types of instruments are used in testing
• Demonstrate methods used to test the properties of plastic materials
• Possess the technical background necessary to select the optimum resin for a given application
• Apply measurements to the standards and specifications so the material and design meet an application’s service requirements

Who Should Attend
This seminar will benefit product and part designers, engineers, engineering managers and those involved in the development of plastic parts. Specifically designed to enhance on-the-job effectiveness for professionals at all levels of plastics part development, this course will provide an invaluable foundation for selecting plastic materials and understanding their capabilities and limitations.

Topical Outline
DAY ONE
• Introduction to Plastic Materials
  • Definitions
  • Thermoset vs. thermoplastics
  • Good (and bad) characteristics
• General properties
• Brief history
• Economic “position” (commodity vs engineering vs specialty)
• Plastics-General Overview
  • Materials form; Shipment sizes
  • Pre-compounded vs blended
  • Drying/storing
  • Handling
Surface Texture: Specification and Control
1 Day
I.D.# C1110

Surface texture is one of the most important topics in today’s world of design, development and performance. As tolerances are shrinking and performance demands are increasing, surface texture is rapidly becoming one of the most important aspects of engine and vehicle performance. Every moving component on a vehicle or engine is influenced by surface texture in one or more of the following ways: vibration, sealing, adhesion, traction, emissions, safety, durability, wear/failure analysis. Many of the industry’s top warranty issues (leaks, noise, vibration, etc.) are a direct result of surface texture implications. Rather than focus on the theories of surface texture, this course will focus on the applications of these concepts to automotive applications - thereby giving the attendees tools that they can immediately use as they solve automotive problems such as cylinder bores and emissions control, crankshafts, camshafts and early engine failures, brakes and NVH, wheel bearings and vibration, gaskets and sealing, bearings and durability, pistons and durability, and shaft straightness and vibration.

Learning Objectives
By attending this seminar, participants will be able to:
• Communicate clear descriptions of surface texture in reports and product documentation
• Recognize roughness and waviness impacts on components
• Recognize measurement errors and avoid misinterpretations of results
• Specify surface texture according to ISO 1302
• Identify and specify functional wavelength regimes for surface texture

Who Should Attend
This topic bridges all fields within the automotive industry and is designed for engineers and technicians involved in: the specification of mechanical systems and components; failure analysis and warranty; quality control and measurement functions, manufacturing and process development. The areas of interest could include: sealing, sliding, cosmetic appearance, friction, leakage and more.

Topical Outline
• The Language of Surfaces
  • Roughness
  • Waviness
  • Form
• The Measurement of Surfaces

Instructor: Robert G. Speirs
Fee $1370 1.3 CEUs
MATERIALS AND MANUFACTURING

- Describing Wavelength Regimes
- Separating roughness from waviness
- Distortions that can occur in the data and how to deal with them
- Choosing the right filter cutoff
- Surface Texture Interactions with other Tolerances like GD&T
- Parameters
- Specifying Surface Texture

Instructor: Mark Malburg
Fee $810 .7 CEUs

METALLURGY

Principles of Metallurgy
4 Hours
I.D.# PD261322ON

This on demand course teaches the basic microscopic structures present inside of metals, how these structures and metal composition influence metal strength, and how these structures can be modified using common manufacturing processes to obtain specific mechanical properties. Several examples are presented to demonstrate how common alloying and manufacturing methods are used to modify the microscopic structures and properties of metals. It includes twelve modules followed by a quiz.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.

Failure Analysis of Metals
5 Hours
I.D.# PD261505ON

Quickly getting to the bottom of a metal failure is critical for preventing future failures, keeping customers happy, and keeping manufacturing lines running. This course will teach you how to perform failure analysis of fracture, corrosion, and manufacturing failures.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.

Hardness Testing
30 Minutes
I.D.# PD261331ON

This on demand course focuses on Rockwell and Brinell hardness testing and Vickers and Knoop microhardness testing. Participants will learn about how the tests are performed, test sample requirements, test parameter selection, and testing requirements. The course can be completed in 30 minutes.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.
MATERIALS AND MANUFACTURING

Metallurgy of Precipitation Strengthening
2 Hours
I.D.# PD261329ON
This on demand course teaches about the microscopic changes that take place in a precipitation strengthened alloy and their effects on the properties of the alloy. The effects of the different heat treating steps (solution treatment, quench, and aging) and heat treating process parameters (solution treatment temperature and time, quench rate, and aging temperature and time) on the alloy microstructure and the effects on alloy strength are discussed. The course is divided into five modules followed by a quiz.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Metallurgy of Steel Through Hardening
1 Hour
I.D.# PD261330ON
This on demand course teaches about the metallurgy of the following steel through hardening processes: quench and temper, martempering, and austempering. Participants will learn about the effects of heat treating temperature and cooling rate on steel microstructure and properties, and the effects of the interaction between heat treating process parameters and steel composition on through hardened steel microstructure and strength. This course takes one hour to complete.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Metallurgy of Steel Case Hardening
1 Hour
I.D.# PD261333ON
This on demand course discusses common steel case hardening processes and how they are used to modify the surface layers of steels to obtain specific mechanical properties. Participants will learn about the process parameters and how they affect case composition, depth, microstructure, and properties. The course takes one hour to complete.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Metallurgy of Steel: Principles
3 Hours
I.D.# PD261326ON
This on demand course teaches the phases and microstructures that form in steels, their effects on steel properties, the microstructure changes that occur when steel is heated and cooled, and the effects of carbon content and cooling rate on the microstructures that form. Also, how to read the iron-carbon phase diagram will be discussed. All this information is applicable to understanding the effects of steel heat treating processes and heat treating process parameters on the microstructure and properties of heat treated plain carbon, low-alloy, and tool steels. The course is divided into six modules followed by a quiz.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.

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**Tensile Testing**

**Duration:** 30 Minutes  
**I.D.#** PD261308ON  

This on demand course teaches about tensile testing of metals with a focus on how the testing is performed and tensile properties are measured. It includes one module followed by a quiz.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.

**Electroplating**

**3 Hours**  
**I.D.#** PD261735ON  

Electroplating involves the deposition of thin layers of metal on metal components and metal stock. There are several uses for electrodeposited coatings including cosmetic, corrosion resistance, and wear resistance. Knowledge about electroplating and electroplated coatings is important for product design, preventing and solving quality problems, and evaluating supplier capabilities and quality.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.

**Aluminum Metallurgy**

**1 Hour**  
**I.D.#** PD261734ON  

There are a wide variety of wrought aluminum alloys, each developed to provide specific properties. Getting the strength you need in an aluminum alloy requires knowledge of the effects of alloy composition, cold-working, and heat treating on aluminum metallurgy and properties. A good understanding of how aluminum alloys behave and what can be done to modify their properties is critical for being more productive and profitable. The course takes about one hour to complete and consists of one module and a final exam. Also, quizzes and problems give you opportunities to apply the concepts taught.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.

**Corrosion of Metals**

**5 Hours**  
**I.D.#** PD261328ON  

This online course teaches about corrosion of metals. The physics of corrosion is explored as a background for the discussion of seven common types of corrosion (uniform, galvanic, crevice, pitting, intergranular, stress corrosion cracking, and dealloying). Students will learn why and how corrosion occurs and methods for controlling corrosion. It includes eleven modules followed by a quiz.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.
RELATING TRAINING SOLUTIONS
Some of our courses apply to more than one technology category. Consider these related courses described in other sections of this resource guide.

Design for Manufacturing & Assembly (DFM/DFA)
Design for Manufacturing and Assembly (DFM+A), pioneered by Boothroyd and Dewhurst, has been used by many companies around the world to develop creative product designs that use optimal manufacturing and assembly processes. Correctly applied, DFM+A analysis leads to significant reductions in production cost, without compromising product time-to-market goals, functionality, quality, serviceability, or other attributes. In this two-day seminar, you will not only learn the Boothroyd Dewhurst Method, you will actually apply it to your own product design!
Read more about this course on page 48

Design for Manufacture and Assembly (DFM/DFA)
This seminar provides a functional understanding of the principles involved in conducting a Design for Manufacture/Design for Assembly study. DFM/DFA can support both manual and automated processes resulting in significant cost savings through simpler designs with fewer components.
Read more about this course on page 54

Sound Package Materials for Vehicle Noise Control
The two day seminar starts with the fundamentals of NVH and sound quality related to sound package materials and discusses the importance of various noise sources that impact the development of sound package treatments in a vehicle.
Read more about this course on page 146

Vehicle Sound Package Materials
This four-session web seminar provides a detailed understanding of the source – path-receiver relationship for developing appropriate sound package treatments in vehicles, including automobiles, commercial vehicles, and other transportation devices.
Read more about this course on page 147
NOISE, VIBRATION AND HARSHNESS

Includes acoustics, engine noise control, sound package materials, vibration, and harshness.

Acoustic Fundamentals for Solving Noise and Vibration Problems Web Seminar and Web Seminar RePlay

6 Hours
Web Seminar: I.D.# WB1309
Web Seminar RePlay: PD331309ON

This web seminar will provide an introduction to the characteristics of sound waves, human perception of sound, sound and vibration measurements, measurement facilities, and various noise sources and noise control principles. It will include an overview of sound pressure, power, intensity, decibels, and frequencies. Practical examples will be used to familiarize participants with the acoustic fundamentals for solving noise and vibration problems and the associated solution principles.

Learning Objectives

By connecting with this web seminar, participants will be able to:
• Discuss the differences of various acoustic terminologies that are important to solve noise and vibration problems
• Define a relationship between sound pressure, sound power, and sound intensity
• Associate decibel to both sound and vibration
• Prepare effective acoustic specifications encompassing all variables that affect noise and vibration
• Select correct instrumentation for noise and vibration measurements recognizing the challenges of measurements
• Define the source-path-receiver relationship
• Determine the steps of noise and vibration source identification process for a given application
• Employ different noise control options to address specific noise and vibration issues

Who Should Attend

This fundamental web seminar will be especially valuable for technical staff, engineers, and managers with limited experience in noise and vibration. It is designed to be suitable for all areas of the mobility industry. An Associate degree in the field of science or technology is recommended; BS degree is preferred.

Topical Outline

Session 1
• Introduction
  • Waves
  • Pressure, power, intensity
  • Frequency
  • Human perception of sound
• Decibels
  • What is decibel
  • Addition and subtraction of decibels
  • Background noise
  • Linear averaging/spatial averaging
• Frequency
  • Frequency Analysis
  • Linear and logarithmic frequency
  • Filters
Session 2
• Human Perception of Sound
  • Equal Loudness contours
  • Frequency weighting of sound
  • Loudness, loudness level, articulation index
• Instrumentation and Facilities
  • Transducers
  • Spectrum analyzers
  • Anechoic/hemi-anechoic room
  • Reverberation room
NOISE, VIBRATION AND HARSHNESS

- Sound power measurements
- Source-path-receiver relationship

Session 3
- Various Noise Sources
  - Product noise
  - Community Noise
  - Industrial noise
  - Vehicle noise
  - Aircraft noise
- Noise Control Principles
  - Sound package materials
  - Absorber, barrier, damper, isolator
  - Mufflers, resonators
  - Active and passive noise control

Instructor: Pranab Saha
Fee $550 .6 CEUs

Diesel Engine Noise Control Web Seminar and Web Seminar RePlay

4 Hours
Web Seminar: I.D.# WB1041
Web Seminar RePlay: I.D.# PD331041ON

This web seminar provides an in-depth overview of diesel engine noise including combustion and mechanical noise sources. In addition, the instructor will discuss a system approach to automotive integration including combining sub-systems and components to achieve overall vehicle noise and vibration goals.

Learning Objectives
By connecting with this Web Seminar, participants will be able to:
- Identify and analyze commonly occurring diesel engine noise sources
- Understand how analytical and experimental techniques can be used to solve diesel noise issues
- Prescribe appropriate noise control analysis and solutions for specific diesel engine NVH issues

Who Should Attend
Those who wish to understand the root causes of many diesel engine noise issues, and how to use this understanding to better diagnose and control diesel engine-related noises.

Prerequisites
Those intending to take this web seminar should have at least a Bachelor’s degree in engineering, or equivalent, and be familiar with basic engineering mechanics and vibrations.

Topical Outline
Session 1
- The Basics of Diesel Engine Noise
- Combustion Noise Forcing Functions
- Combustion Mode Switching
- Mechanical Forcing Functions in Diesels
- Separating Combustion and Mechanical Noise Sources
- Strategies for Reducing Forcing Functions

Session 2
- Surface Radiated Noise
- Exterior Covers: Radiated Sound and Simulation Modeling
- Gear Train Noise Issues and Countermeasures
- Drive-By Noise Contribution
- Diesel Engine Design Considerations for Low Noise
- Application Noise Issues

Instructor: Thomas Reinhart
Fee $425 .4 CEUs

Introduction to NVH Aspects of Hybrid and Electric Vehicles

1 Day
I.D.# C1128

The influx of different hybrid and electric vehicle configurations has brought about unique NVH challenges from a variety of sources. NVH refinement is an important aspect of powertrain development and the vehicle integration process. While developing the NVH behavior of the vehicle is critical to satisfy customer expectations, it is also important to consider the influence of reduced exterior noise levels on pedestrian safety. This seminar introduces participants to basic NVH principles and unique NVH challenges encountered in the development of HEV, ReEV, and EV including engine start/stop behavior, electric motor whine, driveline NVH, body structure, influence of noise from accessories, and sound quality development, as well as potential countermeasures.
Learning Objectives
Upon completion of this seminar, participants will be able to:
• Articulate the basic principles of NVH
• Describe the relative importance of powertrain noise, wind noise, and road noise in the vehicle’s interior
• Identify the key sub-components of powertrain noise and means to control them
• Explain the key NVH issues specific to electrified vehicles and means to develop appropriate countermeasures
• Identify key metrics available to assess the NVH performance of electrified vehicles
• Develop an awareness of advanced NVH methodologies available to design the sound character of electrified vehicles

Who Should Attend
This seminar has been developed for engineers involved in all fields related to the design or development of electrified vehicles. Individuals involved with component design/release responsibilities in ICE, electric motor, transmissions, powertrain mounts, vehicle body, and chassis areas will find this course helpful.

Prerequisites
An undergraduate degree in engineering or a strong technical background is highly recommended. A basic knowledge of college algebra, college physics, and a familiarity with vehicle and powertrain systems is needed.

Topical Outline
• Automotive NVH Fundamentals
  • Fundamentals of noise, vibration, and sound quality
  • Vehicle NVH
  • Powertrain-induced interior noise
  • Engine noise
  • Transmission noise
  • Driveline noise
  • Intake noise
  • Exhaust noise
  • Road-induced noise
  • Wind noise
  • Vehicle interior noise simulation for powertrain-induced noise
  • Vehicle interior noise simulation for road-induced noise
  • Vehicle sound quality
  • Vehicle exterior noise simulation
• HEV, ReEV, PHEV, and EV NVH
  • HEV, ReEV, PHEV, and EV architecture definition
  • “Road Map” for vehicle NVH development of HEV, ReEV, PHEV, and EV
  • ICE start/stop noise using case study examples
  • ICE start/stop vibration using case study examples
  • Active control for start/stop refinement using case study examples
• Motor NVH using case study examples
• HEV/EV driveline NVH using case study examples
• Power electronics noise
• Accessory noise
• Application of powertrain-induced vehicle interior noise simulation
• Application of road-induced vehicle interior noise simulation
• Sound character of EV using case study examples
• Sound character of ReEV using case study examples
• Exterior noise considerations for EV and ReEV

Instructor: Kiran Govindswamy
Fee $810 .7 CEUs

Practical NVH Signal Processing Methods
2 Days
I.D.# C0431

Signal processing has become a critical tool in optimizing vehicle noise. This seminar will help you to understand the foundation common to all NVH data acquisition equipment including digitizing, windows, aliasing, averaging techniques, and common analysis functions such as the power spectrum, transfer function and coherence. Fundamental concepts such as filtering, modulation, convolution, and correlation, as well as specialized techniques used in rotating machinery such as adaptive re-sampling and order tracking, will be covered. The seminar will also cover multi-input multi-output (MIMO) signal processing, array based solutions for force identification, source and path characterization and data visualization. Brief introductions to emerging concepts will also be explored and computer demonstrations, physical experiments and case studies will be used to illustrate applied, real-world problems.

Learning Objectives
By attending this seminar, participants will be able to:
• Explain the fundamental controls typical in modern spectrum analysis tools
• Interpret NVH data and judge its relevance to physical phenomena
• Extract new types of useful information from NVH data
• Implement new signal processing techniques

Who Should Attend
NVH technicians, engineers and managers who want to understand how NVH data is produced and interpreted will find this seminar valuable. The material is presented at a level suitable for beginners, but offers the more experienced practitioners new insight into the concepts presented through the illustrations and demonstrations that are included.
Sound Package Materials for Vehicle Noise Control

2 Days
I.D.# 92032

Similar content is available in the live, online web seminar - Vehicle Sound Package Materials – see course description below.

The sound package materials for vehicle noise control seminar provides a detail and thorough analysis of three different classes of acoustical materials – namely absorbers, barriers, and dampers, how they are different from each other, and acoustical properties that materials should possess for optimum vehicle noise control. The seminar addresses new advances in acoustical materials, primarily in absorption materials that impact the vehicle acoustics. The seminar covers ways to evaluate the acoustical performance of these materials using different test methods, including material, component, and vehicle level measurements. The two day seminar starts with the fundamentals of NVH and sound quality related to sound package materials and discusses the importance of various noise sources that impact the development of sound package treatments in a vehicle.

Learning Objectives

By attending in this seminar, participants will be able to:
• Identify various descriptors that are used in NVH and sound quality while working with sound package materials
• Recognize various noise sources and paths in a vehicle
• Identify three different classes of acoustical materials
• Describe ways that acoustical materials work and how they differ from each other
• Road map for vehicle sound package development
• Distinguish test methods used to evaluate the acoustical performance of material

Who Should Attend

Designed for OEM or supplier employees responsible for various noise activities, such as design, evaluation, trouble-shooting, procuring, supplying, and/or manufacturing noise control treatments and parts. This seminar will also benefit those with responsibilities including the areas of manufacturing, design, engineering, process, noise and release engineering, supervision or management. Attendees should have an undergraduate engineering degree and/or a working knowledge of noise control and automotive acoustics.

Topical Outline

• Fundamentals of NVH and Sound Quality
  • Defining acoustical performance of acoustical parts
  • Definition of terms
  • Human response to sound
  • Various noise and vibration instrumentation

Instructor: Michael F. Albright

Fee $1370 1.3 CEUs
• Vehicles Noise Sources and Solutions  
  • The noise system  
  • Vehicle noise sources  
  • Road and wind noise  
  • Miscellaneous noise sources  
  • Noise control solution - source, path, receiver  
  • Noise control system using sound package materials  
• Materials for Vehicle Noise Control  
  • Absorber, including case studies and test methods  
  • Barrier, including case studies and test methods and the effect of holes  
  • Damper, including case studies and test methods  
  • Isolator  
• Different Automotive Measurements  
  • Vehicle  
  • Component  
  • Material

Learning Objectives
By participating in this web seminar, participants will be able to:
• Identify various descriptors that are used in acoustics while working with sound package materials  
• Identify three fundamentally different sound package materials that are used in the industry  
• Explain how these materials work and how to improve their performance  
• Describe how various measurements are made and why they are necessary on a material level, component level, and vehicle level  
• Prescribe appropriate sound package materials for specific NVH issues  
• Construct proper protocols for combining different sound package materials for different components so that the final vehicle meets the required acoustic target

Who Should Attend
This web seminar will be especially valuable for those new to the vehicle sound package area and those interested in how absorbers, barriers, and dampers work, how they are different from each other, how they interact with each other in an application, and what one needs to be aware of while making measurements so the results are meaningful. The course is also designed for OEM or supplier engineers and those in roles involved with design, evaluation, trouble-shooting, procuring, releasing, supplying, and/or manufacturing noise control materials and parts for passenger cars and light trucks, heavy trucks, off-highway vehicles, farm machinery, and other transportation systems including aircraft, watercraft and rail transit. An undergraduate degree and familiarity with basic acoustics and vibration, or acoustical materials would be beneficial.

Topical Outline
• Vehicle Noise Sources and Solutions  
  • The noise system – sources  
  • Ranking noise paths  
  • Source-path-receiver relationship  
  • The noise control system using sound package materials  
• Sound Package Material – Absorber  
  • Application  
  • Primary function  
  • Effect of various parameters  
  • How it works  
  • How to improve performance  
  • Case studies  
  • Measurements

Instructor: Pranab Saha  
Fee $1370  1.3 CEUs

Vehicle Sound Package Materials Web Seminar and Web Seminar RePlay
8 Hours  
Web Seminar: I.D.# WB1204  
Web Seminar RePlay: I.D.# PD331204ON

Similar content is available in the classroom seminar – Sound Package Materials for Vehicle Noise Control – see course description above.

This four-session web seminar provides a detailed understanding of the source – path-receiver relationship for developing appropriate sound package treatments in vehicles, including automobiles, commercial vehicles, and other transportation devices. The course provides a detailed overview of absorption, attenuation (barrier), and damping materials and how to evaluate their performances on material, component, and vehicle level applications. A significant part of this course is the case studies that demonstrate how properly designed sound package materials successfully address vehicle noise issues.
NOISE, VIBRATION AND HARSHNESS

- Sound Package Material – Barrier
  - Application
  - Primary function
  - How it works
  - How to improve performance
  - Case studies
  - Measurements

- Sound Package Material – Damper
  - Application
  - Primary function
  - How it works
  - How to improve performance
  - Case studies
  - Measurements

- Component and Vehicle Level Noise Measurements
  - Why
  - How
  - The need for standards and targets for NVH studies

Instructor: Pranab Saha
Fee $640 .8 CEUs

RELATED TRAINING SOLUTIONS
Explore these courses related to noise, vibration, and harshness listed in other sections of this resource guide.

Brake Noise Problem Resolution
This course will provide you with an overview of the various damping mechanisms and tools for analyzing and reducing brake noise. A significant component of this course is the inclusion of case studies which will demonstrate how brake noise squeal issues have been successfully resolved.

Read more about this course on page 11.

Introduction to Brake Noise, Vibration, and Harshness
This seminar provides an introduction to brake NVH, including a concise summary of the various brake NVH problems, current lab and vehicle measurement techniques and SAE global standards which are utilized to characterize the noise correctly in order to get the best option/solutions quickly.

Read more about this course on page 18.

Vibration Analysis Using Finite Element Analysis (FEA) Web Seminar
This web seminar introduces vibration analysis performed with Finite Element Analysis (FEA). The course reviews basic concepts of vibration analysis and illustrates how they are implemented in FEA to simulate product behavior. The most common types of vibration analysis such as modal, time response, and frequency response are covered.

Read more about this course on page 66.
POWER AND PROPULSION

Includes the vehicle powertrain and components: transmissions and the drivetrain; all-wheel drive systems; gasoline and diesel engines and engine components; emissions and emissions control; hybrid and electric vehicles; and fuels.

POWERTRAIN AND DRIVETRAINS

A Familiarization of Drivetrain Components

2 Days
I.D.# 98024

Similar content is available in an on demand course. Review the course info in the On Demand Courses Guide on page 199.

An efficient, robust, and quiet running drivetrain is as essential to customer satisfaction as styling and interior creature comforts. In this seminar, you will be exposed to various methods that can be used to accomplish this goal. Designed to help you visualize both individual components and the entire drivetrain system - without reference to complicated equations - this seminar focuses on the terms, functions, nomenclature, operating characteristics and effect on vehicle performance for each of the drivetrain components. Attendees will receive an introduction to the various components of the drivetrain, including the clutch or torque converter, manual or automatic transmission, driveshaft, axle, wheel ends, and brakes.

This course also provides insight into: the structure and function of each component; vehicle integration; and related noise, vibration and harshness issues. You will be equipped to evaluate the space requirements, mounting needs, clearances required, and effect on vehicle response for each component.


Learning Objectives
By attending this seminar, participants will be able to:
• Discuss both practical and technical aspects of smoothing clutch operation by incorporating cushion and torsional dampers.
• Compare different types of transmission synchronizers, automatic transmission torque converters, hydraulic clutch operation and epicyclic gear trains.
• Describe the interaction of gear ratios and vehicle performance as related to engine horsepower and torque curves.
• Explain phasing and mounting of propeller shafts as related to torsional excitation and secondary couple loads.
• Review different types of differentials.
• Compare common misconceptions of limited slip devices to their actual performance.
• Recognize four-wheel drive systems and the need for an inter-axle differential.
• Appraise electronic control of torque through braking and clutching devices.
• Evaluate the total drivetrain package as a system.

Who Should Attend
This seminar is intended for engineers now working with passenger car, sport utility, truck, bus, industrial, and off-highway vehicles who have had minimal prior experience with the total drivetrain.
Topical Outline

DAY ONE
- Clutch (dry/wet)
- Pressure Plate (Cover)
  - Direct pressure
  - Indirect pressure
  - Belleville
  - Over center springs
- Disc
  - Hub
  - Facing support member
- Torsional damper - damper springs; co-axial damper springs; damper friction devices
- Facings - Organic; Ceramic/metallic; cushion types
- Linkage
  - Hydraulic
  - Cable
  - Mechanical
- Transmission
- Automatic
  - Hydraulically controlled
  - Electronically controlled
  - Planetary or epicyclical gearing
  - Hydraulic multi-disc clutches
- Torque Converters
  - Impeller
  - Turbine
  - Stator
  - Lock-up clutch
- Manual
  - Synchronized
  - Non-Synchronized
  - Electronically shifted
  - Gear rattle
- Propshaft
- Cardan Joints
  - Torsional excitation - cancellation (two or more joints)
  - Secondary couple
- Constant Velocity Joints
  - Rzeppa type
  - Others
- Axle
  - Rigid - Semi-float; Full-float; Carrier type; Banjo type
  - Steering
  - Independent
  - Gearing - Spiral bevel; Hypoid
  - Differentials
    - Two pinion; Four pinion
    - Limited slips
    - Full locking

DAY TWO
- Axle (continued from Day One)
- Transfer Case
  - Full Time
    - The requirement for a differential - bevel differential; planetary differential
  - Part Time
    - Two-wheel drive; Locked four-wheel drive
- Wheel Ends
  - Independent
  - Live vs. Dead Spindle
  - Bearing architectures
- Brakes
  - Disc; Drum
  - Hydraulics
    - Master Cylinder, Proportioning valve
  - Electronic Control of Brakes and Torque
  - Anti-Lock Brake Systems

Instructor: Joseph Palazzolo
Fee $1535 1.3 CEUs

A Familiarization of Drivetrain Components

5.25 Hours

Similar content is available in the classroom seminar – see course info above.

Convenient, portable, and with core content from the instructor-led seminar (content and description similar to the preceding classroom counterpart), this five and a quarter hour on demand option offers an alternative way to receive the same instruction without the expense of travel and time away from the workplace. This is divided into seven video modules and a coordinated handbook.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.
Continuously Variable Transmission (CVT) Systems: Technology and Applications Overview Web Seminar

8 Hours  
I.D.# WB1616

Continuously Variable Transmission (CVT) technology is both a theoretical and practical option that addresses a number of system level improvement opportunities within the automotive and mobility industries. Although this technology has been available for many years and is now fully matured as a production ready technology, it is often not fully understood. This web seminar presents a focused view of CVT technology in all its forms and implementations. The aim of this course is to provide a more complete understanding of all the technologies that are considered continuously variable and to order them in terms of their automotive applicability. Time will be spent discussing application strategies, control and communication requirements with the rest of the powertrain, durability and lubricant requirements.

This eight-hour web seminar provides a thorough survey of all technologies that are considered applicable to automotive powertrains. These technologies will be reviewed within the contexts of both the other CVT technologies and suitability. Finally, the requirements of the device will be discussed and contrasted to appropriateness for use in a modern automotive application.

Learning Objectives

By connecting with this Web Seminar, participants will be able to:
- Recognize all technologies classified as continuously variable
- Explain the fundamentals of friction and lubrication applied to mechanical power transmission
- Discuss the meaning and use of the functional properties of current lubricant technology
- Represent the concept of friction-required and friction-not-required as applied to mechanical power transmission
- Summarize the function and operation of all major CVT technologies
- List the requirements of CVT and Traction specific lubricants

Who Should Attend

Designed as an introduction, this course is intended for anyone who is not familiar with the function, requirements, and application of continuously variable transmission technology to modern passenger vehicle transmission systems. The material covered in this seminar is targeted at a number of design and engineering disciplines including, but not limited to:
- Design engineers and engineering managers
- Vehicle powertrain and driveline designers
- Component suppliers

Topical Outline

Session 1
- Review of the Various CVT Strategies;
  - Overview of all major types of continuously variable technologies
  - Pros and cons of each
  - Comparison of ‘Stepped’ vs. ‘Stepless’ Transmission Technology
  - A brief review of transmission technology evolution
  - Benefits and drawbacks of two modes of operation
  - Concept of ‘friction required’ transmissions (i.e. belt / chain CVT, Toroid, etc.) versus ‘friction not required’ technology (i.e. gears, etc.)
  - Conceptual and functional differences between mechanical power transmission systems that require friction to operate and those that do not

Session 2
- Vehicle Powertrain Optimization Example
- The systemic effect of stepped versus stepless power transmission powertrain performance
- Develop a model of the theoretical optimum functional requirement of a transmission

Session 3
- Technology overview of belt style CVT (i.e. push / pull) and requirements of lubricant (CVT oil)
- The specifics of a belt style CVT; most commonly based on a ‘push’ belt technology, and the requirements of the lubricant to support expected performance levels
- Technology overview of chain style CVT (i.e. pull)
  - The specifics of a chain style CVT, most commonly based on a ‘pull’ belt technology
  - The requirements of the lubricant to support expected performance levels

Session 4
- Technology overview of toroidal style CVT and the requirements of the lubricant (traction oil)
- Specifics of a toroidal style CVT, most commonly based on a ‘bell’ idler engaged with a set of toroids
- Requirements of the lubricant to support expected performance levels
- Technology overview of sphere style CVT
  - The specifics of a toroidal style CVT, most commonly based on a spherical planet (e.g. planet pinion gear of an epicyclic gear set) engaged with a set of conical races
  - Requirements of the lubricant to support expected performance levels

Instructor: William Mark McVea
Fee $640 .8 CEUs
Fundamentals of Automotive All-Wheel Drive Systems

1 Day  
I.D.# C0305

Similar content is available in an on demand course. Review the course info in the On Demand Courses Guide on page 199.

This seminar provides an introduction to the fundamental concepts and evolution of passenger car and light truck 4x4/all-wheel drive (AWD) systems including the nomenclature utilized to describe these systems. Basic power transfer unit and transfer case design parameters, component application to system function, the future of AWD systems, and emerging technologies that may enable future systems are covered.

This course is an excellent follow-up to the A Familiarization of Drivetrain Components. See course description on page 149.

Learning Objectives
By attending this seminar, participants will be able to:
• Identify front wheel drive and rear wheel drive vehicle architectures
• Identify part time, full time, and on demand all-wheel drive systems
• Explain the benefits of all-wheel drive over two-wheel drive
• Quantify all wheel drive traction and mobility benefits
• Describe auxiliary axle disconnect systems
• Explain basic vehicle dynamics performance and the effect of AWD on performance
• Identify couplers vs. biasing devices and their basic function
• Describe the differences between mechanical and electrical implementation in AWD systems
• Describe basic control strategies and logic
• Discuss advanced propulsion concepts and systems

Who Should Attend
This seminar is designed for engineers (working with passenger cars, light trucks, and SUVs) who need to master AWD componentry, and the function and effect of those components. Engineers new to the 4WD/AWD field, as well as managers, marketing personnel, purchasing professionals and others interested in all-wheel drive fundamentals will benefit from this seminar.

Topical Outline
• Front wheel drive and rear wheel drive vehicle architectures
  • Engine layout - Transverse vs. longitudinal
  • Transmission layout - Transaxle vs. longitudinal
  • Axle layout - Independent vs. beam
  • Powerflow - typical power transmission arrangements
• Part time, full time, and on demand all wheel drive systems
  • Modes of operation
  • Performance benefits
  • Usage profiles
  • Twin systems
• Benefits of all-wheel drive as compared to two-wheel drive
  • Performance
  • Weight
  • Packaging
• Quantifying all-wheel drive traction and mobility benefits
  • Vehicle dynamics
  • Stability Acceleration
• Auxiliary axle disconnect systems
  • Function
  • Design
• Basic vehicle dynamics performance and the effect of AWD on performance
  • Oversteer
  • Understeer
  • Neutralsteer
  • Traction Effects
  • Stability Effects
• Couplers vs. biasing devices
  • Functions of couplers
  • Functions of biasing devices
  • Types - mechanical, electrical, speed sensing, torque sensing
• Mechanical vs. electrical implementation in AWD systems
  • Active control
  • Passive control
• Effects of AWD driveline configuration on NVH and weight
  • Consequences of axle ratio selection
  • Halfshaft and propshaft options
• Basic control strategies and logic
• Advanced propulsion concepts and systems
  • Active differentials
  • Independent wheel control
  • Hybrid electric all-wheel drive

Instructor: Joseph Palazzolo
Fee $810 .7 CEUs
Fundamentals of Automotive All-Wheel Drive Systems e-Seminar

4.5 Hours

Similar content is available in the classroom seminar – Fundamentals of Automotive All-Wheel Drive Systems – see course info above.

Convenient, portable, and with core content from the instructor-led seminar (content and description similar to the preceding classroom counterpart), this 4.5-hour on demand option offers an alternative way to receive the same instruction without the expense of travel and time away from the workplace. It is an excellent follow-up to SAE’s A Familiarization of Drivetrain Components e-Seminar (which is designed for those who have limited experience with the total drivetrain).

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available. Call the SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.

Fundamentals of Gear Design and Application

2 Days
I.D.# C0223

Through informative discussions and detailed explanations, this seminar will provide a solid and fundamental understanding of gear geometry, types and arrangements, and design principles. Starting with the basic definitions of gears, conjugate motion, and the Laws of Gearing, those attending will be given the tools needed to understand the inter-relation and coordinated motion operating within gear pairs and multi-gear trains. Basic gear system design process and gear measurement and inspection techniques will also be explained. In addition, the fundamentals of understanding the step-wise process of working through the iterative design process required to generate a gear pair will be reviewed, and attendees will also briefly discuss the steps and issues involved in design refinement and some manufacturing considerations. Also, an explanation of basic gear measurement techniques, how measurement equipment and test machines implement these techniques, and how to interpret the results from these basic measurements will be covered.

Learning Objectives

By attending this seminar, participants will be able to:
• Describe the “Law of Gearing,” conjugate action and specifically, involute profiles
• Review the various definitions and terms used in gearing
• Identify the function and operation of all gear arrangements
• Appraise preliminary design considerations and the gear system design process
• Explain practical gear measurement and inspection techniques, tools and equipment
• Recognize “Best Practices” in regards to gear system design
• Discuss some of the new and automated gear design systems

Who Should Attend

The intended audience for this seminar is powertrain engineers, engineering directors and managers, component suppliers, vehicle platform powertrain development specialists, and those involved in the design and application of geared systems and assemblies. This seminar will appeal to anyone who is interested in gears, gear systems, design development or measurement and inspection techniques.

More specifically, anyone responsible for the following will benefit:
• Mechanical power transmission system design, development, durability assessment and application
• Application and development of geared systems technologies
• Management of transmission designers and manufacturers
• Supply of components and sub-systems to mechanical power transmission system manufacturers

Prerequisites

Attendees should have an undergraduate engineering degree to attend this program. This seminar is intended for powertrain engineers, engineering directors and managers, component suppliers, vehicle platform powertrain development specialists, and those involved in the design and application of geared systems and assemblies. Anyone who is interested in gears, gear systems, design development or measurement and inspection techniques should attend.

Topical Outline

DAY ONE
• Principles of Gears
  • Purpose of gears
  • Basic concepts -- Law of gearing; common tooth forms
  • Classification of gears
  • Definitions and terms used in gearing
  • Velocity ratio
  • Pitch surfaces
**POWER AND PROPULSION**

- Gear Tooth Action
  - Conjugacy
  - Profile curves
  - Surface of action
  - Profile sliding
- Gear Geometry and Nomenclature
  - Principle of planes
  - Tooth nomenclature
  - Blank nomenclature
- Gear Arrangements
  - Simple gear train;
  - Compound gear train - ratios
  - Epicyclic - configurations (solar, planetary, star); ratios; tooth number selection and build requirements; application
- Preliminary Design Considerations
  - Gear type selection
  - Preliminary estimate of size
  - Stress formulations
  - Gear Drawing Data

**DAY TWO**

- Gear System Design Process
  - Calculation of gear tooth data
  - Gear rating practice
- Gear Design Process
  - Layout
  - Root geometry
  - Backlash
- Gear Measurement and Inspection
  - Dimension over pins
  - Pin diameter
  - Modify pin diameter and dimension over pins
  - Pin contact point
  - Charts - involute; lead; red liner
  - Dimension sheet
- Gear Design Systems and Best Practices
  - Common proportions
  - Interchangeability
  - Tooling considerations
  - Mounting considerations
  - Best practices
  - Application

**Fundamentals of Modern Vehicle Transmissions**

3 Days  
I.D.# 99018

Similar content is available in an on demand course. Review the course info in the On Demand Courses Guide on page 199.  

Starting with a look at the transmission’s primary function -- to couple the engine to the driveline and provide torque ratios between the two -- this updated and expanded seminar covers the latest transmission systems designed to achieve the most efficient engine operation. Current designs, the components and sub-systems used, their functional modes, how they operate, and the inter-relationships will be discussed.

A manual transmission display will be used to explain ratios and how they function within the driveline. Automatic transmission design will illustrate the concept of automatic control and hydro-mechanic decision theory and implementation. Attendees will have the opportunity to supplement these theoretical concepts with practical, “hands-on” experience using the various transmission models and components provided. Mechatronics, toroidal transmission functions, and the future of the automatic transmission will also be discussed.

Continuously Variable Transmission (CVT) systems, which represent a fundamental shift in the way power is transmitted from the primary source to the remainder of the driveline will be the focus of in-depth coverage on the third day of this seminar.

**Learning Objectives**

By attending this seminar, participants will be able to:

- Explain the development, operational aspects and design principles of passenger vehicle and light truck transmission systems, their major components and sub-systems
- Describe the operational parameters and inter-relationships of each of the sub-systems
- Apply basic design synthesis and analysis techniques for each of the major components and sub-systems
- Compare and contrast ‘stepless’ to ‘stepped’ transmission technology
- Identify and describe the function and operation of all major components and sub-systems by participating in hands-on demonstrations
- Recognize the limitations, technological trends, and potential new products under consideration
- Summarize the direction of new passenger car transmission designs and systems

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<thead>
<tr>
<th>Instructor:</th>
<th>William Mark McVea</th>
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<tbody>
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<td>Fee</td>
<td>$1405 1.3 CEUs</td>
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POWER AND PROPULSION

Who Should Attend
This seminar is intended for anyone not familiar with the operational theories or functional principles of modern vehicle transmission systems. As the material covered is targeted at a number of design and engineering disciplines, attendees should have a minimum of two years design experience in the automotive powertrain field, or preferably a B.S. in engineering or related field.

Topical Outline
DAY ONE
- Overview of Mechanical Power Transmission in a Passenger Vehicle and Light Truck -- Manual transmission; automatic transmission; continuously variable transmission (CVT)
- Theory, Function and Operation of Manual Transmission -- Design; main components; common configurations
- Vehicle Powertrain Requirements and Specifications Assessment
- Shift Strategy Analysis and Control System Implementation
- Components and Sub-systems -- Shifters, clutches, synchronizers, gears, shafts
- Basic Gear Theory and Application Development
- Powerflow Analysis
- Synchronizer Operation and Analysis
- Lubrication and Cooling Requirements Review

DAY TWO
- Development and Layout of the “Automatic” Transmission -- Front-wheel drive; rear-wheel drive; four-wheel drive
- Functionality -- Torque converter operation; gear systems; gear design considerations; type; layout; NVH (Noise, Vibration and Harshness); epicyclic powerflow
- Extension of Gear Theory to Epicyclic Gear-trains
- Design and Operation of Clutches and Bands
- Application of One-Way/Over-Riding Clutches
- Powerflow Analysis of Torque Converters, Epicyclic Gear Sets
- Review of Shift Strategy
- Implementation of Shift Strategy Through Hydro-Mechanical Control Systems
- Simple Shift Model Analysis
- Lubrication and Cooling Requirements Review

DAY THREE
- CVT Design and Operation -- Theory and function; typical layout; main components
- Technological Development of the CVT
- Basic Theory of Friction Drives
- Toroidal Drive Technology -- Theory of operation; main components; benefits and limitation of the technology
- Functionality and Characteristics of CVT Components, Sub-systems -- Gearbox housing; variators; forward clutch; converter housing; input shaft; selector shift valve; differential; output shaft; mechatronic control unit; belt/push chain
- CVT Power-Flow -- Torque converter; primary variator; secondary variator; output shaft
- Mechatronics -- Theory and operation; general implementation; CVT application
- CVT Manufacturing -- Considerations; major manufacturers; future CVT development
- Future Technologies -- “Manualized” automatics, automated manuals; DCT, SSCT, DSCT

Instructor: William Mark McVea
Fee $1790 2.0 CEUs

Fundamentals of Modern Vehicle Transmissions
14 Hours

Similar content is available in a classroom seminar – Fundamentals of Modern Vehicle Transmissions – see course info above.

Convenient, portable, and with core content from the instructor-led seminar (view seminar description above), this 14 hour on demand option offers an alternative way to receive the same instruction without the expense of travel and time away from the workplace.

The course is divided into nine video modules, accompanied by a handbook.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available – call SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.
High-Performance Differentials, Axles, & Drivelines

2 Days
I.D.# C1113

Every automobile has a differential and most have axles, yet the exact function of these is not common knowledge. This comprehensive seminar introduces participants to the function and interfaces of axles and their individual components. As we modify cars for street performance or all out race applications, it is important to know the trade-offs in the drivetrain system. The theory and practice of axle systems is introduced along with a hands-on style approach to repairing and modifying axles for high performance applications. For this hands-on approach, actual hardware will be reviewed in an informal setting.

The seminar begins by defining the axle fundamentals and operation followed by an in-depth review of original equipment axles, differentials, torque bias, hypoid gears, and rebuild steps. The different manufacturing and service techniques required for different gear architectures is also reviewed. The seminar concludes with a unique applications-specific workshop and industry trends discussion. Upon completion of the seminar, attendees will have a working knowledge of axles, hypoid gearing, and differentials (open and limited slip), along with typical performance enthusiast modifications for race teams and weekend warriors.

The book, “High-Performance Differentials, Axles, and Drivelines,” by Joseph Palazzolo is included in the course materials.

Learning Objectives

By attending this seminar, participants will be able to:

- Identify vehicle specific axle types
- Evaluate the differences between open and limited slip differential (LSD)
- Distinguish between the different torque transfer characteristics of the different LSD technologies
- Identify how to correctly set and adjust bearing preload and hypoid contact patterns
- Describe how to assemble and disassemble a differential
- Explain the steps to set-up a new gear set and bearings
- Recognize the difference required between typical passenger car applications and high-performance, race style axles

Who Should Attend

This seminar is intended for automotive engineers and mechanics who are working in the driveline area. This also includes performance shop mechanics and race teams that are modifying axles for specific on and off-road applications. Any performance-minded amateur, professional racer, or race team would also benefit from attending this seminar.

Topical Outline

- Axle Fundamentals
  - Lube flow
  - Venting
  - Housing reaction loads
- Axle housing types
  - Beam axles - Banjo / Salisbury
  - Independent axles
  - Quick change axles
  - Axle tubes
  - Axle shaft retention methods
  - Common axle identification
- Axle rebuild
  - Common axle problems
  - Axle disassembly
  - Component inspection
  - Axle Reassembly
- Differentials
  - Theory and practice of open differential
  - Factory installed limited slip differentials
  - Torque bias ratio explanation
  - Teardown and rebuild process
  - Review preload and friction modifier
- Aftermarket differentials
  - Review advantages and disadvantages of the following:
    - Open differentials
    - Limited slip differentials
    - Spool and mini-spoons
    - Locking differentials
    - Helical differentials
    - Viscous control differentials
    - Torque Vectoring
- Hypoid Ring and Pinion Gears
  - Gearing fundamentals
  - Spiral bevel review
  - Hypoid
  - Review face milling vs. face hobbing
  - Review how to correctly set-up gear set
  - Review correct contact pattern
  - Importance of bearing preload and how to set
  - Break-in procedure
  - Tire size, speedometer accuracy
- Axle Shafts
  - Primary function; Materials
  - Spline details
- Driveshafts
  - Driveshaft considerations
  - Universal joint: Replacement; Sizes; Retention methods
- Pinion angle

Instructor: Joseph Palazzolo

Fee $1370 1.3 CEUs
Fundamentals of Truck and Off-Highway Transmission Systems

2 Days
I.D.# C0024

This course will develop a basic understanding of the fundamentals of operation and explain the current state-of-the-art design of the modern transmission designs. Transmission systems in current production will be used as a practical example throughout the seminar. Two basic product areas of truck and off-highway transmission systems will be reviewed: Planetary Automatic Transmissions, and Power-Shifted Transmissions.

The functional requirements of the “current” market and the operational needs of its drivers will drive the course. Course material will be presented in the chronological order in which it was introduced into the marketplace. This order is shown through the requirements of “new” functionality by the marketplace at the time it was introduced. The design advances that satisfied these requirements will be discussed and used to show design progression through to the current state of design.

This “current state-of-the-art” design schematic will then be used to show the driving forces behind the next evolutionary step in the development of future designs of transmission systems. All aspects of current designs will be reviewed in depth; the components used, how they operate and the interrelation of all components. All functional modes of the major components and sub-systems will be discussed and explained to the audience. Based on this working knowledge of transmission components and systems, attendees will work through design specifications, functional modes and considerations of reliability and life for each major sub-system in a transmission system.

The seminar will conclude with a brief discussion of the future of transmission systems and what functional requirements are likely to be expected by the users of the next generation vehicles within this market.

Learning Objectives

By attending this seminar, participants will be able to:
- Identify the major components and system functions in a modern truck or off-highway transmission system
- Compute powerflow, relative rotational speeds of various components, and the functional relationships that exist between these components
- Specify the size of a truck or off-highway transmission, select the numbers of speed ranges and ratios for each, and assess system efficiency
- Explain the operational aspects and design principles of each of the major components and sub-systems of a transmission
- Describe the operational parameters and inter-relationships of each of the sub-systems within the truck transmission
- Summarize basic design synthesis and analysis techniques for each of the major components and sub-systems of a transmission
- Discuss the direction of new truck and off-highway equipment transmission designs

Who Should Attend

The intended audience for this seminar is powertrain design engineers, designers, engineering directors and managers, component suppliers, platform powertrain test and development specialists, and those involved in the application, design and discussion of engines. This seminar will appeal to anyone who is interested in truck or off-highway vehicle operation and design.

Topical Outline

- Theory of Operation of a Basic Transmission
  - Basic transmission layout
  - Main components
  - Common configurations/transmission types
- Development of the “Automatic” Transmission
  - Major Components of a Modern Automatic Transmission
    - Torque converter
    - Planetary gears
    - Clutch packs and bands
    - Powerflow
  - Functionality
    - Torque converter operation
    - Gear systems
    - Gear design considerations
  - Type
  - Layout
  - NVH (Noise, Vibration and Harshness)
  - Planetary powerflow
    - Common gear arrangements and standard design configurations
    - Clutches and bands
      - One-way/over-riding clutches
    - Comparisons to Power-Shift transmissions
  - Operational characteristics of power-shift transmissions
  - Components and typical layouts
  - Clutch packs
  - Shift systems
  - Application and duty cycle consideration
  - Design considerations for Over-The-Road Transmissions
  - Process to select the number of speed ranges
  - Select approximate gear ratios for each speed range
  - Calculate losses and efficiencies
  - Power-flow optimization
  - Duty cycle considerations
  - Design for reliability and life
  - Design considerations for Off-Highway transmissions
POWER AND PROPULSION

- Process to select the number of speed ranges
- Select approximate gear ratios for each speed range
- Calculate losses and efficiencies
- Design information content of engine curves
- Duty cycle considerations
- Design for service, repair and “rebuildability”
- Future direction of technologies

Ininitely Variable Transmissions (IVT) Using a Toroidal Traction Variator Web Seminar RePlay

2 Hours
Web Seminar RePlay I.D.# PD331709ON
This two-hour course will discuss the packaging, functionality, and economics of IVT architecture and expose the positive and negative aspects of IVT. The IVTs discussed use a particular type of CVT called a Double Roller Full Toroidal Variator (DFTV) which is the most compact and efficient CVT technology currently available.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Mechanical Shifting Devices in Automotive Transmissions Web Seminar RePlay

40 Minutes
Web Seminar RePlay I.D.# PD331711ON
The Controllable Mechanical Diode is a new technology that improves fuel economy, mass and packaging in modern automatic transmissions. In this 40-minute course, participants will gain an understanding of the base construction, function and value of the new Controllable Mechanical DiodeTM innovation. Advantages of its use in new automatic transmissions will be explained along with examples of the CMD’s alignment to electrified transmissions.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Performance and Use of Polymer Plan Bearings in Transmission Design Web Seminar RePlay

90 Minutes
Web Seminar RePlay I.D.# PD331710ON
This course presents the tribological performance of polymeric plain bearings as related to transmission applications. Will deal with the various wear and damage mechanisms that can occur with a polymer bearing in transmissions. The damage mechanisms discussed will include adhesion, abrasion, fatigue and erosion. A brief discussion of relevant lubrication states, boundary lubrication and fluid film formation, will also be included.

The course will also address specific mechanical design issues associated with using polymer plain bearings within the transmission.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

TRANSMISSION/DRIVETRAIN CERTIFICATE PROGRAM
Watch for the certificate icon to indicate course titles that are part of an SAE multi-course certificate program.

This program familiarizes you with key drivetrain components and how those components function as a system. Complete this certificate to increase your expertise within the drivetrain body of knowledge and, at the same time, earn the SAE Certificate of Achievement.

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• Fill out the online quote request at sae.org/corplearning • Email us at Corplearn@sae.org
Powertrain Selection for Fuel Economy and Acceleration Performance

2 Days  
I.D.# C0243

Developing vehicles that achieve optimum fuel economy and acceleration performance is critical to the success of any automotive company, yet many practicing engineers have not received formal training on the broad range of factors which influence vehicle performance. This seminar provides this fundamental understanding through the development of mathematical models that describe the relevant physics and through the hands-on application of automotive test equipment. Attendees will also be introduced to software used to predict vehicle performance.

The course begins with a discussion of the road load forces that act on the automobile (aerodynamic, rolling resistance, and gravitational) followed by a review of pertinent engine characteristics. This background information is then used to show how appropriate gear ratios for a vehicle transmission are selected and to develop models for predicting acceleration performance and fuel economy. The models form the basis for the computer software used to predict vehicle performance. Participants will also use an in-vehicle accelerometer, GPS fifth-wheel, and an OBDII scanner to measure vehicle performance.

Learning Objectives

By attending this seminar, participants will be able to:

- Explain the basic operation of the components in an automotive powertrain
- Calculate road loads on a motor vehicle
- Select appropriate gear ratios for a given engine/chassis combination
- Predict the effect of gear selection, body design, and weight on the fuel economy of a vehicle
- Explain and utilize the mathematical models for predicting the acceleration of an automobile
- Explain and utilize the mathematical models for predicting the fuel economy of an automobile
- Use computer software for predicting vehicle fuel economy and performance

Who Should Attend

As this seminar is designed for automotive engineers involved in the design and development of automotive powertrains (with special value for entry-level engineers and others seeking to develop a fundamental understanding), attendees should have a degree in mechanical engineering or a related field, be able to apply Newton’s second law of motion, and be familiar with spreadsheets and simple computer programming concepts.

Topical Outline

DAY ONE

- Course Introduction/Powertrain Configuration
  - Powertrain layout: front-wheel drive, rear-wheel drive, four-wheel drive
  - Powertrain components: engine, clutch/torque converter, transmission, drive shaft, differential, tires
- Road Load Forces and Power
  - Vehicle freebody diagram
  - Aerodynamic forces
  - Rolling resistance forces
  - Gravity forces
- Vehicle Coastdown Test
  - Theory behind coastdown test
  - GPS fifth-wheel
  - SAE Recommended Practice J1263
- Vehicle Tractive Effort
  - Characterization of internal combustion engines
  - Characterization of pneumatic tires
- Drivetrain Selection
  - Vehicle design criteria
  - Selection of top gear ratio
  - Selection of low gear ratio
  - Selection of intermediate gear ratios

DAY TWO

- Analysis of Power and Torque Flow in Drivetrain Components
  - Clutches
  - Standard & planetary gear sets
  - Axles and differentials
  - Manual transmissions
  - Automatic transmissions
  - Torque Converters
- Acceleration Performance Prediction
  - Vehicle acceleration modeling
  - Effects of drivetrain component selection
- Road Load and Acceleration Power Testing Laboratory
  - In-vehicle accelerometer
  - GPS fifth-wheel
  - SAE Recommended Practice J1491
POWER AND PROPULSION

- Fuel Economy Prediction
  - Vehicle fuel economy modeling
- EPA driving cycles
- CAFE standards
- Effects of drivetrain component selection
- SAE recommended practice J1256
- Emissions prediction
- Demonstration of Vehicle Performance Software
  - DOE Advisor
  - Commercial packages
  - Effects of drivetrain component selection

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<thead>
<tr>
<th>Instructor:</th>
<th>Craig J. Hoff &amp; Gregory Davis</th>
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<td>Fee $1370</td>
<td>1.3 CEUs</td>
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Powertrain As-Installed Driveline Subsystems (PAIDS) - Ford On Demand Course

8 Hours
I.D.# PD111014ON

Powertrain as-installed subsystems have a common fundamental function to perform in harmony, enabling the engine to power the vehicle and/or accessories. There is a need to avoid issues such as idle roughness and to realize these are system interaction issues. For example, modal alignment affects idle roughness, and improving idle roughness can affect fuel economy.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity and site license options are available. Call the SAE Corporate Learning Solutions hotline for a quote - +1.724.772.8529.

Powertrain As-Installed Stationary Subsystems (PAISS) - Ford On Demand Course

12 Hours
I.D.# PD111015ON

Powertrain as-installed subsystems have a common fundamental function to perform in harmony, enabling the engine to power the vehicle and/or accessories. There is a need to avoid issues such as idle roughness and to realize these are system interaction issues. For example, modal alignment affects idle roughness, and improving idle roughness can affect fuel economy.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity and site license options are available. Call the SAE Corporate Learning Solutions hotline for a quote - +1.724.772.8529.

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Powertrain Driveability - Ford On Demand Course

3 Hours  I.D.# PD111016ON

Driveability is the result of a system’s interaction between the powertrain, the vehicle, and the customer. Driveability concerns can arise in any mode of operation and have a common factor that all are the result of a change in engine/torque speed. Driveability is a key customer-driven Powertrain attribute. Improving driveability is critical to improving customer satisfaction and competitiveness of vehicles.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity and site license options are available. Call the SAE Corporate Learning Solutions hotline for a quote - +1.724.772.8529.

Powertrain Performance Feel - Ford On Demand Course

3.5 Hours  I.D.# PD111017ON

In addition to NVH, Driveability, and Shift Quality, Performance Feel is among the four Powertrain attributes that directly influence customer satisfaction. It is defined in terms of the availability of power to the end customer and is the customer perception of performance that includes the effects of vehicle acceleration, accelerator control characteristics, shift character, and sound quality.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity and site license options are available. Call the SAE Corporate Learning Solutions hotline for a quote - +1.724.772.8529.

Advanced Diesel Particulate Filtration Systems

2 Days  I.D.# C0502

As diesel emissions regulations have become more and more stringent, diesel particulate filters (DPF) have become possibly the most important and complex diesel aftertreatment device. This seminar covers many DPF-related topics using fundamentals from various branches of applied sciences such as porous media, filtration and materials sciences and will provide the student with both a theoretical as well as an applications-oriented approach to enhance the design and reliability of aftertreatment platforms. Structure, geometry, composition, performance, applications and optimizations of DPFs are some of the main topics covered in this advanced level seminar. Computer simulation techniques for analysis and optimization of DPF performance are also demonstrated.

Learning Objectives

By attending this seminar, participants will be able to:
- Discuss fundamental, moderate and advanced topics on DPF structure, geometry, composition, performance, applications and optimizations
- Formulate porosity, permeability, inertial loss coefficient, flow resistance descriptors, different particulate transport modes (diffusional, interceptive), etc. to develop models for predicting backpressure of DPF
- Recognize different modes of particulate filtration regimes in DPF
- Select, design, utilize and optimize DPF for various light duty and heavy duty aftertreatment applications
- Predict, via modeling and simulations, various important DPF performance features (backpressure, peak regeneration temperature, etc.) as well as to analyze their failure modes and thus enhance the reliability of diesel exhaust aftertreatment platform designs
Who Should Attend

This seminar is designed for engineers, scientists, investigators and consultants involved in researching, developing, applications, designing or optimizing diesel exhaust aftertreatment components and systems. Individuals from technical and regulatory institutions as well as individuals from OEMs, suppliers, emissions service companies, research facilities and universities will gain modern knowledge of diesel filter performance.

Prerequisites

Students should have some technical insight into the performance of exhaust emission aftertreatment. Attendees with science or technology background (mechanical/chemical engineering, chemistry, physics) will benefit substantially from this seminar.

Topical Outline

DAY ONE

Porous Media Basics for Diesel Particulate Filters
- Pore space and structure definitions (definitions of relevant length scales, derivation of “pore metrics” such as correlation lengths, lineal path distributions.)
- Simplified representations of structures (unit cell models based on granular, cylindrical and composite collectors.)
- Flow resistance descriptors (Darcy permeability, Forchheimer coefficient, inertial loss coefficient as functions of wall micro-geometry, cell density, wall thickness, plug length)

Filtration Concepts for Diesel Particulate Filters
- Particle transport and deposition phenomena -- Condensed vs. vapor phases in diesel exhaust; Diesel fractal soot aggregate basics; Diffusional transport; Thermophoretic transport; Direct interception mechanism; Inertial transport mechanism; Other phenomena (electrical effects, sticking, entrainment by exhaust flow)
- Continuum filtration theory -- Deep-bed filtration regime; Cake filtration regime reconstruction of filter media
- True-to-the-geometry representations (digital reconstruction of filter media, micro-flow simulation with Lattice-based techniques and discrete particle dynamics. Examples applied to granular ceramic extruded filters, sintered metal filters, foam filters and fibrous textile filters.)

Diesel Filter Types: Materials and Configurations in Practice
- Materials aspects
  - Ceramics - Oxide based: Cordierite, Mullite, other (Tialite/Aluminum Titanate, etc.); Non-oxide based: Recrystallized Silicon Carbide (R-SiC), Siliconized Silicon Carbide (Si-SiC), Silicon Nitride
  - Metallics (high temperature alloys) - Sintered grains and fibers
  - Configurations
    - Wall-flow honeycombs (square, triangular, symmetric vs. asymmetric channels.)
    - Pleated, foiled (sheet-based) designs
    - Fibrous, textile cartridges
    - Foam-based designs
    - Flow-through particulate collectors

DAY TWO

Applications, Performance Optimization and Modeling of Diesel Particulate Filters
- Filter backpressure/particulate loading - Porosity, permeability, pore structure issues; Role of catalyst coatings; Filter size effects (length, diameter, cell density, wall thickness); Microstructure of soot deposits (physical and chemical properties); Soot deposition conditions and role on soot structure: Steady state, transients, cycles; Modeling aspects
- Filter Regeneration
  - Soot reactivity and structure -- Oxidation mechanisms (thermal, catalytic, NO2); Kinetic descriptions
  - Types of regeneration technologies -- Raising exhaust temperature by post-injection and/or by exhaust-port injection in combination with DOxC; Fuel borne additive-assisted regeneration; Catalyst coating-assisted regeneration; Reactive species-assisted regeneration (NO2-assisted, non-thermal plasma, etc.)
  - Simulation Techniques for Diesel Particulate Filters -- Brief history of DPF performance modeling; Backpressure -- Theory, insights and lessons; Modeling: demonstrations, validations; Regeneration -- Theory, insights and lessons; Modeling: demonstrations, validations
  - Ash Effects -- Ash production, transport, deposition and thermal history; Ash effects on filter thermal management, catalyst activities, and filter sizing

Instructor: Athanasios Konstandopoulos & Mansour Masoudi

Fee $1370 1.3 CEUs
Introduction to Commercial & Off-Road Vehicle Cooling Airflow Systems Web Seminar RePlay

12 Hours
Web Seminar Replay: PD331240ON

The goal of this six-session web seminar replay is to introduce engineers and managers to the basic principles of diesel cooling airflow systems for commercial and off-road vehicles. Participants will learn about vehicle/product constraints, integration issues, cooling airflow, system resistance, fans, shrouds, radiators, coolers, estimating heat rejection, thermal recirculation, and overall system performance. Basic concepts will be reinforced with examples and a cooling performance calculation of a diesel cooling system.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Catalytic NOx Control Technologies for Diesel and GDI Engines Web Seminar and Web Seminar Replay

6 Hours
Web Seminar I.D.# WB1237
Web Seminar Replay I.D.# PD331237ON

Lean burn engines (diesel and GDI) boast higher fuel economy and cleaner emissions than conventionally tuned engines while producing equivalent power. They employ higher combustion chamber compression ratios, significant air intake swirl and precise lean-metered direct fuel injection. The downfall of lean-burn technology, however, is increased exhaust NOx emissions (due to higher heat and cylinder pressure) and a somewhat narrower RPM power-band (due to slower burn rates of lean mixtures). Removal of NOx from exhausts is a critical need for emission standards and ambient ozone requirements.

This three session web seminar will examine the various catalytic processes for lean burn applications, including Selective Catalytic NOx Reduction (SCR), NOx Trap Technologies (i.e. LNT, NSR), and the combination of SCR, NOx Trap and Hydrocarbon NOx Reduction (LNC). It will focus in on SCR NOx fundamentals, equipping participants with the basic concepts for NOx control and important design parameters for SCR NOx catalyst. The course will examine the system design for SCR in diesel applications including passenger cars and heavy duty trucks, including SCR catalysts, SCR integration with diesel particulate filter, key sensor development catalyst durability issues and urea control.

Learning Objectives
By connecting with this Web Seminar, participants will be able to:

• Define NOx catalysis and identify key acronyms
• Describe in-use issues
• Cite key elements in NOx catalyst design for diesel applications
• Define SCR design for passenger cars and heavy duty applications
• Identify available sensors for SCR catalyst performance monitoring
• Determine where lean NOx traps may be appropriate versus SCR NOx control

Who Should Attend
This web seminar will be especially valuable for mechanical, metallurgical and chemical engineers, materials scientists, and chemists involved in the design, operation and calibration of a NOx emission control system for both mobile and stationary source applications, such as automobiles, trucks, buses, ships, locomotives, stationary engines, small engines, etc. It will also help the newly hired engineer assigned to an emission control team, the seasoned veteran who just transferred to the emission control group, sales people responsible for emission controls, plant managers concerned about meeting new regulations with catalytic controls, and regulators now involved in transmission technologies. Participants should have a basic familiarity with automotive emissions for gasoline engines, diesel engines or off-road applications.

Topical Outline
Session 1
Lean NOx Catalysis
• NOx reduction catalytic approaches
• Lean NOx reduction fundamentals
• Hydrocarbon NOx reduction (LNC)
• NOx traps technologies (LNT, NSR or NAC)
• SCR Catalytic NOx reduction (ammonia based)
• Combination SCR/NOx traps

Session 2
SCR NOx Catalyst
• SCR NOx catalytic approaches (Vanadia and Zeolite)
• Performance characteristics of SCR NOx catalysts (Vanadia and Zeolite)
• Comparison of commercial issues with lean NOx traps and SCR

Catalog Key Classroom Live, Online On Demand Certificate ACTAR approved
Combustion and Emissions for Engineers

3 Days
I.D.# 97011

Public awareness regarding pollutants and their adverse health effects has created an urgent need for engineers to better understand the combustion process as well as the pollutants formed as by-products of that process. To effectively contribute to emission control strategies and design and develop emission control systems and components, a good understanding of the physical and mathematical principles of the combustion process is necessary. This seminar will bring issues related to combustion and emissions “down to earth,” relying less on mathematical terms and more on physical explanations and analogies.

Learning Objectives
By attending this seminar, participants will be able to:
• Identify and describe the important processes in combustion and emission
• Identify the formation mechanisms and reduction strategies of pollutant species in combustion systems
• Recognize the effects of engine design and operating conditions on combustion and emission
• Explain the technology and the logic behind after-treatment of pollutants
• Identify the underlying laws and principles used in combustion and emission black-boxed computer programs
• Explain the role chemical kinetics plays in the design of low-emission combustion systems
• Identify design trade-offs between increasing engine performance and maintaining low emission characteristics

Who Should Attend
Engineers working on the design of combustion engine components, software development and application for modeling of thermal-fluid, combustion and emissions processes, and those working on the reduction of harmful pollutants emissions will find this course valuable.

Topical Outline
DAY ONE
• Air Composition
• Concept of “Complete Combustion”
• A/F & Stoichiometric (A/F)ST, and (Equivalence Ratio)
• Lean, Rich, Stoichiometric Mixture
• First and Second Law and Applications in Combustion Systems
• Adiabatic Flame Temperature, Heat of Reaction (or Heating Value) and Their Usage
• Thermodynamic and Chemical Equilibrium
• Demonstration Applications of Equilibrium Using Computer Simulation (SuperState)

DAY TWO
• Chemical Kinetics
  • General concept and rate of reaction (RR)
  • Classifying reactions
• Reaction Between Gas Molecules and a Solid Surface
  • Physical absorption, chemisorption, and heterogenous catalysts
  • Nature of catalysis reaction
  • Arrhenius equation and activation energy
  • Analysis of data for complex reaction
  • General characteristics of catalysis
• Explosion
  • Simplified generalized kinetic model (slow reaction and explosion)
  • Explosion and flammability limits
• Mechanism of H2O2 Reaction
• Oxidation of CO
• Explosion Limits of Hydrocarbons (HC)
  • Experimental combustion characteristics
  • Methane and Paraffin oxidations
  • Demonstration applications of chemical kinetics using SuperState
• Autoignition and Induction Time Using SuperState
• Flame and its Propagation
  • Laminar flame structure
  • Laminar flame speed (SL)
  • Flammability limits
  • Quenching distance dr
  • Flame stabilization

DAY THREE
• Combustion in SI Engines
  • Simple thermodynamic analysis of SI engine combustion
  • Flame and unburned gas motions
  • Mass fraction burned and heat release analysis
  • Combustion process characterization
  • Flame structure, speed, and effects of various parameters on burning rate
  • SL turbulence & turbulent flame
  • Cyclic variability, partial burning & misfire
Designing On-Board Diagnostics for Light and Medium Duty Emissions Control Systems

3 Days
I.D.# C0707

On-board diagnosis of engine and transmission systems has been mandated by government regulation for light and medium vehicles since the 1996 model year. The regulations specify many of the detailed features that on-board diagnostics must exhibit. In addition, the penalties for not meeting the requirements or providing in-field remedies can be very expensive. This course is designed to provide a fundamental understanding of how and why OBD systems function and the technical features that a diagnostic should have in order to ensure compliant and successful implementation.

Fundamental design objectives and features needed to achieve those objectives for generic on-board diagnostics will be covered. The course will also include a review of the California Air Resources OBD II regulation, providing students with a firm foundation for reading and understanding the requirements, including the in-use rate portion of the regulations and how to properly calculate and output the required rate information. Relationships between the regulation and various SAE and ISO recommended practices will be reviewed. The course will also explore the relationship of the OBD system with the underlying control system.

Note that because of proprietary considerations, this class does not provide details of algorithm design, algorithm performance, or algorithm application. The class will cover general OBD algorithm designs and the features required to promote sound OBD system design.

Learning Objectives

By attending this seminar, participants will be able to:

- Articulate the underlying design objectives of on-board diagnostic systems
- Use the latest California Air Resources Board On-Board Diagnostic Regulation for Light and Medium Vehicles to find and apply OBD requirements
- Apply the design features that all diagnostics need for successful implementation
- Design diagnostics to comprehend variation
- Successfully implement algorithms to track in-use rates in accordance with the CARB OBD II Regulation
- Use SAE J1979 to implement generic scan tool support in diagnostic design
- Implement OBD design requirements in control system design

Who Should Attend

This course is designed for engineers involved in either the design or control of on-board diagnostic systems for engines or transmissions for light and medium duty on-road vehicles. Individuals working in the heavy duty industry may also find the information interesting, but should note that the examples will be geared towards spark ignition engines and light and medium duty regulations. In addition, engineers involved in engine and transmission hardware will benefit by obtaining a better understanding of the OBD systems. Engineers new to the area of OBD system design and engineers involved in the design of control systems wishing to obtain a better understanding of OBD requirements will also find the course valuable.

Prerequisites

An undergraduate engineering degree or a strong technical background is highly recommended. A basic knowledge of college algebra, college physics, and a familiarity with modern engine or transmission systems is required.

Topical Outline

DAY ONE

- Fundamental Design Objectives for OBD Systems
- Basic Design Features for OBD Systems
- Exercise: “Customers” and their OBD Requirements
- Overview of the World Wide OBD Regulatory Structure
- California Air Resources Board (CARB) Regulatory Process
Evaporative and Refueling Emission Control

2 Days I.D.# C0928

All gasoline powered vehicles and equipment create exhaust and evaporative and refueling emissions. Unlike exhaust emissions, which occur only when the engine is operating, evaporative emissions (evap emissions) occur all the time. Controlling evap emissions to PZEV levels is as challenging as controlling exhaust emissions. It becomes even more important in the case of plug-in hybrid electric vehicles (PHEV) and extended range electric vehicles (EREV) which generate evaporative fuel vapors, but have no place to burn/consume the vapors when the engine does not operate for extended periods of time. Constantly changing evaporative regulations including new test procedures for accommodating future EREVs and PHEVs vehicle evap systems, new test fuels to reflect changing commercial gasolines, identifying and controlling new sources of fuel vapor emissions, etc., require that individuals working in this area have a solid understanding of both regulatory and system design issues for evap emissions control.

This comprehensive seminar introduces the participants to the principles of gasoline evaporative fuel vapor generation (diurnal, hot soak, running loss, and refueling) from the vehicle fuel tank, fuel vapor storage in activated carbon canisters, and fuel vapor desorption and consumption in engine combustion. The seminar begins with an analysis of gasoline and gasoline/ethanol blends and estimation of their vapor pressures and vapor generation. In-depth analysis of various vapor generations as a function of fuel properties (ethanol content, Reid Vapor Pressure, etc.) and ambient conditions will be presented. Activated carbon canister design, OBD II leak detection, hydrocarbon permeation, and CARB and EPA evaporative test procedures will also be covered. Participants will have the opportunity to apply the knowledge gained by designing a sample evaporative and refueling emissions control system in class.

Participants are asked to bring a calculator for use in classroom exercises.

Learning Objectives

By attending the seminar, participants will be able to:
- Identify various sources of evaporative fuel vapor emissions
- Predict the effects of ethanol on evaporative emissions
- Estimate diurnal and refueling vapor generation
- Analyze the differences in the test procedures: U.S., Europe, and Asia
- Explain activated carbon canister operation: loading, purging, vapor redistribution, and back-purge
- Identify potential solutions to induction hydrocarbon emissions
- Estimate the effect of altitude on evaporative emissions

Who Should Attend

This course is designed for engineers in all fields related to the design and development of evaporative and refueling emission control systems including platform fuel system design engineers for fuel tanks, onboard refueling vapor recovery systems, evaporative emission control canisters, fuel vapor lines, vapor purge lines, purge and vent valves, etc. Air induction system design engineers dealing with induction hydrocarbon adsorbers, powertrain fuel delivery design engineers responsible for canister purge vapors, powertrain calibration engineers responsible for evaporative canister purge and evaporative emission diagnostics, and environmental engineers who deal with state and federal emission regulations, will all find the seminar valuable.
Power and Propulsion

Prerequisites
An undergraduate engineering degree or strong technical skills with some knowledge in basic organic and physical chemistry is required.

Topical Outline
DAY ONE
- Introduction
  - Evaporative and refueling emission control system
  - Why and how to control fuel vapor emissions
- Fuel and Fuel Vapor Pressure
  - Hydrocarbon fuels
  - Oxygenated fuels and non-ideal solutions
  - Estimation of vapor pressures of ideal (hydrocarbon fuels) and non-ideal solutions (oxygenated fuels)
  - Flexible Fuel Vehicles (FFV) and fuel commingling
  - Vapor pressure and boiling point estimation
- Fuel Vapor Generation
  - Diurnal, hot-soak, running loss
  - Refueling - liquid seal and mechanical seal, hot tank/cold dispensed fuel, cold tank/hot dispensed fuel, RVP, air entrainment and vapor recirculation, etc.
  - Effect of altitude on vapor generation and fuel boiling in running loss test
  - Effect of oxygenates on fuel vapor generation and fuel boiling in running loss test

DAY TWO
- Carbon Canisters
  - Adsorbents and isotherms
  - Activated carbons
  - Adsorption/desorption phenomena
  - Canister vapor loading, purging, redistribution, and back-purge
  - Canister design
- Evaporative and Refueling Emission Control System Design
  - Test procedures - EPA & CARB 3-day test, EPA-ORVR, EPA & CARB 2-day test, ECE and other global EVAP test procedures, etc.
  - Canister sizing - determine optimum size
  - Purge air volume requirement
- Miscellaneous Evaporative Emission Control Topics
  - Hybrid and plug-in hybrid evaporative emission control
  - Pressurized/sealed and bladder fuel tank for evaporative emission control
  - Evap OBD II leak detection
  - Permeation losses - effects of materials, temperature, fuel composition, etc.

Instructor: Sam Reddy
Fee $1370 1.3 CEUs

Exhaust Flow Performance and Pressure Drop of Exhaust Components and Systems
1 Day
I.D.# C0235
Designing more efficient and robust emission control components and exhaust systems results in more efficient performance, reduced backpressure and fuel penalty, and higher conversion efficiency. This course will help you to understand the motion of exhaust flow in both gasoline and diesel emission control components including flow-through and wall-flow devices such as catalytic converters, NOx adsorbers, diesel oxidation catalysts, diesel particulate filters as well as flow through the overall exhaust system. Discussions will also cover: flow recirculation in inlet cones, flow maldistribution and its effect on conversion efficiency in flow throughs, non-uniform particulate deposit in diesel filters, and roots of non-uniformity in flow distribution due to exhaust system design such as bends.

Learning Objectives
By attending this seminar, participants will be able to:
- Describe how exhaust stream is distributed in flow-throughs in gasoline or in diesel emission components and in wall-flow components (catalytic converters, NOx adsorbers, DOC, diesel particulate filters), including in inlet cones, exit cones, bends, elbows, flow constrictions, and in other components of an exhaust system
- Design exhaust systems yielding higher conversion efficiency, lower backpressure, faster light-off, and optimal performance
- Design diesel particulate filter systems yielding more uniform soot distribution in filters, thus lowering both filter backpressure and its peak regeneration temperature
- Describe connections between flow distribution and thermal performance such as light-off and radial and axial temperature gradients

Who Should Attend
This seminar is intended for engineers, managers, designers, researchers and technical associates who wish to gain deeper insight into developments and optimization of exhaust systems and components. This also includes professionals involved with catalyst and emission components and exhaust sensors.

Topical Outline
- Flow-throughs (e.g. catalytic converters or NOx adsorbers)
  - The basics: flow distribution; roots of and various contributors to pressure drop; effect of geometry; effect of surface area, length and diameter; role of catalyst; etc.
  - How to optimize the performance
  - How to measure the pressure drop
POWER AND PROPULSION

• Wall-flows (e.g. diesel particulate filters)
  • The basics: flow distribution; roots of and various contributors to pressure drop; effect of geometry such as wall thickness, cell density, plugs, and aspect ratio; transport and deposit of particulate in filters and its effect on the filter performance; role of exhaust flow on regeneration
  • How to optimize the performance
  • How to measure the pressure drop
• Inlet and exit cones: flow recirculation in cones and its effect on backpressure and performance (e.g. conversion efficiency, particulate deposit, light-off, etc.)
• Similar analysis of other exhaust system components such as pipes, bends, elbows, and constrictions and expansions in the path of the exhaust flow

Exhaust Gas Recirculation (EGR) for Diesel Engines

2 Days
I.D.# C1214

Meeting the requirements of heavy-duty engine emissions regulations is a challenge for all engine manufacturers. Since the introduction of Exhaust Gas Recirculation (EGR) in medium and heavy-duty diesel engines, these systems have become more sophisticated and tightly integrated with emission control systems.

This 2-day seminar will explore the advantages and disadvantages of EGR and the most effective implementation of various EGR systems. This seminar will begin by defining EGR and why it is used in diesel engines, along with an explanation of the mechanisms by which EGR is able to reduce NOx. This seminar will then move into implementation of EGR systems and examples of these systems on medium and heavy-duty diesel engines. In addition, the impact of EGR on various engine components will be discussed and will include EGR coolers, valves and piping. Finally, a section will be devoted to the comparison between EGR and SCR and their future roles in reducing NOx emissions, as well as their impact on fuel efficiency and CO2 emissions. Emphasized in this comparison is the use of EGR in novel combustion systems and its ability to reduce emissions in-cylinder.

Learning Objectives
By attending this seminar participants will be able to:
• Define EGR
• Recognize the different types of EGR systems used in diesel engines
• Evaluate the overall advantages and disadvantages of EGR systems in diesel engines
• Identify the impact of EGR on the combustion process
• Identify the impact of EGR on NOx and PM emissions
• Compare and evaluate EGR and SCR systems as a means to meeting emissions regulations

Who Should Attend
This seminar is designed for engineers and managers working in diesel combustion and emissions control technologies.

Topical Outline
DAY ONE
• Fundamentals of Exhaust Gas Recirculation
  • Defining EGR
  • Purpose of EGR
  • How EGR works
  • Why EGR is used in diesel engines
• Types of EGR Systems and Implementation
  • HPL EGR
  • LPL EGR
  • Combination HPL and LPL
  • Venturi-Assisted EGR
  • Dedicated EGR
• Advantages and Disadvantages
  • EGR in general
  • HPL EGR
  • LPL EGR
• Impact of EGR
  • On emissions
  • On fuel economy
  • On engine wear
• Opportunities for Unique EGR System Implementations
  • Air-Augmented EGR systems
  • EGR filtration systems
• EGR System Design
  • Calculations
  • Modeling and Simulation
• Controls
  • System delay and control
  • Model-Based control system
  • Optimizing for BSFC
  • Optimizing for smoke
  • Optimizing for NEDC
  • Strategy for hybrid EGR
  • Throttle control valve
DAY TWO
• Impact of Turbocharging on EGR Performance
• EGR Coolers and Mixers
  • Installation
  • Design
  • Effects of EGR
Examples of Production EGR Systems
- Cummins
- Volvo
- Mack
- Detroit Diesel
- Navistar

Issues and Challenges of EGR Implementation
- Primary issues
- Power density
- Component design
- Performance and combustion
- Components

Effect of EGR on Diesel Combustion
- Emissions
- Fuel consumption
- Torque and power
- Temperature

EGR and Selective Catalytic Reduction (SCR) Systems Comparison
- General comparisons
- Future roles in reducing emissions

Learning Objectives
By attending this seminar, participants will be able to:
- Describe the important processes in ignition and its relation to engine performance, efficiency, and emission
- Explain the combustion process in internal combustion engines
- Apply ignition strategies for reduction of engine pollutants
- Recognize the effects of ignition system design and engine operating conditions on combustion and emission
- Describe the technology and the logic behind the current and future ignition-based engine diagnostics
- Assist in the design of critical components such as combustion chambers and exhaust systems
- Identify key design components of an ignition system for optimum combustion chamber design and low engine emission of pollutants

Who Should Attend
This seminar will be especially valuable for engineers, technical and project managers, researchers, and academicians involved in ignition and combustion/emission aspects of the combustion engines. Currently, the design strategy of many components in these engines is affected by combustion and emission control measures to meet customer’s, federal and local government’s demands and regulations. Therefore, engineers working on the design of components for high efficiency and performance of combustion engines as well as those directly and indirectly involved in ignition and emission reduction strategies will highly benefit from this seminar.

Topical Outline
DAY ONE
- A Concise Background on Combustion in Spark Ignited (SI) Engines
  - Cylinder pressure traces
  - MBT and ignition timing
  - Flame propagation issues
  - Combustion characterization
  - Cyclic variability
- Ignition Fundamentals
  - Spark Ignition
  - Function of ignition system
  - Commonly used ignition systems
  - What determines the amount of ignition energy
- Four Phases of Spark Ignition
  - Pre-breakdown, breakdown, arc, and glow discharge

DAY TWO
- Effects of Some Key Parameters on Combustion, Emission and Performance
  - Higher power and/or energy
  - Longer duration discharge

Instructor: Magdi Khair
Fee $1370 1.3 CEUs

Ignition Issues and Their Impact on Engine Performance, Efficiency and Emission

2 Days
I.D.# C0131
Improved understanding and control of ignition and thereby combustion are critical in dealing with the problems of pollutants formation, engine performance, and fuel economy. This seminar will provide you with basic knowledge and recent advances in combustion-initiation (ignition) issues to more intelligently evaluate and harness their potentials. Thermodynamic and fluid mechanical properties of the unburned charge near the spark plug and at the time of ignition strongly affect the quality of the combustion and therefore the emission of the pollutants from the engine. Furthermore, a weak ignition limits engine performance and drivability. The so-called cyclic variability, which affects and bounds the lean and knock limits of an engine design is to a great degree influenced by the ignition system. Equally important, the ignition system can and is being used to provide local in-cylinder information on air-fuel ratio, misfire, knock, and mass fraction burned in each individual cylinder. Hence, great potential exists for applications of this information for individual cylinder control strategy to attain a more fuel efficient and environmentally compatible engine.
• Multiple spark plugs
• Different spark plug designs
• Alternative Ignition Methods
• Corona ignition system
• Plasma-jet ignition system
• Flame-jet ignition system
• Activated radical (AR) ignition
• Others
• Diagnostic and Control Opportunities
• Use of spark voltage for monitoring combustion
• Spark spectroscopy
• Ionization measurement for engine health monitoring & diagnostics
• Ignition Systems for Highly Diluted Mixtures
• Conclusions

Instructor: Bruce Chehroudi
Fee $1370 1.3 CEUs

Selective Catalytic Reduction for Diesel Engines

2 Days
I.D.# C0913

Stringent requirements of reduced NOx emission limits in the US have presented engineers and technical staff with numerous challenges. Several in-cylinder technical solutions have been developed for diesel engines to meet 2010 emission standards. These technologies have been optimized and have yielded impressive engine-out results in their ability to reduce emissions to extremely low levels. However, current and state-of-the-art in-cylinder solutions have fallen short of achieving the limits imposed on diesel emissions for 2010. To help meet emissions requirements, the catalyst industry has developed exhaust emission reduction technologies with impressive levels of performance. These technologies include hydrocarbon selective catalytic reduction (SCR), NOx absorber catalysts, and urea SCR.

This seminar will begin with an explanation of NOx formation in diesel engines and in-cylinder methods for reducing these emissions. The aftertreatment systems for NOx reduction will be explained and the advantages and disadvantages of these emission reduction technologies will be discussed.

In this two-day seminar, the primary focus is on urea SCR and its technology will be fully examined. The important chemical reactions and methods for improving SCR performance by encouraging desirable reactions and avoiding undesirable reactions are explained. Additionally, the components and control of a urea SCR system are detailed and the necessary sensors for its control are described. The SAE paper Laboratory Testing of Urea-SCR Formulations to Meet Tier 2 Bin 5 Emissions is included in the course materials.

Learning Objectives
By attending this seminar participants will be able to:
• Identify how NOx is formed in diesel engines
• Identify the in-cylinder means for reducing NOx
• Evaluate NOx aftertreatment technologies for diesel exhaust.
• Describe the characteristic of selectivity in catalytic aftertreatment
• Apply selectivity to urea SCR
• Describe the features and components of a complete urea SCR system
• Learn how to optimize the control of a urea SCR
• Distinguish the differences between various catalytic SCR formulations

Who Should Attend
This seminar will benefit engineers and technical staff who are developing urea aftertreatment systems for diesel engines, including catalyst engineers who supply NOx aftertreatment systems to the diesel industry. Also benefitting will be suppliers of other NOx reducing technologies, such as EGR components and fuel injection systems, as well as on-highway and off-highway diesel engine technical staff.

Prerequisites
Attendees should have knowledge of how a diesel engine operates, including its 4-stroke operation. Additionally, attendees should have basic knowledge of the emission formation mechanism in internal combustion engines.

Topical Outline
DAY ONE
• Introduction
  • On-Highway diesel emission regulations
  • Non-Road diesel emission regulations
  • Passenger car diesel emission regulations
  • Light-Truck diesel emission regulations
  • EURO IV Regulations
  • EURO V Regulations
  • NOx regulations in Japan
  • Drivers for controlling NOx
  • NOx Formation in Diesel Engines
  • Diffusion combustion model
  • The Zeldovich Mechanism
Turbocharging for Fuel Economy and Emissions Web Seminar and Web Seminar Replay

4 Hours
Web Seminar: I.D.# WB1018
Web Seminar Replay: I.D.# PD331018ON

Turbocharging is already a key part of heavy duty diesel engine technology. However, the need to meet emissions regulations is rapidly driving the use of turbo diesel and turbo gasoline engines for passenger vehicles. Turbocharged diesel engines improve the fuel economy of baseline gasoline engine powered passenger vehicles by 30-50%. Turbocharging is critical for diesel engine performance and for emissions control through a well designed exhaust gas recirculation (EGR) system. In gasoline engines, turbocharging enables downsizing which improves fuel economy by 5-20%.

This web seminar will explore turbocharging for gasoline and diesel (heavy and light duty) engines, including the fundamentals of turbocharging, design features, performance measures, and matching and selection criteria. It will discuss the interaction between turbocharging and engine systems and the impact on performance, fuel economy and emissions. Developments in turbocharging technology such as variable geometry mechanisms, two-stage and sequential (series & parallel) turbocharging, EGR including low pressure loop, high pressure loop and mixed mode systems and novel turbocharging systems will be described using figures and data.

**Learning Objectives**
- Identify the basics of how a turbocharger works, how to measure the appropriateness of a turbocharger, and how to select and match a turbocharger to the needs of your powertrain
- Estimate the impact of turbocharging on performance and emissions
- Anticipate potential issues such as packaging, noise, driveability, reliability, and durability
- List the latest developments in turbocharging technology, their impact on engine performance and emissions, and the use of turbocharging world-wide

**Who Should Attend**
This course will be beneficial to powertrain development engi-
neers, component development engineers, engineering managers, product planners, service engineers, and those developing product strategy. Heavy duty diesel engine development engineers may find the course helpful by increasing their knowledge of turbocharging and EGR systems.

Topical Outline

Session 1
Introduction to Turbocharging
• Fundamentals, Functionality, and Basic Design Features of Turbochargers
• Impact of Turbochargers on Engine Performance, Emissions, and Fuel Economy
• Performance Maps, Selection Criteria, Comparison and Matching of Turbochargers to Engine and Powertrain Needs

Session 2
Advanced Issues and Technology
• Turbocharger Noise, Reliability, and Durability Considerations
• Advanced Technology Developments Including Variable Geometry, EGR Systems, and Multi-Stage Turbocharging
• Worldwide Growth in Application of Turbocharging

Instructor: Kevin Hoag & Roy J. Primus
Fee $425 .4 CEUs

HYBRID AND ELECTRIC VEHICLES

Introduction to Hydraulic Hybrid Systems for Road Vehicles

2 Days
I.D.# C0833

Considerable attention has been given to the design and efficiencies of electric hybrid propulsion systems and energy storage technologies. Although they draw much less attention, hydraulic hybrid propulsion and regenerative braking systems for road vehicles are a cost effective alternative to electric systems and have relevance to important sectors of the passenger and commercial vehicle markets.

In this two-day seminar, hydraulic hybrid vehicle systems and their potential will be examined using model based evaluations. This will include an evaluation and comparison of hybrid configurations as well as the introduction of components used in these hydraulic hybrid systems. Also provided will be details on how hydraulic systems are designed and integrated into vehicles, including interactions with braking systems and various other vehicle systems. Recent developments in hydraulic machines and an update on the component technology needed to implement these solutions will also be presented.

Learning Objectives

By attending this seminar, participants will be able to:
• Identify the fundamentals of parallel and series hydraulic hybrid vehicle transmission systems and components
• Evaluate the applicability of such systems to particular vehicle applications
• Identify how hydraulic hybrid system components can be integrated into the vehicle
• Recognize the interactions with other vehicle systems (e.g. engine, transmission, ABS, foundation brakes) and integration of controls

Who Should Attend

This course will benefit individuals new to hydraulic hybrid systems as well as engineers and designers involved in all areas related to the design and development of vehicle powertrain systems. Also benefiting will be individuals interested in the interaction of this hybrid system with braking systems and engine controls.

Topical Outline

DAY ONE
• Introduction and Overview
  • Objectives
  • Course outline and scope

SAE SI ENGINE CERTIFICATE PROGRAM

Watch for the certificate icon to indicate course titles that are part of an SAE multi-course certificate program.

Designed to familiarize you with key spark ignition engine components and technologies and how they function as a system, completing this certificate delivers a fairly deep level of engine expertise and, at the same time, an SAE credential. Complete the SI Engine Certificate and earn seven or eight graduate credits towards the SAE/Kettering University 20-credit Certificate in Automotive Systems and Kettering’s 40-credit M.S. in Mechanical Engineering. Visit training.sae.org/collegecredit. View the list of required and elective courses and additional information on enrolling in this SAE certificate program: training.sae.org/certificate/siengine
• Hybrid Vehicle Systems - Outline and Comparisons
  • Definitions
  • Energy storage
  • Basic electric and hydraulic configurations: Parallel and Series - Efficiency evaluations; Weight comparison; Cost outline
• Hydraulic Components for Vehicle Hybrid Systems
  • Accumulators - Types; Size and weight; Efficiency and response; Installation
  • Pumps and Motors: Requirements - Efficiency and response
  • Types: Descriptions and Potential Applications (Axial Piston; Swash Plate; Bent-Axis; Radial Piston; Other
  • Other components - valves pipes, filters, coolers, etc.
• Controls - System; Vehicle

DAY TWO
• System Design
  • Simulation strategy - Drive cycles; Launch criteria; Maximum speed; Towing/grades
  • Stop/Start functionality - Accessory drives
• Control Strategies
  • Regenerative braking
  • Parallel hybrid hydraulic systems
  • Series hybrid hydraulic systems
• Engine operation management - Simplified engine calibration for emissions and fuel economy; Advanced engines enabled by series hybrids
• Safe Operation
• Application Examples
  • Car and taxi
  • Light truck (SUV, pickup, work truck)
  • Light delivery truck and shuttle bus
  • Refuse and transit bus
  • Off-highway
• Hydraulic Hybrid Potential and Developments

Instructor: Simon J. Baseley
Fee $1370 1.3 CEUs

Introduction to Hybrid and Electric Vehicle Battery Systems

2 Days
I.D.# C0626

Driven by the need for lower emissions, better fuel economy and higher efficiency, hybrid vehicles are appearing in many different configurations on today’s roadways. While the powertrain components such as the drive motor, motor controller and cooling system are somewhat familiar to the automotive industry, the battery systems are a relatively unfamiliar aspect. This seminar will introduce participants to the concepts of hybrid vehicles, their missions and the role of batteries in fulfilling those requirements. Battery topics including limitations, trends in hybrid development, customer wants and needs, battery system development timelines, comparison of electrochemistries and safety will be examined. Current offerings, cost factors, pack design considerations and testing will also be reviewed.

Students will have an opportunity to perform a battery pack analysis exercise using a real world application and are requested to bring a calculator to class.

Learning Objectives
By attending this seminar, participants will be able to:
• Capture customer wants and expectations of the battery system
• Identify factors that drive power and energy requirements
• Determine test program structure
• Compare and contrast the newest relevant battery technologies
• Calculate estimates of electric range and quantify the assumptions
• Critically assess media claims of new battery discoveries

Who Should Attend
This seminar is primarily intended for vehicle systems engineers, battery system integration engineers, testing engineers, electrical engineers and thermal management engineers recently assigned to their roles or returning to hybrid or electric vehicle programs. It will also be beneficial to those involved in the specification, design, development, testing and planning of hybrid vehicle programs. Product planners and program managers will find the overview aspects helpful.

Topical Outline

DAY ONE
• Terminology, Definitions and Conventions
• Brief Review of the Hybrid Market
  • Market drivers and expectations
  • Market influences
  • Competing technologies
  • Customer expectations
• Review of Common Vehicle Product Offerings (battery descriptions, power, technology, size, architecture)
• Fundamentals
  • Fossil fuel vs. hybrid vs. electric
  • Source ragone plot
  • Efficiencies, weights
  • Cost of fuel (fossil vs. electrons)
• Role of Battery
  • ICE vs. electric systems
Safe Handling of High Voltage Battery Systems

1 Day  
I.D.# C1019

Electric and hybrid vehicles are becoming more visible on today’s roadways and the automotive companies are working hard to make these vehicles as transparent as possible to enhance consumer acceptance. The battery system forms a key part of any of these vehicles and is probably the least understood. With practically no moving parts the battery systems show no visible or audible warning of any latent dangers. This seminar will introduce participants to the risks encountered in handling high voltage battery systems and their component parts. With the understanding of these risks, the seminar will then address how to raise risk awareness and then methods of dealing with those risks. The outcome of this seminar should be improved avoidance of personal injury, reduced risk of reputation loss and product liability actions and reduced risk of loss of property and time.

Students will have an opportunity to participate in a real world battery handling case study scenario in which they will identify solutions for potential risk situations.

Learning Objectives
By attending this seminar, participants will be able to:
- Identify the handling risks of the battery system
- Respect the risks and work with them
- Develop a safety program to manage the risks

Who Should Attend
This seminar is primarily intended for vehicle and battery engineers, battery system integration engineers, battery testing engineers, safety systems engineers, electrical engineers and thermal management engineers recently assigned to their roles or returning to hybrid or electric vehicle programs. It will also be beneficial to those involved in the specification, design, development, testing and planning of hybrid vehicle programs. Prototype shop staff will find the safety protocol aspects helpful.

Prerequisites
The SAE course Introduction to Hybrid and Electric Vehicle Battery Systems (#C0626; page 173), is recommended as a prerequisite. Material presented will be practical in nature and is based on selected fundamentals of chemistry, materials science, electrical and mechanical engineering.

Topical Outline
- High Voltage Batteries
  - Electrochemical energy
  - Construction aspects and controls
  - DC vs AC
  - Lithium Ion aspects
- Risks of HV Batteries
  - Team exercise: identifying the risks
  - Risk drivers
  - Hazards classifications
  - Cell vs pack level
- Risk Management
  - Abuse prevention
  - Best practices, design measures, error proofing
POWER AND PROPULSION

- Prevention & warnings
- Claims vs. test data
- Housekeeping
- Containment
- High Voltage Issues in Engineering and Manufacturing Environments
  - Avoidance of internal dangers from handling
  - What can go wrong in different environments
  - MSDS
  - Special tools
  - Handling of ‘failed’ batteries or cells
  - Dealing with an incident - team exercise

Instructor: Erik Spek
Fee $810 .7 CEUs

ENGINES

Automotive Heat Transfer

2 Days
I.D.# C1230

Heat transfer affects the performance, emissions and durability of the engine as well as the design, packaging, material choice and fatigue life of vehicle components. This course covers the broad range of heat transfer considerations that arise during the design and development of the engine and the vehicle with a primary focus on computational models and experimental validation covering the flow of heat from its origin in the engine cylinders and its transfer via multiple paths through engine components. Specifically, the course will cover heat transfer design considerations related to the following: engine cooling and lubrication systems as well as bay-to-bay breathing; exhaust system and after-treatment components; tail pipe gas temperatures, as well as thermal interactions between the engine and its exhaust system with the components in the vehicle under-hood and under-body; turbochargers; passenger cabin HVAC system, including windshield de-icing; battery cooling; heat exchangers and challenges associated with predicting thermal mechanical fatigue life of components.

Learning Objectives

By attending this seminar, participants will be able to:

- Formulate solutions to heat transfer problems to optimize component design for durability and cost
- Make more reliable predictions of engine in-cylinder heat transfer rates (and therefore thermal stresses and fatigue life) for engine components, namely, the cylinder head, piston, cylinder liner, valves and ports
- Optimize design decisions for above engine components by improving trade-offs between material choices, design, durability, packaging, heat flow map and cost
- Specify thermal boundary conditions for under-hood and under-body CFD models early in a vehicle development program when only high level engine and performance metrics have been defined.
- Predict energy losses due to bay-to-bay breathing
- Describe techniques to facilitate thermal management of exhaust aftertreatment devices (DOC, SOC, particulate filters) and tail pipe exit gas temperatures for diesel vehicles

Who Should Attend

This course will be valuable to engine and vehicle engineers dealing with heat transfer issues. Specifically thermal and structural analysis engineers will learn best practices for making reliable analysis predictions. Hardware release engineers will gain a better appreciation of the limits and capabilities of the analysis and measurement technologies that drive their decisions. Supervisory and managerial persons with the responsibility for solving thermal problems that arise during sub-system design and development will gain a better appreciation of the uncertainties and trade-offs behind the thermal decisions for which they are ultimately responsible. Vehicle thermal engineers will gain knowledge to assist them in making design and packaging decisions in the early stages of vehicle development. This unique course will give in-depth insights into thermal considerations spanning the entire vehicle, providing subsystem specialists with an overall perspective of the other vehicle system issues and constraints with which they may not be familiar.

Topical Outline

DAY ONE

- Introduction
  - Engine and exhaust components
  - Heat transfer CFD
- Engine In-Cylinder Heat Transfer
  - Background
  - Benchmark in-cylinder measurements
  - Interaction of heat transfer with combustion
  - Zero & multi-dimensional modeling
  - Standard and modified wall functions
POWER AND PROPULSION

- Low Reynolds Number Model
- Heat transfer coefficients
- Validation with measurements

Engine Component and Sub-System Heat Transfer
- Overview
  - Piston, liner, head and valve temperatures
  - Bay-to-bay breathing
  - Engine cooling system considerations
  - Engine lubrication system considerations

DAY TWO
- Exhaust System Heat Transfer
  - Interaction with under-hood components
  - Design decisions early in a vehicle program
  - Turbochargers
  - After treatment devices
  - Tail pipe gas temperatures
  - Materials, properties and temperatures
  - Thermo-mechanical fatigue
- Heating, Ventilation and Air Conditioning
  - Passenger compartment human comfort
  - Energy transactions and heat transfer parameters
  - Air management
  - Refrigeration considerations
  - Windshield de-icing
- Heat Exchangers
- Battery Cooling
- Best Practices and Challenges
  - Best practices for heat transfer modeling
  - Challenges in simulation and measurement

Learning Objectives
By attending this seminar, participants will be able to:
- Identify the basic principles of diesel engines and diesel fuel injection
- Distinguish the main properties of diesel and diesel alternative fuels
- Compare and evaluate various diesel engine applications
- Describe the main systems and sub-systems of common rail diesel fuel injection and how these systems interact
- Identify the main design features of the common rail components
- Discuss basic common rail control strategies

Who Should Attend
This course will benefit engineers and other individuals involved in the design, application, and service of common rail diesel engines utilized in passenger cars, light/medium/heavy-duty trucks, and off-highway vehicles, including marine and farm machinery.

Prerequisites
Familiarity with basic engine design and operation theory is recommended.

Topical Outline
- Basic Principles of Diesel Engines
- Basic Principles of Diesel Fuel Injection
- Diesel and Alternative Fuels
- Applications - Passenger car; Light-duty; Heavy-duty; Off-highway; Pressure history
- Common Rail System Overview
  - Low-pressure system
  - High-pressure system
  - Controls
- Hydraulic Components
  - Pumps - Radial piston; Inline piston
  - Rails
  - Injectors - Solenoid; Piezo
  - Nozzles
  - Control valves - Pressure control valve; Metering unit; Pressure relief valve
  - High-pressure lines
- Controls
  - Overview

Common Rail Diesel Fuel Injection
1 Day
I.D.# C0920
The improved efficiencies of the modern diesel engine have led to its increased use within the mobility industry. The vast majority of these diesel engines employ a high-pressure common rail fuel injection system to increase the engine’s fuel-saving potential, emissions reduction, and overall performance.

This one-day seminar will begin with a review of the basic principles of diesel engines and fuel injection systems. Diesel and alternative fuels will be discussed, followed by current and emerging diesel engine applications. The majority of the day will be dedicated to the common rail system itself, beginning with a comprehensive overview of the complete system. The instructor will then introduce the main subsystems, including hydraulics and controls. Finally, the subsystems will then be broken-down into their respective components.
Diesel Engine Technology

2 Days
I.D.# 93014

Similar content is available in an on demand option. Review the course info in the On Demand Courses Guide on page 199.

As diesel engines become more popular, a fundamental knowledge of diesel technology is critical for anyone involved in the diesel engine support industry. This course will explain the fundamental technology of diesel engines starting with a short but thorough introduction of the diesel combustion cycle, and continue with aspects of engine design, emission control design, and more. An overview of developing technologies for the future with a comprehensive section on exhaust aftertreatment is also included.

The text, Diesel Emissions and Their Control, authored by Magdi Khair and W. Addy Majewski is included with the seminar.

Learning Objectives
By attending this seminar, participants will be able to:
• Summarize the technological advances in modern diesel engines
• Evaluate the sources of emissions from diesel engines and the influence of engine component design on curbing these emissions
• Explain diesel exhaust aftertreatment systems and their effectiveness in reducing emissions
• Recognize the importance of fuel injection parameters to performance and emission control

Who Should Attend
You should attend this seminar if you are involved in diesel engine support industries such as catalytic converters, lube oils, gaskets, and turbocharger suppliers, and if you are not well versed with diesel engines although they play a major role in your career’s survival.
POWER AND PROPULSION

- Development of injection pressure in HEUI
- Desired injection flexibility
- Operation differences between HEUI-A & HEUI-B
- The HEUI-B injection system
- HEUI-A and HEUI-B injectors
- Air Management - Supercharging & Turbocharging
  - The purpose of air charging
  - Methods of air charging
  - Supercharger drives; Types of superchargers
  - Schematic representation of supercharger types
  - Sample performance map of a supercharger
  - Photographs of two centrifugal superchargers
  - Sample performance map of a centrifugal supercharger
  - Types of turbochargers
  - Schematic representation of a turbocharging system
  - Exhaust and charge airflow through a fixed geometry turbocharger
  - Anatomy of a turbocharger
  - Energy conversion in a turbocharger
  - The importance of A/R in a turbocharger design
  - Cutaway in a modern turbocharger
  - Sample performance map of a turbocharger
  - Waste-gated turbocharger
  - Variable geometry turbocharger
  - Combination system - wave charging
  - Turbocompounding
  - Sequential turbocharging
- Emissions Formation in Diesel Engines
  - Hydrocarbon
  - Carbon monoxide
  - Nitrogen oxides
  - Particulate matter
  - Smoke
- Emission Standards
  - Europe; North America
- Steps Towards the Modern Diesel Engine
  - Injection
  - Combustion
  - Induction
  - Oil consumption
  - Engine electronics
  - Other design parameters
- Current and Future Technologies
  - Exhaust gas recirculation
  - Multiple injections
  - Auxiliary emission control devices (aftertreatment)
  - Fuels and emulsions

Diesel Engine Technology

13 Hours

Similar content is available in the classroom seminar – Diesel Engine Technology – see course info above.

Convenient, portable, and with core content from the instructor-led seminar (content and description similar to the preceding classroom counterpart), this nearly 13 hour on demand option offers an alternative way to receive the same instruction without the expense of travel and time away from the workplace. The course is divided into an introduction and eight modules.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Quantity discounts and Site License options are available – call SAE Corporate Learning Solutions hotline at +1.724.772.8529 for a quote.

SAE DIESEL TECHNOLOGY CERTIFICATE PROGRAM

Watch for the certificate icon to indicate course titles that are part of an SAE multi-course certificate program.

Designed to equip you with a solid understanding of diesel engines, emissions and aftertreatment strategies, and related components, the program requires completion of courses that address these areas and then facilitates further depth in aftertreatment technologies through a menu of electives. Complete the Diesel Technology Certificate and earn eight graduate credits towards the SAE/Kettering University 20-credit Certificate in Automotive Systems and Kettering’s 40-credit M.S. in Mechanical Engineering. Visit training.sae.org/collegenetcredit for more information. View the list of required and elective courses and more information on enrolling in this SAE certificate program: training.sae.org/certificate/dieselttech.

Diesel Engine Noise Control Web Seminar and Web Seminar RePlay

4 Hours

Web Seminar: I.D.# WB1041
Web Seminar RePlay: I.D.# PD331041ON

This web seminar provides an in-depth overview of diesel engine noise including combustion and mechanical noise sources. In addition, the instructor will discuss a system approach to automotive integration including combining sub-systems and components to achieve overall vehicle noise and vibration goals.

Instructor: Magdi Khair
Fee $1675 1.3 CEUs

3 ways to get a no-obligation price quote to bring a course to your company • Call SAE Corporate Learning at +1.724.772.8529
• Fill out the online quote request at sae.org/corplearning • Email us at Corplearn@sae.org
POWER AND PROPULSION

Learning Objectives
By connecting with this Web Seminar, participants will be able to:
• Identify and analyze commonly occurring diesel engine noise sources
• Understand how analytical and experimental techniques can be used to solve diesel noise issues
• Prescribe appropriate noise control analysis and solutions for specific diesel engine NVH issues

Who Should Attend
Those who wish to understand the root causes of many diesel engine noise issues, and how to use this understanding to better diagnose and control diesel engine-related noises.

Topical Outline
Session 1
• The Basics of Diesel Engine Noise
• Combustion Noise Forcing Functions
• Combustion Mode Switching
• Mechanical Forcing Functions in Diesels
• Separating Combustion and Mechanical Noise Sources
• Strategies for Reducing Forcing Functions
Session 2
• Surface Radiated Noise
• Exterior Covers: Radiated Sound and Simulation Modeling
• Gear Train Noise Issues and Countermeasures
• Drive-By Noise Contribution
• Diesel Engine Design Considerations for Low Noise
• Application Noise Issues

Instructor: Thomas Reinhart
Fee $425 .4 CEUs

Engine Failure Investigation and Analysis
2 Days
I.D.# C1344

Engine failures can occur in a variety of equipment, vehicles, and applications. On occasion, a single vehicle type or equipment family will even experience multiple engine failures leading to the inevitable need to determine what the most likely cause of one or all of those failures was. This comprehensive seminar introduces participants to the methods and techniques used to understand the types of variables and inputs that can affect engine reliability and then determine the most likely cause of an individual engine or group of engine failures in the field.

The seminar begins with a discussion of customer expectations and experiences and how any disconnect between the two can affect the customer’s overall perception of an engine’s performance and reliability. The seminar then focuses on the concepts of uncertainty and deterministic design, what is a failure, and how a combination of factors from design inputs to supplier variability can affect the reliability of all or just a portion of an engine population. This is followed by a review of the investigative process and analytical methods required to arrive at an objective and thoroughly developed conclusion as to the nature and cause of the failures at issue. The seminar finishes with a review of case studies that involve customer related issues and failures arising due to a variety of inputs including design, manufacturing, duty cycle, and maintenance.

Learning Objectives
By attending this seminar, participants will be able to:
• Analyze engine failure claim narratives and how they relate to the customer experience
• Explain the concept of uncertainty and how it relates to failures and complaints attributed to an engine system
• Analyze and interpret engine and/or vehicle warranty data
• Reconcile the physical evidence with the narrative and warranty evidence
• Determine the most likely cause of engine failure based on the available evidence
• Reconcile any disconnect between customer expectations and experience and determine what if any corrective actions are required

Who Should Attend
This course has been developed for engineers and technical professionals in all fields related to the investigation, analysis, and root cause determination of engine failures in various types of vehicles and equipment used in both on-road and off-road applications. In addition, this course can be valuable to individuals involved with handling and processing customer warranty and insurance claims for engine related issues.

Individuals directly involved in the investigation of engine failure and failure related issues will benefit most from this material. Please note that this course is not intended to provide an in depth discussion of individual component failure modes within the engine. The focus of the course is to understand the fundamental types and sources of inputs that contribute to engine failures and the process and methods used to identify them and determine what, if any, type of corrective actions should be implemented.
POWER AND PROPULSION

Topical Outline

DAY ONE
• The Customer Experience
  • Expectations
  • Perceptions
  • Experiences
  • Metrics
• Uncertainty in Design and Development
  • Design
  • Development
  • Design Entropy
• Engine Characteristics
  • Creation
  • Components
  • Production
  • Integration
• Contributing Factors
  • Contributors
  • Inputs
  • Controlling Uncertainty
DAY TWO
• Investigative Process
  • Goals
  • Evidence
  • Collecting Information
• Analytical Method
  • Analysis Steps
  • Population Identification
  • Analysis Methods
• Selected Case Studies
  • Competing Requirements
  • Oil Consumption
  • Customer Maintenance
  • Engine Integration & Duty Cycle
  • Development Quirks

Instructor: Robert (Skip) Kuhn
Fee $1370 1.3 CEUs

Gasoline Direct Injection (GDI) Engines

3 Days
I.D.# C1009

The quest for more efficient, smarter, and environmentally cleaner liquid-fueled spark ignition (SI) reciprocating engines is more alive and intense now than ever before. GDI SI engines have overcome many of the original limitations and are now becoming commonplace. This seminar will provide a comprehensive overview of GDI engines. Mixture preparation and the combustion process, with an emphasis on strategies for both homogenous and stratified charge operation and control, including issues related to the direct injection of gasoline into the combustion chamber, and fuel injection system requirements for optimal spray characteristics will be explored. Emission of pollutants, fuel economy and effects of some key design and operating parameters will also be covered. The seminar concludes with an overview of a select list of production and prototype GDI engines.

Learning Objectives

Upon completion of this seminar, participants will be able to:
• Describe the rationale behind the GDI engine operation
• Analyze the important processes in GDI engines
• Explain liquid atomization, sprays, and injector requirements for successful GDI operation
• Utilize the technology and the logic behind gasoline direct injection
• Estimate and predict effects of key engine design and operating conditions on performance, combustion, and emission in GDI engines
• Communicate effectively with engineers working on fuel injection, combustion and emission aspects of the GDI engine in your firm or with customers
• Effectively contribute to the design of critical components such as combustion chambers, injectors, and emission reduction strategies
• Explain and utilize trade-offs between increasing engine performance and maintaining low emission characteristics

Who Should Attend

This seminar will be especially valuable for engineers, technical and project managers, researchers, and academicians. Engineers working on the design of components for high efficiency and performance of GDI engines as well as those directly and indirectly involved in mixture preparation and emission reduction of harmful pollutants from these engines will highly benefit from this course. Environmental engineers desiring to expand their understanding of fuel spray formation, combustion and emissions from GDI engines will benefit, as well as, engineers active in the development and application of software for the modeling and design of combustion chambers, fuel spray dynamics, combustion and emission issues.
Who Should Attend
Attendees should have general knowledge of engine operation especially in-cylinder combustion processes. However, a very concise review of the subject is presented.

Topical Outline

DAY ONE
- Combustion Systems
  - Relative position of spark plug and fuel injector
  - How to achieve homogeneous and stratified charge - spray-, wall-, and air-guided combustion systems
- Fuel Injection System
  - Fuel injection system requirements
  - Fuel injector requirements and classification
- Fuel Spray Characteristics
  - Spray atomization requirements
  - Sac spray consideration
  - After-injection
  - Fuel spray penetration and cone angle
  - Split injection
  - Sprays characteristics of injectors
  - Effects of ambient pressure (density) on spray
  - Spray characterization (GDI)

DAY TWO
- Mixture Formation
  - In-cylinder flow characteristics and GDI combustion
  - Fuel-air mixing process
  - Spray-wall interactions
  - Cold start and wall wetting issues
- Combustion Process and Control Strategies
  - Engine Operating Modes and Fuel Injection Strategies
    - Early-injection, late-injection, stoichiometric operation
    - Operating mode transition
  - Split Injection Strategy
    - Two-stage, split, and post injection
  - Combustion characteristics
    - Homogeneous-charge and stratified-charge combustion
- Effects of Engine Operating and Design Parameters on GDI Combustion
  - Injection and ignition timings
  - Spray cone angle
  - EGR
  - Knock resistance characteristics
  - Air-assisted versus single-fluid GDI fuel system
- Injector, Combustion Chamber, and Intake Valve Deposits

DAY THREE
- Emissions of Pollutants - Reduction Approaches
  - Hydrocarbon, NOx, particulate and noise emissions
- Fuel Economy
  - Factors affecting improved fuel economy
  - Fuel economy versus emissions compromise
  - Select Gasoline Direct-Injection Engines
    - Early DISC engine
    - Mitsubishi reverse-tumble-based wall-guided
- GDI Fuel Rail Technology
- Benefits of Turbocharging a GDI engine

Instructor: Bruce Chehroudi
Fee $1790 2.0 CEUs

High Performance Engine Design and Development

1 Day
I.D.# C0725

Ever since Beau de Rochas patented the four stroke cycle in 1862, engineers have pursued the development of high performance engines for road and racing applications at an accelerated pace. While this course will not cover such ancient history, it will focus on engine design and development advances over the last 40 years from “BC to AD” (“Before Cosworth to After Duckworth”), covering the concepts and designs behind the modern racing engines for series including Formula One, Indy Cars, the IRL, and NASCAR.

This course will help you determine how to design a championship-winning racing engine including many of the key calculations that support the pursuit of power. Attention to detail on every aspect of engine design is emphasized with focus on applying simple math, physics, and even plain old common sense, rather than relying heavily on sophisticated software.

The course begins with a review of the major advances in engine design, then explores the design of the engine’s primary systems and structures including oil systems, cam drive systems, water systems, inlet systems, exhaust systems, cylinder heads, cylinder blocks, and sumps. It will then explore how combustion works and how to analyze the major parameters involved in burning different fuels. This will be followed by the design and optimization of inlet and exhaust systems and applying mathematics via simple excel spreadsheets to determine the key factors for cam design, port design, inlet and exhaust tuning, and turbocharger/supercharger matching for those formulae that permit the use of boost to increase the inlet pressure. The day concludes with a discussion and opportunities to continue design exercises that will allow attendees
to put into practice several of the key concepts learned throughout the seminar.

Detailed course notes and illustrations are provided along with example calculations to enable the attendee to calculate the key parameters required in the design and development of racing engines.

Learning Objectives
By attending this seminar, participants will be able to:
- Describe the key parameters and choices facing the high performance engine designer
- Consider a variety of tips and solutions which can be applied by both design and development engineers to enhance the performance of competition engines
- Select “the least worse design solution” for any particular problem
- Summarize the major advances in engine design over the past 40 years

Who Should Attend
This course is for individuals with a thirst to improve their understanding of what makes a racing engine a championship winner. It can be valuable to those responsible for engine design, component design, and overall engine performance calculations or those who are merely interested in the subject.

Prerequisites
An undergraduate engineering degree or a strong automotive technical background is highly recommended. A basic knowledge of college algebra, college physics, and a familiarity with how we currently think engines work is helpful.

Topical Outline
- Engines from BC to AD
  - A brief outline of racing engine history covering the design and development of several famous racing engines to highlight how fundamentally different approaches to design and manufacturing can generate championship winning engines for various classes of racing
- Detailed Design of Engine Systems
  - How does a modern racing engine work and why?
  - Review of fundamental systems of the modern racing engine
- Engine Structures
  - Designing from the inside out, focusing on performance design
  - Adding the structures to integrate the load paths throughout the engine core
- Combustion
  - How any given fuel burns and what the combustion processes are that underpin performance
  - Combustion kinetics and fuel chemistry to enable calculation of energy release, peak combustion temperatures, and tail pipe emissions for any fuels or fuel mixtures.
  - Major fuel types and how to deal with any fuel starting from its basic chemical equations
- Engine Tuning
  - Inlet systems
  - Exhaust systems
  - Simple math for optimizing tuning orders and lengths
  - Camshafts
- Turbocharging and Supercharging: How to calculate the requirements and the major performance parameters before starting the design process
- Discussion and Design Exercise How to design the next engine to move the boundaries of engine performance forward again

Instructor: Geoff Goddard
Fee $810 .7 CEUs
POWER AND PROPULSION

- Describe the characteristics of several commercial engines that use HCCI combustion during a portion of their operating range
- Evaluate current research being performed and with support from governmental agencies
- Assess the potential and future direction of HCCI technology

Who Should Attend
This course is designed for engineers, technicians, managers, and students that are associated with engine design. In addition, personnel in the transportation industry that are involved in the research of advanced low pollutant emission technologies and high thermal efficiency engine concepts will benefit from this seminar.

Prerequisites
Attendees should have at least a basic understanding of fluid dynamics, thermodynamics, internal combustion engine operation, and combustion.

Topical Outline
DAY ONE
- Introduction and HCCI Overview
  - What is Homogeneous Charge Compression Ignition?
  - HCCI and other low temperature combustion strategies
  - HCCI for diesel engines - Advantages; Limitations
  - HCCI for gasoline engines - Advantages; Limitations
  - The importance of R&D in HCCI
- Benefits and Challenges
  - Benefits - Efficient; Fuel flexibility; Lower emissions
  - Challenges - Controlling ignition timing over a range of speeds and loads; Extending the Operating Range to High Loads; Cold-Start Capability; Hydrocarbon and Carbon Monoxide Emissions
- Developments in HCCI for Diesel Engines
  - Fundamental understanding
  - Advancements in speed and load control
  - Results using different fuels
  - Early applications of HCCI technology
- Developments in HCCI for Gasoline Engines
  - Fundamental understanding
  - Advancements in speed and load control
  - Results using different fuels
  - Early applications of HCCI technology
DAY TWO
- Future Directions
  - Ignition Timing Control
  - Low Temperature Combustion Strategies
  - Combustion Rate Control for High-Load Operation
  - Cold-Start
  - Emission Control
  - Exhaust Aftertreatment
- Transient Operation
- Dynamic Predictive Control and Mode Transitioning
- Advanced Control Systems
- High Pressure and Low Pressure EGR Applications
- Valve Train Development
- Fuel Injection System Development
- Multi-Cylinder Effects
- Combustion Modeling

Instructor: Gerald J. Micklow
Fee $1370 1.3 CEUs

Introduction to Powertrain Calibration Engineering Web Seminar and Web Seminar Replay
5 Hours
Web Seminar: I.D.# WB1346
Web Seminar Replay: PD331346ON

Driven by the need for lower emissions, better fuel economy and improved drive quality, optimized powertrain calibrations are required for the many different vehicle configurations on today’s roadways. While powertrain components such as the internal combustion engine, transmission, and hybrid electric powertrain are somewhat familiar to the automotive industry, the control theory, calibrations and system interactions between these components are a relatively unfamiliar aspect.

This web seminar will introduce participants to the concepts behind optimized powertrain calibrations and how they impact fuel consumption, exhaust emissions, and vehicle performance. Participants will also gain exposure to the role that the calibration plays in the system level interactions of the various powertrain components.

Each participant will be asked to view the recording from the one-hour SAE Vehicle/Powertrain Calibration Engineering: What Is It and Why Is It For You? Telephone/Webcast as a course requirement.

Learning Objectives
By connecting with this Web Seminar, participants will be able to:
- Describe the role of calibration in powertrain and vehicle performance
- Identify the fundamental requirements that drive powertrain calibration development
- List the major international regulatory agencies
- Identify the driving factors for complexity of powertrain systems
POWER AND PROPULSION

• Identify the powertrain system interactions that are influenced by calibration
• Recognize tools used in the development of powertrain calibrations
• Diagram the high level calibration process flow

Who Should Attend
This web seminar is intended for anyone who would like a better understanding of powertrain calibration and how it influences vehicle performance and drivability. Engineering students with an automotive interest through automotive professionals will gain insight into the calibration process and its system impact. It will also be beneficial to those involved in the specification, design, development, testing and planning of vehicles and powertrains. Product planners and program managers will find the overview aspects helpful.

Prerequisites
Material presented will be practical in nature with basic mathematics used to describe quantitative measures. A background in mechanical or electrical engineering will assist in gaining maximum benefit from the material presented. Experience or training in engine or transmission engineering is helpful, but not essential.

Topical Outline
Session 1
Requirements, Boundary Conditions and Complexity
• Fundamental requirements driving powertrain calibration
  • Regulations
  • Vehicle Requirements
  • Environmental requirements
• Overview of the factors driving complexity in powertrain calibration systems
  • Global requirements
  • Fuels
  • Product hardware
Calibration Functional Objectives
• Overview of some basic powertrain calibration tasks including base engine, transmission, OBD, aftertreatment, vehicle driveability
• Base Engine Calibrations
  • Steady state models (air charge, exh backpressure, knock thresholds)
  • Single point optimizations (spark, AFR, VVT, EGR, FUP, etc.)
  • Simple transients
• In-vehicle validation of dyno cals
  • Steady state correlation
  • Transient conditions
  • Knock behavior and fuel sensitivity
• Vehicle-specific Calibrations
  • Pedal progression
  • Drive/shift quality
  • Emissions
  • Performance
• Location-Specific Calibrations
  • Customer expectation of "normal" behavior in all climates
  • Hot weather (component protection)
  • Cold Weather (Emissions, startability, drive quality)
• Altitude (Emissions, startability, drive quality, performance)
Session 2
• Systems - How they interact
  • What is a powertrain system?
  • Powertrain subsystem calibration and interactions (engine, aftertreatment, transmission, hybrid, control)
  • Overview of some basic powertrain components and their effects on the overall system
  • Communication between systems and components
  • The calibration engineer’s role in the overall development process as the bridge between hardware and controls
• Calibration Tasks
  • Testing environments for calibration engineers including simulations, engine test cells, powertrain test cells, chassis dynamometer test cells and test track/field testing
  • Tools of the trade - industry standard tools and specialized tools that calibration engineers use
  • Using test data to create a calibration including modeling, optimization and table generation

Instructors: Julian Blair, Greg Banish, Talus Park, Chi Binh La
Fee $425 .5 CEUs

Internal Combustion Systems: HCCI, DoD, VCT/VVT, DI and VCR
3 Days
I.D.# CO613
Societal and regulatory demands to lower emissions and increase engine-operating efficiencies have forced engine designers to adopt new technologies and control strategies. This has resulted in dramatic evolutions of the technology of internal combustion engines and their support systems in recent years. These operational management strategies have evolved into more robust control systems and sensory packages, which in turn has driven the need for more accurate and specific information being communicated between the various systems found within a modern automobile.
This seminar will expose you to the emerging technologies in engine design and operation that can significantly improve operational efficiencies. The fundamental science and implementation technology of the various internal combustion engine systems will be presented. Attendees will learn how the Engine Control Module (ECM) uses information related to the operational status to implement real-time running efficiency of the engine. You will also learn how the ECM effects changes in the operation of the engine through the control systems that manage its operation. With this understanding, you will be able to derive your own set of improvement criteria that could be made to address the limitations of current engine technology.

Learning Objectives
By attending this seminar, participants will be able to:
• List the typical sensors, the sensory information they collect and describe the use of that information as it addresses improved fuel economy and reduced combustion emissions
• Describe the significance, technology, and application of:
  • Direct Injection (DI) of both gasoline and diesel fuels
  • Homogeneous Charge Compression Ignition (HCCI)
  • Displacement on Demand (DoD) Systems
  • Variable Cam Timing (VCT) and Variable Valve Timing (VVT)
  • Variable Compression Ratio (VCR) engine designs
• Explain the fundamental physics of the various technologies
• Specify the operational parameters and inter-relationships of each of the sub-systems of the enabling hardware
• Describe the basic design synthesis and analysis techniques for each of the major operational improvement technologies

Who Should Attend
This intermediate level seminar is appropriate for a number of design and engineering disciplines including, but not limited to: design engineers and engineering managers, automotive engine designers, component suppliers, engine test and development engineers, design services managers, and others who require the technological knowledge to perform their respective job functions.

Prerequisites
Individuals should have a practical understanding of current internal combustion technology and systems such as that covered in the SAE seminar The Basics of Internal Combustion Engines (ID# C0103, page 187), or its equivalent. An undergraduate engineering degree, or a strong technical background, is highly recommended. Basic knowledge of algebra and physics is essential.

Topical Outline
DAY ONE
• Operation of ECM and Sensor Systems
  • Information requirements
  • Use and distribution of collected information
  • Control theories and implementation of fuel management strategies
• Direct Injection (DI) of Both Gasoline and Diesel Fuels
  • Overview and historical perspective of DI technologies - Gasoline; Diesel
  • DI hardware review
  • Potential and proven benefits of DI - Theory; Aspects of gasoline combustion; Aspects of diesel combustion; Engine hardware development
• Homogeneous Charge Compression Ignition (HCCI) Technologies
  • Overview and historical perspective of HCCI technologies
  • Hardware review
  • Gasoline based HCCI - Theory; Aspects of gasoline combustion; Engine development
  • Diesel based HCCI - Theory; Premixed HCCI; Historical direct inject systems; Current technology direct inject systems; Water injection systems for HCCI control
  • The chemistry of HCCI - Alternative fuels; Fuel blends; Fuel additives
  • HCCI control - Operating range extension; Key parameters for control; Control strategies
  • Kinetics of HCCI combustion

DAY TWO
• Displacement on Demand (DoD) Systems
  • Theoretical improvements to engine system performance and efficiency
  • Historical mechanisms to implement DoD systems
  • Modern approaches to DoD systems
  • Practical results
• Variable Cam and Valve Timing (VCT, VVT)
  • General theory and potential system benefits of varying valve timing
  • Variable cam timing or phasing - Benefits associated with VCT; Mechanisms to implement VCT; Modern approaches to VCT systems
  • Variable valve timing - Benefits associated with VVT; Mechanisms to implement VVT systems; Modern approaches to VVT systems
  • Practical results

DAY THREE
• Variable Compression Ratio (VCR) Engine Designs
  • Theoretical improvements to engine system performance and efficiency
  • Mechanisms to implement VCR technology
  • Modern approaches to VCR systems
  • Practical results
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POWER AND PROPULSION

• General Discussion
  • Use of alternate fuels
  • Implementing dual-fuel engines
  • Engines designed to run multiple fuels (not dual-fuels)
  • Control strategies for implementing and combining above technologies
  • Emerging technologies
  • New technologies

Instructor: William Mark McVea
 Fee $1745 2.0 CEUs

Race Engine Calibration for Optimal Performance
1 Day
I.D.# C0602

The engine control module (ECM, or on-board computer) is the tool used to control the fuel injection rate, fuel injection timing, ignition timing, rate of exhaust gas recirculation (EGR), and other functions. The task of “programming” the ECM is much easier for a race engine than for a production engine because the calibration engineer does not need to be concerned about emissions: EGR, keeping the exhaust catalyst “happy”, etc.

This course provides a practical introduction to ECMs, including the uses for the various sensors. It also covers the specific methods used to incorporate the various sensor signals into the ECM’s control systems for the fuel injection rate, fuel injection timing, and ignition timing. Background information will include an understanding of the desired air/fuel ratio and optimum ignition timing. While examples are tailored around the application of the ECM to Formula SAE race engines, this course is useful for improving any engineer’s understanding of the functions of the ECM for other types of race engines as well as production engines.

Learning Objectives
By attending this seminar, participants will be able to:
• Describe the functions of the crank position sensor, cam position sensor, intake air temperature sensor, manifold air pressure sensor, mass air flow sensor, exhaust “oxygen” or lambda sensor, throttle position sensor, engine coolant temperature sensor, and knock sensor
• Explain how the ECM controls the fuel injection rate, fuel injection timing, and ignition timing
• Interpret base look-up tables, multipliers, and adders
• Develop base look-up tables, multipliers, and adders

Who Should Attend
Anyone interested in engine calibration/programming the on-board computer, especially for race engines. At a minimum, classification as at least a junior in a curriculum leading to a BS degree in engineering or experience in engine development is necessary background for taking this course.

Online Bonus Segments
Attendees will have the opportunity to access online bonus segments after the seminar. Segments will contain presentations by representatives of Ricardo and Performance Electronics, Ltd.

Online Segment by Ricardo in Brief:
Throughout this seminar, Prof. Matthews discusses how an accurate engine modeling code can be used to simplify the effort required to generate the base look-up tables. In this segment, Steve Rawnsley of Ricardo discusses their WAVE engine modeling code, an example of a state-of-the-art engine modeling program that can be used to simplify engine calibration. Seminar attendees will be given information to contact Ricardo Software if they desire a WAVE product evaluation.

Online Segment by Performance Electronics, Ltd. in Brief:
The seminar is focused on learning how to program an after-market Engine Control Module (ECM) to obtain optimal performance from a race engine. In this segment, Brian Lewis of Performance Electronics, Ltd., discusses their aftermarket ECM. He discusses how various aspects of their ECM are to be used given the background from Prof. Matthews’ discussion.

Topical Outline
• Basic engine theory
  • Relationships between torque, brake specific fuel consumption, engine design parameters, engine operating conditions, and four fundamental efficiencies (volumetric, combustion, indicated thermal, and mechanical)
  • Effects of fuel/air equivalence ratio
  • Effects of load
  • Effects of engine speed
  • MBT and LBT
  • Goals for race engines
  • Goals for production engines
  • Correction factors
• Engine sensors-the need for and use of:
  • Crank position sensor
  • Cam position sensor
  • Intake air temperature sensor
  • Manifold air pressure sensor
  • Mass air flow sensor (if used)
  • Exhaust “oxygen” or lambda sensor
• Throttle position sensor
• Engine coolant temperature sensor
• Knock sensor
• Air/fuel ratio control
  • Base pulse width look-up table for speed-density systems
  • Benefits of MAF systems
  • Multipliers
• Ignition timing control
  • Base ignition timing look-up table
  • Adders
• The Calibration Process
  • Explain why the calibration process must be an iterative procedure to obtain the proper ignition timing and fuel injection pulse width for every “cell” in the two base tables
  • Explain that generating the base pulse width table requires few experiments
  • Explain how to embed the “load” multiplier for pulse width
  • Generate the “start” multiplier, or the “crank” and “warm-up” multipliers if your ECM has this option
  • Calculate the intake air temperature multiplier
  • Discuss how to experimentally generate the battery voltage multiplier using an injector test stand
  • Explain why the auto companies take thousands of data points to get MBT timing as accurate as possible in the base table, and why your race team will benefit from an equal effort
  • Discuss the issues or dangers (from the engine durability perspective) involved in generating MBT accurately
  • Discuss the problem that is encountered when trying to find MBT at low load and two techniques that can be used to overcome this problem
  • Explain how to safely identify the Knock Limited Spark Advance regime of engine operation
  • Recognize how to determine the values for the ignition timing adders
• Conclusions
  • List things you should look for in an after-market ECM
  • Concisely review how to generate the base pulse width look-up table, the pulse width multipliers, the ignition timing look-up table, and the ignition timing adders

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**The Basics of Internal Combustion Engines**

2 Days
I.D.# C0103

Similar content is available in an on demand option. Review the course info in the On Demand Courses Guide on page 199.

In your profession, an educated understanding of internal combustion engines is required, not optional. This two-day technology survey seminar covers the most relevant topics - ranging from the chemistry of combustion to the kinematics of internal components of the modern internal combustion engine - for maximum comprehension. Attendees will gain a practical, hands-on approach to the basics of the most common designs of internal combustion engines, as they apply to the gaseous cycles, thermodynamics and heat transfer to the major components, and the design theories that embody these concepts.

**Learning Objectives**

By attending this seminar, participants will be able to:

• Discuss in detail the basic functioning and component interaction in a modern internal combustion engine, specifically; two and four-stroke cycles as they relate to reciprocating and rotary engine designs
• Describe the general thermodynamic concepts governing the operation of an internal combustion engine and its various cycles
• Compare the principle operational differences of the various fuels used in internal combustion engines, their availability, and understand the applicability of each
• Discuss the function and operation of all major components and systems within a modern internal combustion engine
• Identify the operational principles behind the timing and working relationships among all internal components, and articulate the importance of this inter-relationship
• Recognize the limitations of the current designs and implementations of the modern internal combustion engine
• Perform a basic assessment and evaluation of new, cutting-edge designs and new powertrain initiatives as they apply to the mobility industry

**Who Should Attend**

Designed for powertrain engineers, component suppliers, vehicle platform powertrain development specialists, and those involved in the application, design and discussion of engines. It is recommended that seminar attendees have an undergraduate engineering degree.
POWER AND PROPULSION

Topical Outline

DAY ONE
• Fundamental Operating Procedures
  • Open circuit
  • Closed circuit
  • Internal combustion
  • External combustion
  • Spark ignition
  • Compression ignition
• Engine Technology
  • 2-stroke
  • 4-stroke
  • Pistons, connecting rods and crankshaft
  • Valve train, camshaft and timing gear
  • Engine block, cylinder and head geometry
  • Manifold, surface finish, track length
  • Fuel systems, carburetors, fuel injection
  • Turbo- and super-charger
  • Ignition, timing and spark advance
• Fuel Delivery Systems
  • Air intake systems
  • Fuel delivery
  • The problem of part throttle operation
  • Intake manifold design and tuning
  • Turbo-charging
  • Super-charging
  • Introduction to emissions
  • Fuel management and control theory
  • Fuel injection
  • ECU operation
  • Sensors and instrumentation
• Valve Train
  • Operation
  • Arrangement - Push-rod; Single overhead cam shaft (SOHC) design; Dual-overhead cam shaft (DOHC) design
  • Camshaft function and design considerations
  • Valve timing
  • Valve-train design considerations
DAY TWO
• Component and Event Timing
  • Valve actuation timing
  • Valve timing diagram
  • Spark ignition event and timing
  • Compression ignition injection event and timing
• Fuels & Combustion
  • Definition of hydrocarbon based fuels
  • Stoichiometric Burn Efficiency
  • Air / Fuel Ratio
  • Gasoline
  • Diesel
  • Octane rating
  • Cetane rating
  • Hydrocarbon emission
  • Flame types
  • Thermodynamic efficiencies
  • Ignition requirements
  • Combustion chamber and head design
• Ignition
  • Common ignition sources
  • Combustion abnormalities
  • Spark plug design considerations
  • Ignition timing
• Emissions & Controls
  • Chemistry of emissions
  • Emission controls
  • Catalytic converter operation
  • Exhaust gas recirculation (EGR)
  • Valve overlap control
  • Introduction to variable camshaft timing (VCT)
• Thermodynamics
  • Definition and comparison of common internal combustion cycles
  • Otto cycle
  • Diesel cycle
  • Dual cycle
  • Atkinson cycle
• Energy Conversion Kinematics and Mechanisms
  • Cylinder arrangement
  • Piston design considerations
  • Piston ring application
  • Connecting rod design considerations
  • Crankshaft design
  • Balancing

Instructor: William Mark McVea
Fee $1395 1.3 CEUs

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The Basics of Internal Combustion Engines

10 Hours

Similar content is available in the classroom seminar – The Basics of Internal Combustion Engines – see course info above.

Convenient, portable, and with core content from the instructor-led seminar (content and description similar to the preceding classroom counterpart), this more than ten hour e-seminar option offers an alternative way to receive the same instruction as the live classroom learning without the expense of travel and time away from the workplace. The course offers ten video modules accompanied by a handbook.

Learn more about this course in the On Demand Courses Resource Guide on pages 199-259.

Turbocharging Internal Combustion Engines

3 Days
I.D.# C0314

The need to control emissions and maintain fuel economy is driving the use of advanced turbocharging technology in both diesel and gasoline engines. As the use of diesel engines in passenger car gasoline and diesel engines increases, a greater focus on advanced turbocharging technology is emerging in an effort to reap the benefits obtained from turbocharging and engine downsizing.

This seminar covers the basic concepts of turbocharging of gasoline and diesel engines (light and heavy duty), including turbocharger matching and charge air and EGR cooling, as well as associated controls. The limitations and future possibilities of today’s systems will be covered, as well as details on how emerging technologies will impact engine/vehicle performance. The seminar’s primary focus is on the turbocharger-engine interface (subjects such as matching, benefits, limitations, and new technologies) rather than detailed turbocharger aerodynamics and design. Advanced technologies such as variable geometry and multi-stage turbocharging, high and low pressure loop EGR systems, assisted turbocharging and turbocompounding are discussed. Students will have the opportunity to perform hands-on exercises to gain an appreciation of parametric effects in a wide range of engines.

**Participants are expected to bring a laptop computer, with Excel, to the seminar for class exercises.**

Learning Objectives

By attending this seminar, participants will be able to:

- Describe the thermodynamic principles governing the turbocharging of internal combustion engines
- Articulate the critical contribution of turbocharging to modern day diesel engine performance and emission control
- Determine the possible benefits of turbocharging for specific gasoline and heavy and light duty diesel engine applications
- Estimate the appropriate turbocharger characteristics for specific applications based on engine system requirements
- Describe the limitations of current technologies and evaluate new technologies and their possible role in meeting future engine/vehicle system challenges
- Apply the basic principles of matching turbocharger with engine and optimizing overall system for desired performance and emissions

Who Should Attend

This seminar is designed for engineers, managers, and other technical personnel from OEM and support industries concerned with the design and development of optimized diesel and spark ignition engine systems, including performance, fuel economy and emissions for passenger car, light truck and heavy duty engines. Some background in thermodynamics, IC engine performance and emissions will be helpful. Individuals who need more background should consider attending the SAE seminars Diesel Engine Technology (ID# 93014, page 177) or The Basics of Internal Combustion Engines (ID# C0103, page 187).

Topical Outline

DAY ONE

- Engine-Turbocharger Basics
  - Overview
  - Impact of charge density
  - Pumping loop and thermodynamics effects
  - Gas exchange/air flow and performance characteristics - Engine; Turbocharger; Engine/turbocharger interaction
- Turbocharger Design Features
  - Overview
  - Compressor side components and features
  - Turbine side components and features
  - Other significant turbocharger design requirements
  - Charge and EGR cooler features
  - Durability - thermal stress, materials, high and low cycle fatigue
  - Cooling, bearings, lubrication and sealing
  - Noise considerations
- Free-floating, Wastegate, Variable Area or Variable Geometry Turbochargers and Controls
Variable Valve Actuation: Design and Performance Impact on Advanced Powertrains

2 Days
I.D.# C1332

Engine valvetrain systems have become more capable and increasingly more compact in the quest to improve efficiency. The developments parallel the advancements in other key engine components such as fuel injection or spark systems, turbocharging, aftertreatment, base engine and controls. While the gasoline sector has seen a steady rise in the adoption of Variable Valve Actuation (VVA), Diesel systems have lagged behind and only a few systems have seen production. The level of VVA activity however in the Diesel sector is beginning to increase as tighter regulations of CO2 emissions approach. Valve control plays a strong role in a number of key areas: turbocharger systems, allowing for better optimization matching across wide engine operating flows; enabling advanced combustion strategies where control over the charge mass and temperature are important; and cold start, where valve timing can be extremely effective for engine warm up compared with other strategies that rely on additional fueling.

This seminar will cover the range of Variable Valve Actuation technologies present in the market, their operation principles, and their effect on engine performance. Both gasoline and Diesel applications will be covered including how they impact the in-cylinder combustion as well as the aftertreatment. Participants will have the opportunity to perform hands-on exercises to examine the effects of the engine valve profiles on performance and are asked to bring a laptop computer, with Excel, to the seminar for class exercises.

Learning Objectives

By attending this seminar, participants will be able to:
• Describe and differentiate the variable valve actuation technologies present in the automotive industry
• Describe the defining features of each of these technologies, their requirements for engine design layouts, required actuators, lube oil, and need for control and ECU interface
• Apply basic tools to gage the thermodynamic impact effected by varying the valve profiles: impact on pumping efficiency, resulting charge mass trapped in cylinder, estimated bulk and adiabatic flame temperatures
• Articulate the contribution of valve timing and control over the engine performance and aftertreatment in modern engines in the context of today’s emissions standards
• Describe the limitations of current technologies towards more efficient and cleaner engines and the future role of valve actuation and its integration aspects with other advanced powertrain components

**Who Should Attend**
This seminar is designed for engineers, managers, and other technical personnel from OEMs and support industries concerned with the design and development of optimized diesel and spark ignition engine systems, including calibration, performance, fuel economy and emissions for passenger car, light truck and heavy duty engines. It will be particularly interesting to Diesel engineers who will likely adopt some of the technologies developed in the gasoline sector for further improvements in emissions control and gains in fuel economy. It will also be of interest to combustion researchers as VVA will play a strong enabling role to exploring advanced combustion strategies.

**Prerequisites**
Some background in thermodynamics, IC engine performance and emissions will be helpful. Individuals who need more background should consider attending the SAE seminar *The Basics of Internal Combustion Engines* (I.D.# C0103). See the course description on page 187.

**Topical Outline**

**DAY ONE**
- Motivation and Objectives
  - Near and long term landscape
  - Fuel Economy, performance and emission standards
  - Key engine technologies
  - Overview of VVA landscape
- VVA Timeline
  - Efficiency improvements and synergies with other technologies
  - Industry trends and benchmarking
- Basic Engine Definitions
  - Work, fuel consumption, efficiency, exhaust gas recirculation (EGR)
  - Class exercise: engine performance calculator sheet
  - Thermodynamics and chemistry
  - Class exercise: EGR and valve timing effects on combustion
- Variable Valve Actuation Designs
  - Valvetrain overview: lift, timing, valve overlap
  - Cam phasing, cam switching, continuous variable lift
  - Lost motion systems including cylinder cut-off
  - Camless systems, electro-hydraulic, fully electro-magnetic
  - Case study: continuously variable valve system design

**DAY TWO**
- VVA Case Studies and Impact on Gasoline Engine Performance
  - Continuously variable valve system on gasoline engine
  - Atkinson cycle with a hybrid plugin powertrain
  - Miller Cycle
- Engine Brake Systems
  - System description and competitive advantages
  - Class exercise: hydraulic layout of brake system
- Transient Performance
  - Response
  - Engine warm-up strategies
  - Gas exchange interactions (turbochargers)
- Modeling and Controls
  - Physical modeling of air system
  - Integration of multiple actuator systems
  - Enhancing combustion stability
- Future Trends
  - Enabling roles of VVA in advanced combustion engines
  - Stretched efficiency concepts

**Instructor:** William de Ojeda

**Fee:** $1370 2.0 CEUs

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**FUELS AND ENERGY SOURCES**

**Fundamentals of Automotive Fuel Delivery Systems**

**2 Days**

I.D.# C0303

The key to a vehicle’s overall operation is the superior, quality design of its major moving subsystems. Automotive gasoline and diesel fuel delivery systems in particular must be virtually malfunction free for all components for the entire vehicle prescribed service life. Fuel systems must be robust and precise enough to store and deliver the appropriate amount of fuel to power the engine. These stringent requirements necessitate a basic understanding of the subsystem working principles, functionalities and interrelated components.
POWER AND PROPULSION

This course provides a basic yet thorough examination of technical issues involved in automotive gasoline and diesel fuel delivery. Participants will acquire a fundamental understanding of the current technology and requirement guidelines and apply some of the principles through an in-class project and exercises. Examples of frequently encountered technical issues of fuel delivery systems shall also be discussed. The course is designed to encourage discussion, insights, and possible solutions into the engineering problems encountered in the gasoline and diesel fuel delivery systems and components.

Learning Objectives
By attending this seminar, participants will be able to:
• Organize, differentiate and interpret the fundamental concepts, features and applications of fuel delivery systems
• Describe general gasoline and diesel fuel delivery system functionality
• Compare and differentiate individual components comprising the subsystem
• Identify interconnections of system components
• Apply general gasoline and diesel fuel system requirement guidelines

Who Should Attend
You should attend if you are an engineer or engineering manager involved in design, research, testing or implementation of automotive fuel delivery systems. Engine designers, suppliers of fuels and fuel delivery system components, and polymer engineers may benefit as well.

Topical Outline
• Introduction
  • Overview
  • General expectations
• Fundamental Fuel Delivery Systems
  • SI engine fuel delivery systems -- Gasoline; Alternative fuel
  • GDI engine fuel delivery systems -- for stratified; homogeneous; mixed combustion mode
  • Diesel engine fuel delivery systems -- Conventional unit injector system; Electronic controlled intensifier systems; High pressure common rail systems
  • Fuel Cell -- Solid oxide fuel cell; Proton exchange fuel cell
  • Advanced fuel delivery system concept -- Variable valve lifting; Cylinder deactivation
• Fuel Types & Properties
• Fuel Delivery Subsystem Working Principles
  • Delivery modules -- Return systems; Returnless; Mechanical returnless fuel delivery system (MRFS); Electronic returnless fuel delivery system (ERFS)
  • Fuel pump assemblies -- PFI pumps; GDI high pressure pumps; and diesel high pressure common rail (HPCR) pumps
  • Injector assemblies -- PFI injectors; GDI injectors; HEUI injectors; unit injectors; Diesel HPCR injectors and their electronic driving mechanism
  • Injection types -- Multi-point injection (MPI); Sequential multi-point injection (SMPI); Direct injection (DI); Common rail diesel injection (single injection event; Multiple injection events; Rate shaping); Homogeneous charge compression injection (HCCI) for gasoline and diesel
  • Fuel pressure regulation -- mechanical and electronic
  • Onboard refilling vapor recovery system (ORVR) and vapor management
  • Fuel level indication mechanism -- contact; non contact
  • Fuel filtration -- Pump/module inlet filtration; Inline filtration; Integrated filtration system; lifetime filters; filtration efficiency; beta value; and dirt capacity
  • Fuel delivery metering -- High pressure end; Inlet metering
• Fuel Delivery System OEM and Government Regulatory General Requirements
  • Functionality requirements
  • FTP highway and urban cycles
  • Durability requirements
  • Safety requirements
  • Permeation requirements
  • Contamination life requirements
  • Static charge and abatement techniques
• Fuel Delivery System and Components Evaluation and Testing Methods
  • Fuel tank
  • Fuel lines
  • Delivery module
  • Pump
  • Injector
  • Regulator
  • ORVR valve
  • Fuel level gauge
  • Fuel filter
  • Vapor canister
  • Fuel delivery driver module
  • Leak testing
  • Electrical static discharge testing
  • Permeation testing
• Summary

Instructor: Xiaojian Tao
Fee $1370 1.3 CEUs
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Improving Fuel Efficiency with Engine Oils

2 Days
I.D.# C0914

Improving vehicular fuel efficiency is of paramount importance to the global economy. Governmental regulations, climate change and associated health concerns, as well as the drive towards energy independence, have created a technical need to achieve greater fuel efficiency. While vehicle manufacturers are focusing efforts on improved combustion strategies, smaller displacement engines, weight reduction, low friction surfaces, etc., the research involved in developing fuel efficient engine oils has been less publicized. This seminar will highlight the role of lubricants in improving fuel efficiency and provide strategies for selecting the best oil for a given application.

The course begins with a brief overview of the fuel consumption regulations and global perspective of passenger car lubricants and diesel oil specifications in North America, Europe and Asia. Limitations and advantages of various methods to measure fuel consumption in a variety of bench tests, dyno tests and actual vehicles will be presented. Fundamentals of fluid lubrication regimes, as well as detailed aspects of oil formulations which have significant effects on reduction in mechanical friction, such as base oil selection, viscosity grade choice and impact of friction modifiers, will be covered. The performance characteristics of fresh oil versus used oil and lubrication of coated surfaces will also be discussed. Finally, the impact of various emission control devices on overall diesel fuel consumption will be described.

Participants will receive a copy of the SAE Standard J300 - Engine Oil Viscosity Classification.

Learning Objectives
By attending this seminar, participants will be able to:
• Describe the effects of mechanical friction on engine efficiency
• Summarize the pros and cons of various test methodologies used to measure engine friction
• Articulate the limitations in various fuel consumption test methodologies
• Select oils based on frictional control performance
• Describe the role of oil degradation on fuel economy and engine wear
• Evaluate lubricant interactions with low friction surfaces

Who Should Attend
This seminar is designed for engineers, scientists, investigators and consultants involved in designing or optimizing mobile or stationary powertrains. Individuals interested in understanding the role of engine oils in reducing fuel consumption will find the seminar beneficial. Automotive decision makers will also benefit by gaining an understanding of the limitations of fuel economy testing methods.

Prerequisites
Attendees should have a background in science or technology and some technical familiarity with performance of engines. No previous exposure to organic chemistry is required.

Topical Outline
DAY ONE
• Reducing Fuel Consumption
  • Regulations - N. American, Europe and Asia
  • GHG emissions and climate change
  • Petroleum based fuels - availability
  • Biofuels - availability and global trends
• Fundamentals of Engine Friction
  • Gasoline engine
  • Diesel engine
• Methodology - Part 1: How to Measure Engine Friction
  • Examples of bench tests
  • Examples of engine tests
• Methodology - Part 2: How to Measure Fuel Consumption in Real Life Conditions
  • Gasoline vehicles
  • Diesel trucks
DAY TWO
• Fuel Economy Derived Lubricant Specifications
  • N. America - API specifications
  • United Europe - OEM specifications
  • Japan - OEM specifications
• Lubrication Fundamentals
  • Lubrication regimes
  • Stribeck curve
• Lubricant Components - Effects on Fuel Consumption
  • Base oils
  • Viscosity grades
  • Friction modifiers
• Fuel Economy Retention
  • Impact of used oil on fuel consumption vs. engine wear protection
• Lubrication of Low Friction Surfaces
  • Coatings
  • Engineered surfaces
• Impact of Diesel Emission Control Devices on Overall Fuel Consumption

Instructor: Ewa Bardasz
Fee $1445 1.3 CEUs
Liquid Atomization, Sprays, and Fuel Injection

3 Days
I.D.# 98019

Liquid fuel atomization and spray formation is the heart of the majority of stationary and mobile power generation machines that we rely on. This seminar focuses on the process of liquid atomization and spray formation and how it relates to fuel injection systems and emission of pollutants in modern engines. The seminar begins with background coverage of terminology, the purposes of liquid atomization and spray formation, and different designs of atomizers and nozzles employed in various industries. The focus is then directed to gasoline and diesel fuel injections, injector designs, and performance requirements for optimum engine operation with lowest possible emission of harmful pollutants. Based on the idea that knowledge of technical practices and advances in one area (i.e. diesel fuel injection) is beneficial to engineers in other areas (gasoline direct injection, rocket engines), this seminar takes an interdisciplinary approach. Attendees will understand the technology and logic behind different injector designs, and gain the knowledge to judge, adapt and transfer technology advances from one discipline to another.

Learning Objectives

By attending this seminar, participants will be able to:
• Explain important terminology commonly used in atomization and sprays
• Describe important processes in atomization and spray formation
• Articulate the effects of injection system design and operating conditions on engine performance, combustion, and emission of pollutants
• Describe different injector designs and the rationale for the use of each
• Define the role the injection system plays in combustion and emission and how it is used to provide guidance in design of low-emission combustion systems
• Implement appropriate design concepts and logic in the design of critical components such as intake valves and induction systems
• Evaluate future trends and technology developments in fuel injection

Who Should Attend

Automotive and aerospace engineers, technical and project managers, researchers and academicians will benefit by attending this seminar. Automotive engineers working on the design of combustion engine components, reduction of harmful pollutants emissions, software development and application for modeling of thermal-fluid, combustions and emissions and engineers and managers directly involved in fuel injection systems will also benefit. Aerospace engineers involved in the design of gas turbine or rocket engines’ combustion chambers will benefit as well.

Topical Outline

DAY ONE
• Description of the Atomization Process
• Disintegration of the Liquid Jets
  • Rayleigh criterion (no viscosity)
  • Weber’s criterion (effects of viscosity)
  • Ohnesorge criterion for atomization (Ohnesorge Number)
  • Rayleigh, first and second wind-induced breakup and atomization regimes
  • Influence of some parameters -- jet velocity profile; nozzle length-to-diameter ratio; ambient pressure
  • Disintegration of liquid sheets
  • Drop breakup in air flow, turbulent flow, and viscous flow
• Types of Atomizers: Pressure, Air-Assist, Air-Blast, Effervescent, Electrostatic, Ultrasonic, Diesel Injector and Gasoline-Fueled Injectors
• Drop Size Distribution and Measurements
  • Graphical and mathematical representation of drop size distribution
  • Averaged diameter and representative diameters
  • Measurement techniques -- patternation; drop size measurements and spray characterization
  • Mechanical methods -- drop collection on slides; molten-wax and frozen-drop approach; cascade impactors; electrical; charged-wire and hot-wire methods; optical methods; imaging - photography and holography; single-particle light scattering (Phase Doppler Particle Analyzer, etc.); diffraction size analyzer
  • Drop evaporation

DAY TWO
• Diesel Fuel Spray, Injector and Injection System
  • Fuel injection system -- pumps: in-line injection, distributor-type injection, single-barrel injection, and unit injector & unit pumps; injector designs: nozzle holder, nozzles, others
  • Overall spray structure
  • Liquid fuel atomization
  • Spray angle
  • Intact core length
  • Spray evaporation
  • Ignition delay
  • Mixing-controlled combustion
  • HC emission mechanisms in diesel engines and its relation to fuel injection
  • Soot formation and fuel sprays
Modern Fluids for Internal Combustion Engines: An Overview

2 Days
I.D.# C0704

Lubricating fluids are the lifeblood of modern engines, performing numerous vital functions from reducing system friction, temperature, and fuel consumption to minimizing tailpipe emissions. This comprehensive seminar covers the latest developments in lubricating fluids technologies and explores the relationships between lubricating fluids and emissions, after-treatment devices, bio-fuels, and fuel economy. Fundamentals of crankcase lubrication, including the properties and performance requirements of global base stocks and lubricants will be covered. The seminar will further explore the need for lubricating systems to possess thermal and oxidative stability sufficient to withstand the rigors of low-heat-rejection, high performance diesel engines or other modern engines equipped with various emission control devices. Case studies will be utilized to demonstrate the existence of overlapping phenomena aimed at extending oil life and protecting key mechanical components.

Learning Objectives

By attending this seminar, participants will be able to:
- Describe how various classes of additives commonly used in crankcase lubricants impact:
  - wear of bearings, pistons, and piston rings
  - friction and fuel consumption
  - corrosion
  - piston cleanliness
  - swelling of seals
  - hydraulic media in fuel systems, such as hydraulically-activated electronically-controlled unit injector system (HEUI).
- Recognize the limitations and technical trends in new base stocks and additive technologies
- Compare performance characteristics of lubricants designed for passenger cars manufactured in N. America, Europe or Japan
- Identify key lubricant requirements for protecting heavy duty diesel engines
- Select and optimize fluids for various light duty and heavy duty after-treatment applications
- Recognize differences between API, ACEA, and ILSAC lubricant categories

Who Should Attend

This seminar is designed for engineers, scientists, investigators and consultants involved in designing or optimizing mobile or stationary powertrains. Individuals interested in understanding the role of crankcase fluids in extending useful life of the overall systems, minimizing emissions and reducing fuel consumption will find the seminar beneficial.

Prerequisites

Attendees should have a background in science or technology and some technical familiarity with performance of engines and emissions. No previous exposure to organic chemistry is required.

Topical Outline

DAY ONE
- Introduction to Engine Lubricant Formulations
  - What are motor oils?
  - Standardized tests of new oils (SAE J300)
  - Used oils testing
- Lubrication Fundamentals
  - Functions of a lubricant
  - Friction
  - Lubrication regimes (Steinbeck Curve)
  - Wear modes
  - Viscosity
- Base Oils
  - Classes of crude oils
  - Conventional refining processes
POWER AND PROPULSION

• Base oil categories
• Affect of base oils on performance of engine oils
• Additives
  • Composition of motor oils - historical perspective
  • Lubricant additives industry
  • Engine oil additives - Dispersants and dispersant VI improvers; Detergents and overbased detergents; Oxidation inhibitors; Wear inhibitors; Rust inhibitors; Friction reducers; Viscosity improvers; Factors promoting wear and deposits formation; Dispersion of particles in diesel and gasoline engine oils

DAY TWO
• Global Lubricant Specifications
  • Classification of motor oil by performance category
  • API service categories
  • Development of a new diesel engine oil category: PC10
  • Motor oil classifications- API doughnut
  • ACEA European oil specifications for gasoline and diesel engines

Motor Fuel: Technology, Performance, Testing, and Specifications

3 Days
I.D.# 98003

Fuel composition has had to change with the advent of more stringent emission regulations. Reformulated gasoline (RFG), for example, is vastly different from gasoline of even ten years ago. Tightening regulations on diesel emissions will dramatically change both diesel fuel and engine design. This three-day seminar will review the fundamentals of motor fuels, combustion and motor power generation. The primary content of the course provides a basic introduction to the technology, performance, evaluation, and specifications of current gasoline, diesel, and turbine fuels. The first day of the course begins with a brief review of the evolution of motor fuel through 100 years of performance and specification.

Learning Objectives
By attending this seminar, participants will be able to:
• Describe how fuel compositional variables affect engine performance
• Interpret test data to determine if fuel meets required specifications and regulations
• Determine the purpose and mode of action of performance additives
• List the important processes in motor fuel
• Communicate effectively with others working with motor fuels
• Have a working knowledge of motor fuel composition, properties, and performance -- a necessity for engine designers, and fuel and additive formulators

Instructors Wanted...
To shape the future of mobility engineering, SAE International Professional Development is seeking experienced engineering professionals with industry and/or academic backgrounds to develop and teach live classroom or online courses; we are seeking expertise in a variety of topics including:

Classroom Seminar Topics
• Natural Gas Engines and Vehicles
• Sensors and Actuators
• Advances in SI Engines
• Small High-Efficiency Engine Design
• Electric Motors / Power Electronics
• Active Safety
• Heavy Duty Diesel OBD
• Heavy Duty High Voltage Systems
• Heavy Duty Hybrid
• Heavy Duty Electric Drive
• Diesel Emissions and Regulations
• Alternative Fuels and Energy Sources
• Strategies for Diesel Engine Downsizing
• Cybersecurity
• V2V Technologies
• High Speed Digital Design for Rugged Applications
• Material Performance Data

Contact SAE Professional Development to explore how you can help to shape the future of industry.

Classroom Seminars contact Bev Longdon at Beverly.Longdon@sae.org

Online Web Seminars contact Sam Minehart at Sam.Minehart@sae.org.

Instructor: Ewa Bardasz
Fee $1385 1.3 CEUs

Instructor:

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DAY TWO

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- Electric Motors / Power Electronics
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- Diesel Emissions and Regulations
- Alternative Fuels and Energy Sources
- Strategies for Diesel Engine Downsizing
- Cybersecurity
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- High Speed Digital Design for Rugged Applications
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Online Web Seminars contact Sam Minehart at Sam.Minehart@sae.org.

Instructor: Ewa Bardasz
Fee $1385 1.3 CEUs
**POWER AND PROPULSION**

**Who Should Attend**
This course is intended for engine design engineers who need a basic understanding of the fundamental performance properties of motor fuels and additives. The course is also intended for formulators who need to understand the relationships of fuel performance and composition to properly design fuels and additives to meet current and future needs. Engine testing personnel; petroleum company employees; Federal, State, and Local Regulatory personnel, laboratory supervisors; and fuel marketing personnel would also benefit.

**Prerequisites**
Participants should have an undergraduate engineering degree.

**Topical Outline**
- Introduction and History of Motor Fuels
- Overview of Motor Gasoline
  - Gasoline composition, chemistry, production, blending
  - Spark ignition engine and effect of fuel quality on performance
  - Gasoline volatility and combustion
  - Influence of composition on storage stability and engine deposit formation

**DAY TWO**
- Oxygenated Blend Components and Emissions
- Gasoline Specifications
- Overview of Diesel Fuel

- Diesel composition, chemistry, production, blending
- Diesel engine and effect of fuel quality on performance
- Fuel characteristics influencing combustion and emissions
- Low temperature and other fuel characteristics
- Fuel additives

**DAY THREE**
- Alternative Fuels, Future Trends, and Directions
- Diesel Specifications
- Gaseous Fuels for Engines
  - Natural gas combustion, performance, and emissions
  - LPG combustion, performance, and emissions
  - Alternative fuels, future trends, and directions
- Racing Fuels
  - General considerations
  - Hydrocarbon fuels
  - Alcohol fuels
  - Special fuels

Instructor: Kenneth Kipers
Fee $1850 2.0 CEUs

**RELATED TRAINING SOLUTIONS**
Some of our courses apply to more than one technology category. Consider these related courses described in other sections of this resource guide.

**Emissions-Related OBD Systems: A Design Overview**
This one day seminar is designed to provide an overview of the fundamental design objectives and the features needed to achieve those objectives for generic on-board diagnostics. Read more about this course on page 27.

**Hybrid and Electric Vehicle Systems**
This two-day practical and applications based course will concentrate on architectures, operation, functions, and design considerations of the safety, power electronics, energy systems, and failure modes associated with HEV and BEV vehicles. Read more about this course on page 38.

**High Voltage Vehicle Safety Systems and PPE**
This course provides participants with fundamental technical and safety information on high voltage personal protective equipment (PPE). Read more about this course on page 40.
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- delivery formats available for the course
- the course is part of an SAE certificate
- that it is an ACTAR approved course

This catalog contains information on the on-demand courses available from SAE. For information on live learning, visit training.sae.org

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Certificate – indicates the course is part of an SAE International curriculum-based, multi-course certificate. See a list of the multi-course certificates on page XIV

ACTAR logo – indicates the course is an ACTAR approved course. For more information on ACTAR and ACTAR accredited courses, see page XI
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Introduction to Brake Control Systems

9.5 Hours
I.D.# PD130501ON

This is an electronically delivered seminar featuring full-motion video illustrated with synchronized presentation slides. This course is based on the highly-rated classroom seminar.

In this course, James Walker, Jr. delves into brake control technology. Starting with the fundamentals of the tire-road interface, this course introduces participants to brake control system mechanization, system sensor needs, and the basic control strategies employed by anti-lock braking systems (ABS), traction control systems (TCS), electronic stability control systems (ESC), and their derivatives.

Limiting factors and compromises that must be made in the design and development of brake control systems are covered through a brief review of hydraulic brake system functionality, the friction circle concept, and the fundamentals of longitudinal and lateral vehicle dynamics. Brake control system integration with other vehicle on-board technologies are also discussed.

Based on the popular classroom seminar, the nine and a half hour course is divided into 13 modules accompanied by a handbook. Walker revisits key concepts in a summary at the end of the course to reinforce learning and retention.

Learning Objectives

By connecting with this course, participants will be able to:

• Define basic tire-road interface characteristics and performance limits
• Analyze brake system design parameters and their vehicle performance effects
• Evaluate the compromises between stability, steerability, and stopping distance
• Discern the discrete mechanical components of the ABS subsystem
• Compare ABS sensor technologies and packaging strategies
• Specify fundamental ABS performance attributes

• Develop basic DRP operating requirements
• Explain the additional mechanization needs of TCS and ESC
• Contrast the additional sensors required for TCS and ESC
• Reconcile TCS performance expectations vs. method of implementation
• Interpret ESC metrics and ultimate limitations
• Identify special conditions and considerations which can impact performance
• Discuss opportunities for advanced brake control system integration

Is this Course for You?

This course was developed for engineers involved in all disciplines related to the design or development of vehicle braking systems, vehicle dynamics, powertrain systems, or chassis/suspension systems. A basic knowledge of college algebra, college physics, and a familiarity with vehicle foundation brake system functionality is required.

Topical Outline

• Tire-Road Interface Characteristics
• Hydraulic Brake System Overview
• Stability, Steerability, Stopping Distance
• Mechanization of ABS
• ABS Sensor Overview
• ABS Performance
• DRP Performance
• Mechanization of TCS and ESC
• TCS and ESC Sensor Requirements
• TCS Performance
• ESC Performance
• Special Conditions and Considerations
• Advanced Integration

Instructor: James E. Walker
Fee $535 1.0 CEU
Vehicle Dynamics for Passenger Cars and Light Trucks

15 Hours  
I.D.# PD130702ON

This is an electronically delivered seminar featuring full-motion video illustrated with synchronized presentation slides. This course is based on the highly-rated classroom seminar.

This course presents an introduction to vehicle dynamics from a vehicle system perspective. The theory and applications are associated with the interaction and performance balance between the powertrain, brakes, steering, suspensions and wheel and tire vehicle subsystems. The role that vehicle dynamics can and should play in effective automotive chassis development and the information and technology flow from vehicle system to subsystem to piece-part is integrated into the presentation.

Dr. Richard Lundstrom develops and solves governing equations of motion for both steady and transient conditions. He presents manual and computer techniques for analysis and evaluation. Vehicle system dynamic performance in the areas of drive-off, braking, directional control and rollover is emphasized. The dynamics of the powertrain, brakes, steering, suspension and wheel and tire subsystems and their interactions are examined along with the important role of structure and structural parameters related to vehicle dynamics. Physical experiments applicable to vehicle dynamics are also introduced.

Based on the popular classroom seminar, this course offers nearly fifteen hours of instruction and simulations divided into nineteen modules; the Bosch Automotive Handbook and the book, The Automotive Chassis: Engineering Principles by Reimpell, Stoll and Betzler; a coordinated handbook that includes a resource guide and SAE papers and paper collections.

Learning Objectives

By connecting with this course, participants will be able to:

• Summarize how vehicle dynamics is related to the voice of the customer
• Identify important vehicle system parameters useful for effective application of vehicle dynamics to chassis development
• List and explain parameters that effect vehicle performance relative to drive-off, braking, directional control and rollover
• Identify physical measurements needed to effectively apply vehicle dynamics to passenger cars and light trucks
• Define the value of vehicle dynamics simulation in the development and evaluation of vehicles
• Explain the balance required between ride, directional control and rollover and the essential process for this balance to be obtained for marketplace vehicles

Is this Course for You?
This on-demand course is intended for automotive engineers and quality professionals who work in product design, testing, quality, process or development.

Topical Outline

• Vehicle Dynamics: Introduction
• Drive-Off Dynamics: Introduction and Vehicle Resistances
• Drive-Off Dynamics: Vehicle Characteristics and Powertrain Matching
• Drive-Off Dynamics: Tire Patch Forces and Performance Prediction
• Braking Dynamics: Introduction and Balance Characteristics
• Braking Dynamics: Tire/Wheel Limits, Efficiency, and Performance
• Ride Dynamics: Introduction
• Ride Dynamics: Quarter Vehicle Dynamic Model
• Ride Dynamics: Parameter Estimation
• Ride Dynamics: Wheel Motion and Secondary Ride
• Ride Dynamics: Summary
• “Low Speed” Steering Dynamics: Introduction and Steering Geometry
• “Low Speed” Steering Dynamics: Turning Circle
• “High Speed” Steering Dynamics: Introduction
• “High Speed” Steering Dynamics: Tire Forces and Characteristics
• “High Speed” Steering Dynamics: Cornering Compliance and Body Roll
• “High Speed” Steering Dynamics: Understeer Gradient - Rigid Body Contributions
• “High Speed” Steering Dynamics: Understeer Gradient - K & C Contributions
• “High Speed” Steering Dynamics: Transient Cornering Response

Instructor: Richard Raye Lundstrom

Fee $695  1.5 CEUs
Overview and Impact of the ISO 26262
Standard Web Seminar RePlay

4.5 Hours
I.D.# PD3311340N

Overview and Impact of the ISO 26262
Standard Web Seminar RePlay

4.5 Hours
I.D.# PD3311340N

Overview and Impact of the ISO 26262
Standard Web Seminar RePlay

4.5 Hours
I.D.# PD3311340N

Web Seminar RePlays are captures of the live web seminar. The course sessions are unedited and include interactions between the instructor and live participants. A learning assessment is available at the end of the course to reinforce learning and retention and gauge your understanding of the topic.

ISO 26262: Road Vehicle - Functional Safety is now becoming a condition of compliance for doing business in the automotive sector. The Scope states: “ISO 26262 is intended to be applied to safety-related systems that include one or more electrical and/or electronic (E/E) systems and that are installed in series production passenger cars with a maximum gross vehicle mass up to 3,500 kg...”

This course provides background for reading and applying the standard and explains its scope, the major differences from the general safety standard IEC 61508, and how the scope changes with the introduction of new systems. The vocabulary of the standard is used to enable participants to engage in the context of the standard and a selected list of acronyms is provided as reference. An overview of all parts of the standard is provided and its impact is explained, without lengthy examples requiring days of workshop attendance.

Learning Objectives

By connecting with this course, participants will be able to:

• Determine if and how the scope of ISO 26262 applies to your system or component
• Plan a Safety Case based on ISO 26262
• Prepare or reply to Development Interface Agreement compliant to ISO 26262
• Determine the safety goals and Automotive Safety Integrity Level (ASIL)
• Determine the HW requirements based on ASIL
• Determine the SW requirements based on ASIL

Topical Outline

• Motivation for Creating ISO 26262
  • Pre-standard work of France and Germany
  • U.S. involvement and resulting changes to the standard
  • National Academy of Science expectations
• Differences to IEC 61508, the General Safety Standard Previously Used
  • Comparison
  • Impact on Automotive Development
• Overview of the ISO 26262
  • Planning
  • System
  • Hardware
  • Software
  • Operations
  • Supporting Processes
  • ASIL-oriented and Safety-oriented Analyses

Instructor: Joseph D. Miller
Fee $425 .45 CEUs

Is this Web Seminar RePlay for You?

This course would be especially valuable for engineers and managers that desire an overview of the standard’s content, without attending a multi-day workshop or following lengthy technical examples in order to become skilled practitioners. This includes those involved in product development for vehicle manufacturers or suppliers whose products contain electronics or software; engineering quality professionals including SPICE, CMMI, and internal process assessment; attorneys involved in Product Liability; and supplier quality engineers. Course participants should have an engineering degree. Knowledge of automotive product development and electronics or software is helpful. It is recommended that you have a copy of the ISO 26262 Standard, but it is not required. However, the standard is required for application after the course is completed.
ENGINEERING TOOLS & METHODS

Accelerated Test Methods for Ground and Aerospace Vehicle Development

10 Hours
I.D.# PD130624ON

This is an electronically delivered seminar featuring full-motion video illustrated with synchronized presentation slides. This course is based on the highly-rated classroom seminar.

Engineers and managers involved with product development are constantly challenged to reduce time to market, minimize warranty costs, and increase product quality. With less and less time for testing, the need for effective accelerated test procedures has never been greater.

This course covers the benefits, limitations, processes, and applications of several proven accelerated test methods including accelerated reliability, step stress, FSLT (Full System Life Test), FMVT* (Failure Mode Verification Testing), HALT (Highly Accelerated Life Testing), and HASS (Highly Accelerated Stress Screening). It is designed for anyone involved in product design, life testing, reliability testing and validation for passenger cars, light trucks, heavy duty, off-highway or aerospace vehicles, including reliability engineers, validation engineers, design engineers and their managers. Users or purchasers of testing or engineering services will also find this course to be valuable.

Based on the popular classroom seminar, this course offers more than 10 hours of instruction divided into fourteen modules; a coordinated handbook; and an electronic copy of the instructor's book, Accelerated Testing and Validation, which includes numerous hands-on exercises and analytical spreadsheets.

Learning Objectives
By connecting with this course, participants will be able to:
• Choose the accelerated test method for a given application
• Analyze accelerated testing results
• Explain how to accelerate your current test methods
• Explain how to accelerate your validation program
• Adjust accelerated test programs for business situations
• Describe how product development cycles can be reduced from 18 to six months

Is this Course for You?
This on-demand course is designed for anyone involved in product design, life testing, reliability testing and validation for passenger cars, light trucks, heavy duty, off-highway or aerospace vehicles, including reliability engineers, validation engineers, design engineers and their managers. Users or purchasers of testing or engineering services will also find this course to be valuable. There are no prerequisites although a technical background is helpful.

Topical Outline
• Statistical Limitations and Innovation vs. Commodity
• Product Availability and Supply Chain Effects
• Terms and Definitions for Accelerated Testing
• Full Life System Testing
• Step Stress
• Accelerated Reliability
• Highly Accelerated Life Testing (HALT)
• Failure Mode Verification Testing (FMVT)
• Reliability, Warranty and Maturity
• Data Analysis Techniques
• Overcoming Life Prediction Limitations in HALT and FMVT
• Program Acceleration
• Hybrid Test Methods
• Synthesis

Instructor: Alexander J. Porter
Fee $595 1.0 CEU
Design of Experiments (DOE) for Engineers Web Seminar RePlay

12 Hours
I.D.# PD330932ON

Web Seminar RePlays are captures of the live web seminar. The course sessions are unedited and include interactions between the instructor and live participants. A learning assessment is available at the end of the course to reinforce learning and retention and gauge your understanding of the topic.

Design of Experiments (DOE) is a methodology that can be effective for general problem-solving, as well as for improving or optimizing product design and manufacturing processes. Specific applications of DOE include, but are not limited to, identifying root causes to quality or production problems, identifying optimized design and process settings, achieving robust designs, and generating predictive math models that describe physical system behavior. This competency-based course utilizes a blend of reading, discussion and hands-on use of Minitab software. You will also set-up and analyze Robust/Taguchi and Response Surface experiments utilizing computer software.

Each participant will receive a 30 day Minitab™ product trial copy for use while completing the course.

Learning Objectives

Upon successful completion of this course, participants will be able to:
- Determine when DOE is the correct tool to solve a given problem or issue
- Select the appropriate DOE experiment type (DOE Goal) for a given application
- Set up simple Full Factorial DOEs by hand, using cube plots
- Set up and analyze any Full Factorial DOE using Minitab
- Select the appropriate partial factorial design(s) based on one’s application
- Set up and analyze Partial Factorial DOEs, simple Robust Design (Taguchi) DOEs, and simple Response Surface DOEs using Minitab
- Identify and execute the structured process steps recommended when executing a DOE project

Who Should Attend

This course will benefit: engineers involved in problem-solving such as product design or product formulation (e.g., fluid/material composition, prepared food recipes/preparation, etc.) and/or optimization; process design and/or optimization; quality improvement efforts such as defect elimination, warranty avoidance or similar initiatives; test engineers who wish to maximize learning of system behavior with a minimum number of tests; and technicians, analysts and managers who support engineers in the above efforts, so they may be effective participants in DOE activities. There are no specific prerequisites, however participants are expected to have some math background, including the ability to calculate elementary statistics parameters such as an average and a range. Since the course includes demonstration and hands-on use of Minitab, participants should have some familiarity with Windows-based personal computer applications.

Topical Outline

Session 1
- Introduction
- What is DOE (with Initial Data Collection Exercise)
- Full Factorial Experiments using Cube Plots
  - Identifying main effect and interaction terms
  - Determining effects for all terms
- Estimating How Much Experiment Data is Enough
- Assignment for Session 2: Hands-on Exercise using Minitab using Simulator to Generate Data

Session 2
- Review of Exercise Assigned at the end of Session 1
- Set up and Analysis of a Full Factorial Experiment using Minitab
- Review of Minitab's DOE Results
- Review of Methods for Determining Significance
- ANOVA and Regression Overview
- Assignment for Session 3: Hands-on Exercise using Minitab to Analyze Data and Interpreting Statistical and Graphical DOE Results

Session 3
- Review of Exercise Assigned at the end of the Session 2
- The Confounding Principle
- The Benefits and Disbenefits of Confounding and of Partial Factorial Experiments
- How Confounding Occurs in a DOE, including Generators and ‘Design Resolution’ Importance of the ‘‘Alias String’’
- Minitab Demonstration: Setting up Partial Factorial Experiments using Default Generators and by Specifying Generators
- Assignment for Session 4: Partial Factorial Exercise using Minitab and a Simulator to Generate Data for the DOE
ON DEMAND COURSES RESOURCE GUIDE

Session 4
• Review of Exercise Assigned at the end of the Session 3
• When Robust/Taguchi DOE is Appropriate
• How Robust/Taguchi DOE is Different
  • Two-Step Optimization Concept
  • Control vs. Noise
  • Importance of Control-by-Noise Interactions
  • Studying Robustness with Classical DOE vs. Taguchi
  • Taguchi’s Robustness Statistics: Signal-to-Noise (S/N) and Loss
• Applications of Taguchi DOE (incl. Set-up and Analysis in Minitab)
• Minitab Demonstration: Setting Up a Taguchi DOE
• Assignment for Session 5: Robust/DOE Exercise using Minitab and a Simulator to Generate Data for the DOE

Session 5
• Review of Exercise Assigned at the end of the Session 4
• When Response Surface DOE is Appropriate
• How Response Surface DOE is Different
  • Box-Behnken Concepts (with Demonstration of Minitab Set-up)
  • Central-Composite Concepts (with Demonstration of Minitab Set-up)
• Overview of Other Designs/Application: Plackett-Burman and Mixture
• Minitab Demonstration: Response Surface Set-up and Analysis
• Assignment for Session 6: Response Surface DOE Exercise using Minitab and a Simulator to Generate Data for the DOE

Session 6
• Review of Exercise Assigned at the end of the Session 5
• Best Practices: The Problem Solving Process
• Best Practices: The Structured DOE Process
  • The Multi-Step Process for Ensuring Effective DOE Execution and Meaningful Results
  • Discussion “Exercises”: Selecting Factors, Responses, Measurement Systems, etc. for Sample Situations
  • In-class Exercise: How to Conduct a DOE to Evaluate the Quality of a Gauge (Measurement System Assessment or “MSA”)
• FAQ Review and Question and Answer
• Summary

Instructor: Kevin Zielinski
Fee $835 1.2 CEUs

Finite Element Analysis for Design Engineers
8 Hours
I.D.# PD531241
This is a highly interactive on-demand course featuring video, demos, and knowledge checks designed to reinforce learning.

Finite Element Analysis (FEA) is a computer-aided engineering (CAE) tool used to analyze how a design reacts under real-world conditions. Useful in structural, vibration, and thermal analysis, FEA has been widely implemented by automotive companies. It’s used by design engineers as a design tool during the product development process because it allows them to analyze their own designs while they are still in the form of easily modifiable CAD models, providing quick turnaround times and ensuring prompt implementation of analysis results in the design process. While FEA software is readily available, successful use of FEA as a design tool still requires an understanding of FEA basics, familiarity with the FEA process and commonly used modeling techniques, and an appreciation of inherent errors and their effect on the quality of results. When used properly, the FEA becomes a tremendous productivity tool, helping design engineers reduce product development time and cost. Misapplication of FEA, however, may lead to erroneous design decisions, which are very expensive to correct later in the design process.

This online on-demand course provides the skills necessary for proper use of FEA in the design process and ensures that the powerful tool is implemented in the most efficient and productive way. Participants will begin with the foundational FEA process, observe expert demonstrations showing how FEA is conducted using real models, study different types of typically performed analysis, discuss common misconceptions and errors made, and explore how FEA can be implemented within the design environment. Hands-on exercises focusing on FEA fundamentals, different types of analysis, and proper modeling techniques are included.

All topics are illustrated by hands-on examples using FEA software, SolidWorks® Simulation, for which participants will be provided a Student License (compatible with Windows XP, 7; IE 7, 8, 9; MS Excel and Word 2007 or 2010). Acquired skills, however, are not software-specific and no prior exposure to FEA software is required. The eBook, Engineering Analysis with SolidWorks® Simulation by Paul Kurowski, is also included in the course materials. In-class, hands-on exercises and between-session assignments will provide an opportunity to put what is learned into practice.

While the course modules are approximately eight hours in length, the estimated time to completion, including knowledge checks and the learning assessments is 12 hours.
An introduction module and various bundling options are available for this topic. Contact Corporate Learning Solutions to discuss the course options that best fit your need.

Learning Objectives
By participating in this on-demand course, the student will be able to:
• Identify the purpose of using FEA in the design process
• Identify and avoid errors inherent to FEA results
• Identify FEA advantages and shortcomings
• Recognize and avoid common FEA mistakes
• Produce reliable results on time
• Interpret and use FEA results
• Explain an effective approach to FEA project management
• Ensure quality and cost-effectiveness of FEA projects

Major topics include:
• Introduction to Finite Element Analysis
  • FEA Definition and Process
  • Discretizing and Characteristics of Finite Elements
  • Degrees of Freedom
  • Common FEA Assumptions
  • Mesh Concerns
  • Discretization Error and the Convergence Process
• Conducting the FEA Process
  • FEA Preparation Using SOLIDWORKS
  • Model Setup
  • Analysis of Displacement, Strain, and Stress Results
  • Analysis of Convergence Results
  • Types of Convergence Analysis
• Avoiding the FEA Errors
  • Singularities
  • Verification and Validation of Results
  • Control of Modeling Error
  • Useful Modeling Techniques
  • Types of Boundary Conditions
• Common Types of FEA
  • Modal Analysis
  • Buckling Analysis
  • Thermal Analysis
• Conducting Nonlinear Analysis
  • Classifications of Nonlinear Behavior
  • Nonlinear Geometry Analysis
  • Nonlinear Material Analysis
  • Contract Stress Analysis
• Implementation of FEA into the Design Process
  • FEA and the Product Design Process
  • Interfacing between CAD and FEA
  • Project Management of an FEA Project

Is this Course for you?
This course addresses the needs of design engineers using Finite Element Analysis on a new product during the design process. Non-specialized analysts and FEA users, R&D engineers and managers, and project and product engineers can benefit from this introduction to FEA concepts.

What You Will Receive
• 90 days of online single-user access (from date of purchase) to the eight hour presentation
• The eBook, Engineering Analysis using SolidWorks® Simulation by Paul Kurowski (loaded into My SAE Library)
• Student License to SolidWorks® 2015
• Job Aids (included in each module of published course)
• SolidWorks® Models
• Integrated knowledge checks to reinforce key concepts
• Instructor follow-up to your content questions
• 1.2 CEUs*/Certificate of Achievement (with satisfactory learning assessment score)

Fee $720 1.2 CEUs

FMEA for Robust Design: What, Why, When and How Web Seminar RePlay
12 Hours
I.D.# PD331422ON

Web Seminar RePlays are captures of the live web seminar. The course sessions are unedited and include interactions between the instructor and live participants. A learning assessment is available at the end of the course to reinforce learning and retention and gauge your understanding of the topic.

Failure Modes and Effects Analysis (FMEA) is an integral part of product design activity applicable to any type of product or service. It is a qualitative and quantitative step-by-step approach for identifying and analyzing all actual and potential points of failure in a design, product or service. A successful team-based FMEA activity can use their collective experience with similar products to dramatically improve not only product performance but also reduce manufacturing issues at both a component and system and processing level.

This course introduces the five basic types of FMEAs with emphasis on constructing a Design FMEA. Each column of the FMEA form is clearly explained using a typical FMEA example. This example can be a provided sample or a company sample provided candidate. The course covers various methods for
clearly identifying product function at three levels, and associating distinct failure modes, effects and causes related to each function level. Special attention is given to Severity, Occurrence, and Detection and how to develop effective Risk Priority (RPN) strategies and Recommended Actions for significant RPNs.

All material is in conjunction with current industry standards.

**Learning Objectives**

Upon completion, the participant should be able to:

- State the relationship between Product Development, Voice of the Customer (VOC) and the FMEA process
- Recognize why and when to use the five types of FMEAs, specifically Systems and Design
- Apply the FMEA process as a risk management technique
- Organize an effective FMEA team and conduct FMEA work sessions
- Adapt the steps to generate a FMEA process to your specific company needs
- Develop and manipulate Risk Priority and Detection Strategies and customize Risk Ranking tables
- Assign effective Recommended Actions

**Is this Course for You?**

This training option is designed for individuals who are involved in the development of new products and who seek to improve that process. Product development team members including, but not limited to, project and program managers, design and development, process, product, quality, and application engineers will find the course valuable. It is aimed primarily at these managers and engineers who will be facilitating or leading such FMEA activities. Directors, marketing and purchasing personnel will also benefit by understanding why the FMEA process is important to developing a safe and effective product.

**Topical Outline**

Session 1
- FMEA Introduction
  - Background and History
  - The FMEA Standards - MIL-STD_1629, SAE J1739, AIAG
  - Relationship of Design and Process FMEA in a design & manufacturing environment

Session 2
- Five Types of FMEAs

Session 3
- FMEA and Risk Management
  - Defining Risk Management
  - FMEA and Robust Design
  - FMEA as part of Design to Cost
  - FMEA as Product Liability Protection

Session 4
- Managing the FMEA Process
  - Assembling the FMEA Team
  - Facilitator Role during the FMEA Process
  - Capturing the 6 Levels of Voice of the Customer (VOC)
  - The FMEA Database and FMEA Templating
  - Tips for standardizing concise expression of failure modes, effects and causes

Session 5
- Column By Column Review of the FMEA - Part 1
  - Header
  - Item/Function - Primary, Secondary and Customer Satisfaction
  - Failure Mode
  - Effects and Severity
  - Causes and Occurrence
  - Controls and Detection

Session 6
- Column By Column Review of the FMEA - Part 2
  - Calculating and Assessing RPN
  - Risk Tables and RPN assignment strategies
  - Recommended Actions
  - Responsibility and Target Dates
  - Verification

**Instructor:** Angelo E. Mago

**Fee:** $835 1.2 CEUs

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**Introduction to FMEA: What, Why, When and How**

25 Minutes  
I.D.# PD531422ON

This is a highly interactive on-demand course featuring video, demos, and knowledge checks designed to reinforce learning.

Failure Mode and Effects Analysis (FMEA) is an essential part of any product design or redesign activity. FMEA is a proactive, quantitative, qualitative, step-by-step approach for identifying and analyzing all potential points of failure in any product or service. This team-based activity can dramatically improve product performance. It can also reduce manufacturing issues at the component, system, and processing level.

This module gives a high-level overview of FMEA facts: WHAT an FMEA is, WHY they are used, WHEN an FMEA is created, WHO is on the FMEA development team, and HOW the FMEA form is completed. The history of FMEAs, standards, and team responsibilities are also discussed.
ON DEMAND COURSES RESOURCE GUIDE

Additional modules are being planned for release to provide a comprehensive FMEA curriculum. You may also consider the Web Seminar RePlay *FMEA for Robust Design: What, Why, When and How*, with instructor Angelo Mago. Find the course description on page 208.

All material is in conjunction with current industry standards. While the course module is approximately 25 minutes in length, the estimated time to completion, including knowledge checks and the learning assessment is one hour.

A more in-depth on-demand option for the FMEA topic is in development. Contact Corporate Learning Solutions to discuss availability and learning options that best fit your need.

**Learning Objectives**

By participating in this on-demand course, students will be able to:
- Describe the FMEA history, terms, standards and types
- State the benefits and advantages of using an FMEA
- Describe the composition and responsibilities of an FMEA team
- Explain when an FMEA is needed and the timing involved
- Describe the basic information and inputs required in each column of an FMEA form

**Major topics include:**

- Lesson 1: Introduction
- Lesson 2: WHAT is Failure Mode and Effects Analysis?
- Lesson 3: WHY should we use FMEA?
- Lesson 4: WHO is on an FMEA team?
- Lesson 5: WHEN should we develop an FMEA?
- Lesson 6: HOW do we complete an FMEA form?
- Lesson 7: Summary

**Is this On-demand Course for you?**

This course is designed for individuals who need an overview of the Failure Mode and Effects Analysis process and tool including project and program managers, as well as design and development, process, product, quality, and application engineers.

**What You Will Receive**

- 90 days of on line, on-demand single-user access to the 60 minute course
- A printable summary of the key takeaways from each lesson
- Integrated knowledge checks to reinforce key concepts
- Instructor follow-up to your content questions
- .1 CEUs/Certificate of Achievement (with satisfactory learning assessment score)

Fee $85 .01 CEUs

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**Introduction to Design Review Based on Failure Modes (DRBFM) Web Seminar RePlay**

6 Hours
I.D.# PD331047ON

Web Seminar RePlays are captures of the live web seminar. The course sessions are unedited and include interactions between the instructor and live participants. A learning assessment is available at the end of the course to reinforce learning and retention and gauge your understanding of the topic.

Design Review Based on Failure Modes (DRBFM) is a methodology focused on change management and continuous improvement. It centers on early prevention and engineering knowledge, eliminating time spent debating ranking systems, waiting for lead engineers to document and list their concerns, identifying what types of concerns are open for discussion and resolution, and brainstorming without any actionable closure.

This course explains all phases of the DRBFM methodology and provide details on how to accomplish the specific steps. With the *Design Review Based on Failure Modes (DRBFM)* and *Design Review Based on Test Results (DRBTR)* Process Guidebook that is bundled with the course, the instructor provides specific information on each step. Formats, examples, notes and homework slides will be used to illustrate the defined steps of the new SAE J2886 DRBFM Recommended Practice. Similarities in content between DRBFM and FMEA will be discussed, however the focus will be on conducting DRBFM methodology.

This DRBFM Web Seminar RePlay provides roles and responsibilities of management, design engineers, manufacturing engineers, facilitators and technical experts. Those interested in DRBFM will benefit from understanding the rationale behind this methodology and learn to guide teams through the paradigm shifts and mind set that are needed.

**Learning Objectives**

By connecting with this course, participants will be able to:
- Outline the fundamental steps of DRBFM methodology, including:
  - DRBFM Plan and analysis requirements
  - Necessary preparation feeding DRBFM analysis
  - The two phases of DRBFM analysis
  - Documentation of design, validation and manufacturing actions
  - Feedback loop into engineering knowledge documents
- Explain the intent and format of the DRBFM worksheets
ON DEMAND COURSES RESOURCE GUIDE

- Predict what it takes to gain and maintain proficiency and consistent application of the methodology
- Find answers to most DRBFM questions

Who Should Attend

Product engineers, manufacturing engineers, quality engineers, supplier quality engineers, validation and test engineers, and facilitators, trainers and consultants in all industries. This Web Seminar RePlay will benefit beginning engineers, advanced and senior engineers and managers who must participate in FMEA’s and DRBFM.

Topical Outline

Session 1
- DRBFM Procedure, Forms, Planning and Preparation
  • Process Guide and Workbook Overview
  • Scope and Purpose
  • Process Map - General Requirements
  • Planning - Formats, examples, homework
  • Planning Results and Output
  • Preparation - Formats, examples, homework
  • Preparation Results and Linkage with DRBFM Format
  • Definition of Change Section

Session 2
- DRBFM - Forum 1, Design Review, Action Results and Follow Up
  • DRBFM Forum 1 - Engineer analysis
  • Change Point definition
  • Identification of concerns
  • Identification of causes and influences on the vehicle
  • Identification of effects
  • Identification of severity/priority
  • Actions to gain engineering knowledge - evidence

Session 3
- DRBFM - Forum 2, Design Review, Action Results and Follow Up
  • DRBFM Forum 2 - Design Review introduction
  • Change Point overview
  • Identification of additional concerns
  • Identification of additional causes and influences on the product
  • Identification of effects
  • Identification of severity/priority
  • Actions taken to eliminate concerns
  • Design actions to gain engineering knowledge - evidence
  • Validation actions to gain evidence of reliability
  • Manufacturing, assembly, and supplier actions
  • Action results and feedback to design guidelines
  • Roles and responsibilities

Instructor: Bill Haughey
Fee $615 .6 CEUs

Introduction to Weibull Solution Methods
1.25 Hours
I.D.# PD530946ON

This is a highly interactive on-demand course featuring video, demos, and knowledge checks designed to reinforce learning.

Weibull Analysis is the starting point for solving most issues related to product reliability, maintainability, supportability, quality, safety, test planning, and cost control. Weibull Analysis is popular worldwide as the best method for modeling and predicting variability and failure of designs, products, and systems. Instructor Wes Fulton will provide a solid overview of Weibull Solution Methods including an explanation of 16 additional Weibull Analysis capabilities, or Weibull Extensions. This introductory short course should be considered a prerequisite for participation in a Weibull project or for attending additional SAE training that covers advanced Weibull applications.

While the course module is just over 75 minutes in length, the estimated time to completion, including exercises, job aids and the learning assessment is two hours.

Learning Objectives

Upon successful completion, the participant will be able to:
- Determine whether or not the available data is appropriate for a Weibull solution
- Discuss the background and explain the benefits of Weibull solution methods
- Create, interpret and evaluate the correctness of a Weibull plot
- Distinguish between an infant mortality failure issue and a wearout failure issue
- Forecast events under different maintenance strategies
- Determine pass/fail criteria in designing a test program
- Explain 16 additional Weibull analysis capabilities, called Weibull Extensions and locate additional resources

Major topics include:
- Introduction and Background
- Basic Plotting
- Basic Interpreting
- Case Studies
- Variations
- Extensions and Summaries

Is this Course for You?

The Introduction to Weibull Solution Methods on-demand course is designed for technical personnel and engineers who want to discover the best toolset for continuous improvement at their organization or business. Those in any industry including automotive, aerospace, electrical/electronic, transportation, design,
manufacturing, test planning, warranty, reliability, quality, liability, value engineering, and management will benefit. This course is appropriate for anyone who needs an awareness of Weibull’s basic premises and benefits as well as those who need this foundational knowledge as a prerequisite for additional training toward becoming an expert Weibull practitioner.

**What You Will Receive**
- 90 days of online single-user access (from date of purchase) to the course
- Integrated knowledge checks to reinforce key concepts
- Online learning assessment (submit to SAE)
- Job aid for practical application of the topics covered
- Instructor follow up to your content questions
- .2 CEUs*/Certificate of Achievement (with satisfactory learning assessment)

**Instructor:** Wes Fulton  
**Fee:** $160  
**.2 CEUs**

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**Root Cause Problem Solving: Methods and Tools**

8 Hours  
I.D.# PD530931

**This is a highly interactive on-demand course featuring video, demos, and knowledge checks designed to reinforce learning.**

How do you solve a problem? Do you find yourself using quick and easy solutions or a structured methodology? Too often, organizations tend to seek quick solutions to a problem without adequately addressing its underlying cause. These decisions often result in solutions that don’t work or aren’t sustainable, often wasting time, effort, and money. To combat these issues and adopt a fresh approach, teams can use the methods and tools of Root Cause Problem Solving. By first viewing a problem as an opportunity for improvement, the team can then identify the problem’s root cause or causes, and implement solutions to prevent the problem’s reoccurrence.

This six module course introduces the Root Cause Problem Solving approach. It explains how using Root Cause analysis can help improve operational and financial performance by identifying root causes and implementing solutions to significant or recurring problems. This methodology is used by many major automotive manufacturers to improve quality and customer satisfaction, reduce operation costs, and provide greater employee knowledge of work processes.

Participants will become familiar with the eight steps of the Root Cause Problem Solving approach, learning the key actions completed in each step and interacting with examples and scenarios that demonstrate how each step functions to solve problems and keep them from reoccurring in an organization. Participants will also be supplied with tools that assist with the completion of each step that they can use in their own problem-solving efforts on-the-job.

While the course is approximately eight hours in length, the estimated time to completion, including knowledge checks and the learning assessment is ten hours.

**An introductory module and and other purchasing options are available for this topic. Contact Corporate Learning Solutions to discuss the course options that best fit your need.**

**Learning Objectives**

Upon successful completion, the participant will be able to:
- Explain why root cause analysis using the 8-Step Problem Solving Methodology is more effective than non-structured problem solving efforts
- Define the difference between a problem, symptom, cause, and root cause
- Use tools and techniques to solve problems
- Evaluate effectiveness of problems solving efforts
- Describe the role of problem solving in continuous improvement

**Major topics include:**
- Module 1: Foundations for Adopting Root Cause Analysis
  - Identifying Problems
  - How to Approach Problem Solving Using a Process Approach
  - Methods and Tools for Problem Solving: An 8 Step Approach
  - Roles and Responsibilities in Problem Solving
  - Setting Up a Problem Solving Team
- Module 2: Describing the Problem and Implementing Containment
  - How to Describe a Problem
  - Symptoms vs. Causes
  - Methods for Collecting and Analyzing Data
  - Problem Statements
  - Methods for Protecting the Customer
- Module 3: Discovering Root Causes
Is this On-demand Course for you?
This course is applicable to those directly working in or responsible for performance improvement of any definable, repetitive process, e.g. manufacturing, design, logistics, purchasing, sales, or distribution, including:
• Manufacturing managers, supervisors and team leaders
• Manufacturing engineers
• Design engineers
• Quality engineers and technicians
• Technical managers
• Project team leaders
• Problem solving and quality improvement facilitators
• Anyone whose role includes problem solving

What You Will Receive
• 90 days of online single-user access (from date of purchase) to the course
• Integrated knowledge checks to reinforce key concepts

Fee $640 (full course) 1.0 CEU (ful course)

Vibration Analysis Using Finite Element Analysis (FEA) Web Seminar RePlay

12 Hours
I.D.# PD331401ON

Web Seminar RePlays are captures of the live web seminar. The course sessions are unedited and include interactions between the instructor and live participants. A learning assessment is available at the end of the course to reinforce learning and retention and gauge your understanding of the topic.

Finite Element Analysis (FEA) has been used by engineers as a design tool in new product development since the early 1990’s. Until recently, most FEA applications have been limited to static analysis due to the cost and complexity of advanced types of analyses. Progress in the commercial FEA software and in computing hardware has now made it practical to use advanced types as an everyday design tool of design engineers. In addition, competitive pressures and quality requirements demand a more in-depth understanding of product behavior under real life loading conditions. This course will enable participants to expand the scope of FEA to vibration analysis to simulate product behavior under those conditions.

This course introduces vibration analysis performed with Finite Element Analysis (FEA). By considering time-dependent loads and inertial and damping effects, vibration analysis allows for a more in-depth product simulation thus reducing product development cost and time. The course reviews basic concepts of vibration analysis and illustrates how they are implemented in FEA to simulate product behavior. The most common types of vibration analysis such as modal, time response, and frequency response will be covered.

All topics are illustrated using FEA software, SolidWorks® Simulation, for which participants will be provided a student license (compatible with 64-bit Windows 7 SP1, 8.1, 10; IE 10,11; MS Excel and Word 2010, 2013, 2016) and opportunity to practice skills learned. Acquired skills, however, will not be software specific and no prior exposure to FEA software is required. The eBook, Vibration Analysis with SolidWorks® Simulation by Paul Kurowski, will also be included in the course materials. In-class, hands-on exercises and between-session assignments will provide an opportunity to put what is learned into practice.

Learning Objectives
By connecting with this course, participants will be able to:
• Evaluate the importance of dynamic effects in product simulation
ON DEMAND COURSES RESOURCE GUIDE

- Analyze inertial and damping effects in structural response
- Perform modal analysis, time response analysis and frequency response analysis
- Apply proper FEA modeling techniques to model system vibration
- Use vibration analysis as a design tool

Is this Course for You?
The course will be of interest to design, R&D, project, and product engineers who already use Finite Element Analysis (FEA) as a design tool and would like to explore if and how vibration analysis with FEA may benefit the design process. It builds on participants’ experience with static FEA and on knowledge of mechanical vibrations common to any mechanical engineer.

Prerequisites
Participants should have a degree in mechanical engineering and have some experience with FEA either by participating in the SAE Finite Element Analysis for Design Engineers web seminar (I.D.# WB1241) or through equivalent work experience. Familiarity with Windows OS and some CAD is helpful. The textbook, Engineering Analysis with SolidWorks® Simulation by Paul Kurowski, is recommended reading.

Topical Outline
Session 1
- Structure vs. Mechanism
- Simulation Process with the FEA
- Verification and Validation of FEA Results
- Discrete and Distributed Systems
- Mode of Vibration
- Modal Analysis
- Eigenvalues and eigenvectors
- In-class Exercises/Homework Assignment

Session 2
- Modal Analysis
- Convergence of Frequencies
- Rigid Body Modes
- Properties of Lower and Higher Modes
- Modes of Vibration of Single Degree of Freedom Oscillator (1DOF) and Two Degrees of Freedom Oscillator (2DOF)
- In-class Exercises/Homework Assignment

Session 3
- Modal Analysis
- Modeling Techniques in Modal Analysis
- Modes Separation
- Modal Analysis as a Tool to Find “Weak Spots”
- Modal Analysis as a Diagnostic Tool
- In-class Exercises/Homework Assignment

Session 4
- Modal Analysis with Pre-Stress

- Buckling Analysis
- Analogies between Modal Analysis and Buckling Analysis
- Modes of Vibration
- Modal Superposition Method
- In-class Exercises/Homework Assignment

Session 5
- Time Response Analysis
- Load Excitation and Base Excitation
- Impulse Load
- Static vs. Dynamic Response
- Time Response of a 1DOF and 2DOF Systems Time Response of a Distributed System
- In-class Exercises/Homework Assignment

Session 6
- Frequency Response Analysis
- Steady State Harmonic Response
- Force and Base Excitation
- Resonance
- Modal Damping
- Frequency Response of a 1DOF and 2DOF Systems
- Frequency Response of a Distributed System
- Linear vs. Non-linear Vibration Analysis
- Summary for Post-Course Learning Assessment

Instructor: Paul Kurowski
Fee $870 1.2 CEUs

Tolerance Stack-up Fundamentals Web Seminar RePlay
6 Hours
I.D.# 330842ON

Web Seminar RePlays are captures of the live web seminar. The course sessions are unedited and include interactions between the instructor and live participants. A learning assessment is available at the end of the course to reinforce learning and retention and gauge your understanding of the topic.

Analysis of tolerance stacks varies widely. This Web Seminar RePlan introduces the basic tools to create a common methodology for tolerance stack-ups, and ensure seamless documentation. Participants will create 1-D tolerance stacks for parts and assemblies that use geometric dimensioning and tolerancing using a tolerance stack spreadsheet. This simple, manual spreadsheet method produces an easily interpreted and checked documentation trail, and is easily adaptable to common electronic spreadsheet programs. Multiple examples will be provided to assist engineers in applying tolerance stack-up fundamentals to Y14.5 issues.
Learning Objectives
By connecting with this course, participants will be able to:
• Perform and develop a tolerance stack-up analysis
• Correctly enter geometric feature control frame data into a tolerance stack
• Apply a common step-by-step methodology to tolerance stack analysis
Who Should Attend Engineers familiar with concepts and practices contained within Y14.5 and who are looking for a fundamental step-by-step process for getting geometric dimensioning and tolerancing (GD&T) into a tolerance stack will benefit from this course. A basic understanding of GD&T symbols and concepts is required.

Topical Outline
Session 1
• Introduction and review
• Introduction and tolerancing review
• Tolerancing strategies; Review of GD&T
Session 2
• Stack fundamentals
• How to identify the stack path
• The two-column stack spreadsheet
• Entering dimensions into the spreadsheet
• Examples with coordinate dimensions
Session 3
• Factoring GD&T into a Stack
• Location and runout tolerances
• Profile tolerances
• Form and orientation tolerances
Session 4
• Bonus and shift tolerance in a stack
• Overview of bonus and shift tolerance
• Part vs. assembly stacks

Instructor: John-Paul Belanger
Fee $640 .8 CEUs

Fundamentals of Geometric Dimensioning & Tolerancing (GD&T) Web Seminar RePlay
16 Hours
I.D.# PD330933ON

Web Seminar RePlays are captures of the live web seminar. The course sessions are unedited and include interactions between the instructor and live participants. A learning assessment is available at the end of the course to reinforce learning and retention and gauge your understanding of the topic.

Geometric dimensioning and tolerancing (GD&T) is used as a symbolic way of showing specific tolerances on drawings. GD&T is a valuable tool that effectively communicates the design intent to manufacturing and inspection. It is governed by the technical standard ASME Y14.5M-2009. This course introduces participants to the GD&T system, providing a working knowledge of the correct interpretation and application of each symbol, general rules, the datum system, and ‘bonus’ tolerance and highlighting some of the changes in the updated Y14.5 standard. The material is reinforced with many practice exercises.

Learning Objectives
By connecting with this course, participants will be able to:
• Explain the benefits of geometric tolerancing
• Identify datum features and determine their order of precedence
• Identify and interpret each of the characteristic symbols
• Describe the material condition modifiers and how “bonus” tolerance occurs
• Correctly interpret GD&T feature control frames, and explain the impact on manufacturing and inspection

Who Should Attend
This course is ideal for anyone who has a need to apply or interpret geometric tolerances on a product print. Product engineers, manufacturing engineers, CAD designers, quality inspectors, and other engineering and manufacturing personnel will all benefit from a better understanding of design requirements; improved communication with customers and suppliers; and improving designs by taking advantage of bonus tolerance and other GD&T benefits. Participants should have an understanding of basic blueprint reading.

Topical Outline
Session 1
• Why Use GD&T?
  • Review of traditional dimensioning
  • Benefits of GD&T
  • Technical standards
  • Definitions
Advanced GD&T Competencies: Datum Usage
Web Seminar RePlay

1.5 Hours
I.D.# PD331319ON

Web Seminar RePlays are captures of the live web seminar. The course sessions are unaedited and include interactions between the instructor and live participants. A learning assessment is available at the end of the course to reinforce learning and retention and gauge your understanding of the topic.

While the basics of datums are covered in a standard Geometric Dimensioning & Tolerancing (GD&T) course, those discussions often overlook the variations that enable datums to be used in complex ways. This advanced course will detail the proper use of datums, showing their full potential to make your drawings as effective as possible. Most people who use GD&T are familiar with traditional datums derived from flat surfaces, and have adequate knowledge of the principle of establishing 3-2-1 contact points. In this web session, participants will learn to select, identify, simulate, and describe datums and datum features for special uses such as irregular shapes, flexible parts, and datum references that use the maximum material modifier. Also covered are several new modifiers and options given in the ASME Y14.5-2009 standard. Learning these advanced techniques will allow designers to better communicate certain requirements.

Learning Objectives
By connecting with this course, participants will be able to:
- Explain the difference between a datum and a datum feature
- Select appropriate datums for irregularly shaped parts such as body or interior panels
- Properly simulate given datums
- Explain effects of a modified datum on a geometric tolerance
- Interpret new datum tools such as translation and custom degrees of freedom

Who Should Attend
This advanced-level course is intended for designers, product engineers, manufacturing engineers, manufacturing personnel, and quality/gaging inspectors with a basic knowledge of GD&T concepts. It is a companion to the Advanced GD&T Competencies: Composite Positioning and Advanced GD&T Competencies: Profile of a Surface Web Seminar RePlays. See course descriptions on the following pages.

Prerequisites
For those new to GD&T, the Fundamentals of Geometric Dimensioning & Tolerancing web seminar or Web Seminar RePlay is a recommended prerequisite. See the course description for the on-demand Web Seminar RePlay on page 215.
ON DEMAND COURSES RESOURCE GUIDE

Topical Outline
• Brief review of traditional datum usage
• Selecting datums: surface vs. feature of size
• Use of the MMB modifier (formerly MMC)
• Using a pattern as a single datum
• The new translation modifier
• Applying the “M” modifier to a surface
• Customized degrees of freedom
• Irregular feature of size datums
• Moveable datum targets

Instructor: John-Paul Belanger
Fee $215 .15 CEUs

Advanced GD&T Competencies: Profile of a Surface Web Seminar RePlay
1.5 Hours
I.D.# PD331320ON

Web Seminar RePlays are captures of the live web seminar. The course sessions are unedited and include interactions between the instructor and live participants. A learning assessment is available at the end of the course to reinforce learning and retention and gauge your understanding of the topic.

While the topic of profile is covered in a basic Geometric Dimensioning & Tolerancing (GD&T) course, those discussions often ignore the variations allowed with these symbols that enable them to be used in complex ways. This advanced course will clarify the proper use of the profile tolerances in GD&T and uncover the nuances of these two symbols. Since profile of a surface is arguably the most powerful GD&T symbol, its full potential will be explored. It can be used to control size, form, orientation, and location and its relationship to datums can be varied. Learning these advanced techniques will allow designers to better communicate certain requirements. The examples given in this session will also illustrate several of the new options for profile that were introduced in the ASME Y14.5-2009 standard.

Learning Objectives
By connecting with this course, participants will be able to:
• Explain when profile tolerances require a datum reference
• Determine which aspects of GD&T a given profile tolerance controls
• Interpret unilateral, bilateral, and nonuniform tolerances
• Describe how to properly measure profile tolerances

Is this Course for You?
This advanced-level course is intended for designers, product engineers, manufacturing engineers, manufacturing personnel, and quality/gaging inspectors with a basic knowledge of GD&T concepts. It is a companion to the Advanced GD&T Competencies: Composite Positioning and Advanced GD&T Competencies: Profile of a Surface Web Seminar RePlays. See course descriptions just before and just after this description.

Prerequisites
For those new to GD&T, the Fundamentals of Geometric Dimensioning & Tolerancing web seminar or Web Seminar RePlay is a recommended prerequisite. See the course description for the on-demand Web Seminar RePlay on page 215.

Topical Outline
• Review of profile of a surface and profile of a line
• Using profile without datums
• All around and all over
• Locating a profile zone with toleranced dimensions
• Using the MMB modifier with profile
• Composite profile
• The “U” modifier
• Nonuniform tolerancing

Instructor: John-Paul Belanger
Fee $215 .15 CEUs

Advanced GD&T Competencies: Composite Positioning Web Seminar RePlay
1.5 Hours
I.D.# PD331321ON

Web Seminar RePlays are captures of the live web seminar. The course sessions are unedited and include interactions between the instructor and live participants. A learning assessment is available at the end of the course to reinforce learning and retention and gauge your understanding of the topic.

While the basics of position are covered in a standard Geometric Dimensioning & Tolerancing (GD&T) course, and sometimes a lone example of composite position is given, those discussions often overlook the variations allowed that enable more accurate control based on part function. This advanced course will clarify the proper use of “double-decker” position controls in GD&T. There are two distinct types: composite position (one symbol) and two single-segment position controls (two symbols). These are commonly used to locate patterns of features (bolt circles,
etc.), but they are rarely taught in any depth. In this course, participants will learn the difference in showing one vs. two position symbols and the importance of the datum references in understanding each meaning, per the ASME Y14.5-2009 standard. Many samples will be shown of the proper tolerancing of patterns of holes and pins that use each method. Examples and exercises will be provided to allow participants to practice several calculations. Learning these advanced techniques will permit better communication of part and assembly requirements between designers and manufacturers.

Learning Objectives
By connecting with this course, participants will be able to:
• Explain composite positioning tolerancing
• Explain two single-segment tolerancing
• Apply the appropriate callout based on functional requirements
• Describe gages for each and calculate gage sizes

Who Should Attend
This advanced-level course is intended for designers, product engineers, manufacturing engineers, manufacturing personnel, and quality/gaging inspectors with a basic knowledge of GD&T concepts. It is a companion to the Advanced GD&T Competencies: Profile of a Surface And Advanced GD&T Competencies: Datum Usage Web Seminar RePlays immediately before this course.

Prerequisites
For those new to GD&T, the Fundamentals of Geometric Dimensioning & Tolerancing web seminar or Web Seminar RePlay is a recommended prerequisite. See the course description for the on-demand Web Seminar RePlay on page 215.

Topical Outline
• Brief review of position and bonus tolerance
• Explanation of composite tolerancing
• The need to control orientation vs. location
• Adding secondary and tertiary datums to the lower tolerance
• Two single-segment position tolerancing
• Functional gaging and CMM gaging perspectives

<table>
<thead>
<tr>
<th>Instructor:</th>
<th>John-Paul Belanger</th>
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MANAGEMENT: LEADERSHIP

Doing the Right Things Right
30 Minutes
I.D.# PD271715

This is a highly interactive on-demand course featuring video, demos, and knowledge checks designed to reinforce learning.

Are you spending your work time where you should? To be effective and efficient requires thinking, teaming, and tactical skills. How are you using your skills and building those you need to successfully execute in your leadership role? Based on the book by bestselling author and award-winning speaker Laura Stack, Doing the Right Things Right: How the Effective Executive Spends Time, this course focuses on how today’s leaders and managers can obtain profitable, productive results by managing the intersection of two critical values: effectiveness and efficiency. Stack describes her 3T Leadership model which offers twelve practices that will enable executives to apply these values, grouped into three areas where leaders spend their time: Strategic Thinking, Teamwork, and Tactics.

Following an assessment of personal productivity practices, you will learn how to build and apply these practices to situations that require making tough choices about managing your time. With her expert advice, you’ll get scores of new ideas on how you, your team, and your organization can boost productivity. The learning experience is fun and challenging, as you move beyond learning what to do into practicing how to do it when faced with today’s time management complexities.

Learning Objectives
• Fulfill the role of an executive who makes strategic decision, focuses on team efforts, and performs tactical work on behalf of an organization
• Leverage the intersection between efficiency and effectiveness
• Identify your assets and liabilities related to thinking, teaming and tactics
• Model best practices of productivity pros who get the right things done right
• Build skills in strategic thinking, team focus and tactical work
Is this Course for You?
Managers, supervisors, team leaders, HR and benefits professionals, project managers, business owners and executives who wish to enhance their leadership skills for the betterment of themselves and their organizations.

Content Highlights
• Part one-How the Effective Executive Spends Time
• Part two-The Three T Leadership Assessment
• Part three-Become a Productivity Pro

Instructor: Laura Stack
Fee $75 There are no CEU offered for this course.

Out Innovate the Competition
25 Minutes
I.D.# PD271714

This is a highly interactive on-demand course featuring video, demos, and knowledge checks designed to reinforce learning.

Well-intentioned leaders, in their attempts to boost innovation, are inadvertently destroying it. Based on Stephen Shapiro’s bestselling book, Best Practices are Stupid: Ways to Out-Innovate the Competition, this online learning experience offers counterintuitive yet proven strategies for boosting innovation and making it a repeatable, sustainable, and profitable process. He teaches that innovation isn’t just about generating occasional new ideas; it’s about staying consistently one step ahead of the competition. Shapiro shows that non-stop innovation is attainable and vital to building high-performing teams, improving financial outcomes, and staying competitive with peer organizations. Using self-assessment, the goal is to challenge you to think differently about how you approach innovation

Learning Objectives
By connecting with this course, participants will be able to:
• Focus on how you differentiate your organization
• Target your efforts and innovate where your organization differentiates
• Frame your innovation challenges in new ways
• Find breakthrough solutions by connecting with people who have solved similar challenges
• Implement solutions through experimentation rather than failure

Is this Course for You?
Managers, supervisors, team leaders, HR and benefits professionals, project managers, business owners and executives who wish to enhance their leadership skills for the betterment of themselves and their organizations.

Instructor: Stephan Shapiro
Fee $75 There are no CEUs offered for this course.

The Pillars of Leadership
1.3 Hours
I.D.# PD271716

This is a highly interactive on-demand course featuring video, demos, and knowledge checks designed to reinforce learning.

This exciting new series focuses on the extensive research, CEO interviews and corporate engagements of Jason Jennings and Laurence Houghton. Their team has observed and documented the lives of successful leaders. Now these ideas, and valuable practices, have been converted to high-impact elearning as a “Front Row Seat” for managers and leaders – especially new managers and leaders who have great knowledge and technical ability but have not had the opportunity to learn “first hand” from the best in the world.

Each lesson in the series is filled with tips, stories and activities and, in the end, will be able to self-assess your leadership strengths and create an action plan with on-going tips for developing yourself and your team. You will be positioned to commit to growth as a means to sustainable success, instill a sense of meaningful purpose in work, align people in the right roles through effective communication, let go of conventional wisdom in favor of change and reinvention, and adopt a stewardship.

Learning Objectives
• Recognize the importance of attracting, keeping, and growing your people
• The power of focusing on better futures by reinvesting in customers
• Why giving back and growing communities reinforces growth for your company
• Create a meaningful purpose that truly engages today’s workers
• Build a strong purpose into the fabric of the organization
• Build healthier, more focused, and harder working teams
• Find and select the right people for your company culture
• Learn to deeply connect with team members for a long term relationship
ON DEMAND COURSES RESOURCE GUIDE

- Learn the power of discovery conversations
- Understand the four things you have to let go of
- Let go of the habits, and bureaucracy which slow us down
- Learn how to change, innovate, and grow faster, by letting go
- Learn the four keys to Steward Leadership: sharing power, putting others first, caring, and preserving resources
- Learn how to build team alignment toward growth

Is this Course for You?
Managers, supervisors, team leaders, HR and benefits professionals, project managers, business owners and executives who wish to enhance their leadership skills for the betterment of themselves and their organizations.

Topical Outline
Part 1: Growth
- Introduction
- About Growth
- Why Growth?
- People Want and Make Growth
- Benefits of Growth
- Commit to Growth
- Final Assessment
Part 2: Purpose
- Introduction
- About Purpose
- People with Purpose
- Self-Check
- A Better Life for Many
- Companies with Purpose
- Purpose: Bold and Authentic; Not What but Why
- Purpose: It’s Not Financial; Fixes and Injustices
- Purpose: A Journey; Gives Meaning to Life
- Self-Check
- Your Purpose Statement
- Final Assessment
Part 3: Communication
- Introduction
- Connect with People
- Be Interested, Not Interesting
- Self-Check
- Discovery Conversation
- Get Started on the Discovery
- Take the Journey
- The Discovery Destination
- Discovery and Staffing
- Summary
- Final Assessment
Part 4: Letting Go
- Introduction
- About Letting Go
- Catching Monkeys
- Let Go of Four Things
- The Leader’s Challenge
- Letting Go Planner
- Final Assessment
Part 5: Stewardship
- Introduction
- Case Scenario
- About Stewardship
- The Personality of Stewards
- Closing Questions
- Your Leadership Charter
- Final Assessment

Instructor: Jason Jennings
Fee $199 0.1 CEUs

The Art of Leadership Presence
40 Minutes
I.D.# PD271738
This is a highly interactive on-demand course featuring video, demos, and knowledge checks designed to reinforce learning.

Stuff happens. Maybe your team responds to an idea in a way you never expected. Maybe the people who were supposed to show up didn’t. Maybe a colleague expresses concern with your leadership style. Maybe someone finds a serious error in the report.

We all experience surprises. What if you could meet these surprises with ease and confidence? And what if you could create, through your own personal presence, space for more positive, collaborative engagements between people?

You can when you adopt the mindset of an improv actor! This means learning and practicing how to show up and be ready – ready to lead, to influence, and to contribute whether things go the way you expected or not. And to have leadership presence: something that builds the trust we need to work together through good times and bad.

Learning Objectives
- Identify how leadership presence can benefit your work situation
- Recognize the value of different types of leadership presence
- Create a skill development plan for increasing trust and influence at work

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• Fill out the online quote request at sae.org/corplearning • Email us at Corplearn@sae.org
• Acknowledge the power of non-verbal communication and how to use body language and eye contact to demonstrate leadership confidence
• Practice techniques to exude confidence when speaking to others
• Build trust through preparation and follow-through
• Enhance respectful and accountable behavior when playing a team leadership role
• Expand capabilities to use body and mind when dealing with chaos
• Recognize how to acknowledge, deal, and move on from difficult situations

Is this Course for You?
Emerging leaders, managers, and individual contributors whose effectiveness would be enhanced through confidence, consistency and remaining calm in chaos. Participants who want to build trust, influence others and deliver strong presentations will benefit from this course.

Content Highlights
• Part 1: Develop Leadership Presence
• Part 2: Build Leadership Confidence
• Part 3: Practice and Promote Consistency
• Part 4: Remain Calm in Chaos

Instructor: Karen Hough
Fee $199 0.1 CEUs

MANAGEMENT: PRODUCT DEVELOPMENT & QUALITY ASSURANCE

Global 8D - Ford On-Demand Course

12 Hours
I.D.# PD111012ON

Global 8D (G8D) is a disciplined process developed by Ford Motor Company to help product development and manufacturing engineers identify and solve problems. Solving problems results in efficient, as well as effective, resolution to ‘root causes’ of customer satisfaction issues, and helps reduce warranty costs. With this 12-hour on-demand course, participants will learn the methods and tools used to complete each step in the Ford Global 8D find-and-fix problem-solving process, including steps to define the problem, verify the root cause and escape point, and prevent occurrence.

Major topics include:
• Global 8D Overview
• Prepare for Global 8D and Establish the Team
• Describe the Problem and Find the Root Cause
• Choose and Implement a Permanent Corrective Action (PCA)
• Complete the Global 8D

Is this SAE/- Ford On-Demand Course for you?
This course is geared toward quality, manufacturing, and product development engineers. It is recommended that you have an engineering degree and experience in the automotive engineering field.

What You Will Receive
• Four months of on-demand access to the 12-hour course
• Proof of Participation

Fee: $395 There are no CEUs offered for this course.
Introduction to Advanced Product Quality Planning (APQP)

1 Hour
I.D.# PD530908ON

This is a highly interactive on-demand course featuring video, demos, and knowledge checks designed to reinforce learning. To become a preferred supplier in the automotive industry, organizations must demonstrate high-level engineering and organizational capabilities that will meet customers’ needs today and tomorrow. Because the outcome of a product development project may determine whether or not an organization procures a purchase order or contract from a global automotive customer, Introduction to Advanced Product Quality Planning provides an overview of the best practices / methodologies for planning and managing the successful launch of a new product.

The benefits of a successful new product launch are recognized by both global automotive customers and suppliers. There are thousands of great inspirations and great ideas each year, but the difficult task that so many organizations struggle with is how to take those ideas and develop them into a viable product design, and then manufacture the designed product, and then distribute and sell the product. An understanding of the Advanced Product Quality Planning (APQP) process, the management of the process, and the implementation of the process is critical to the product development multi-disciplinary team which includes top management, the project manager, product engineering, process engineering, design and development, manufacturing, quality, and purchasing personnel.

While the course module is approximately one hour in length, the estimated time to completion, including knowledge checks and the learning assessment, is one hour, 30 minutes.

Learning Objectives

By connecting with this course, participants will be able to:
• Explain what APQP is, including its purpose and the goals of an effective APQP process
• Identify the impacts and benefits that an effective APQP process has on both the customer and the supplier
• Describe how an APQP process can be integrated into an organization’s business management system
• Describe the contents of a ‘Master Plan’ for new product introduction, which includes an outline of the inputs and outputs of the various phases of the APQP process
• Explain how APQP leads to continual improvement for the organization and for customer satisfaction

Major topics include:
• What is APQP
• Purpose of APQP
• APQP Integration
• Developing a Master Plan for New Products
• APQP Benefits

Is this Course for You?

Participants in the Introduction to Advanced Product Quality Planning (APQP) on-demand course will gain a ‘common-sense’ perspective for successful new product launches and what needs to be done to comply with automotive customer specific requirements. Participants will also understand how to apply the concepts of ‘front-end’ planning (via the APQP process) that will result in continual improvement of products and services for both the customer and the supplying organization. This course is relevant to individuals with limited or general knowledge of the APQP process and some experience with introducing new products or new manufacturing processes.

What You Will Receive

• 90 days of online single-user access (from date of purchase) to the one hour presentation
• A printable summary of the key takeways from each lesson
• Integrated knowledge checks to reinforce key concepts
• Instructor follow-up to your content questions
• 0.1 CEUs/Certificate of Achievement (with satisfactory learning assessment score)

Instructor: Larry Bissell
Fee $90 .1 CEUs
Patent Litigation in the U.S.: What You Need to Know Web Seminar RePlay

4 Hours
I.D.# PD330940N

Web Seminar RePlays are captures of the live web seminar. The course sessions are unedited and include interactions between the instructor and live participants. A learning assessment is available at the end of the course to reinforce learning and retention and gauge your understanding of the topic.

In today's economic environment, patents have become an increasingly important asset for both individuals and corporations. More and more, individuals and corporations, including those in the automotive and aerospace industries, are recognizing the economic importance of patent rights, whether those rights consist of a single patent, a family of patents or an entire portfolio. Indeed, some companies do not make or sell products; their entire revenue is derived from the licensing of their patents. Suffice it to say, licensing revenue has become a significant source of value in the global intellectual property economy.

This course focuses on the intricacies of patents, patent infringement litigation, and patent licensing. Participants will explore the important subjects of obtaining U.S. and foreign patents, maintaining U.S. and foreign patent rights, enforcing patent rights, defending against patent rights asserted by competitors, and licensing patent rights for revenue. Upon completion, you will effectively understand patents and ways to protect and monetize your company's valuable inventions. Your new knowledge will help your company maintain and enhance its position in the an increasingly competitive marketplace.

Learning Objectives
By connecting with this course, participants will be able to:
• Explain U.S. patent rights, including how patents are obtained and maintained
• Provide an overview of U.S. patent litigation, including recent changes under the The Leahy-Smith America Invents Act (AIA)
• Anticipate the scope of discovery in and avoid the potential business disruption arising from a U.S. patent case
• Explain the basic legal principles for liability and damages in patent cases
• Describe how patent disputes are resolved
• Predict the fees and expenses associated with bringing and/or defending a patent case in the U.S.
• Peek into the future of potential patent law reform

Who Should Attend
This course is geared toward executives, in-house counsel, in-house patent agents, and senior managers across industries, including automotive and aerospace. Participants may be both U.S. and non-U.S.-- anyone who needs help in understanding what to expect and what the practical realities are should they become involved in U.S. patent litigation.

This course complements the Patent Litigation Risk Management Toolkit web seminar or Web Seminar RePlay, which provides practical guidance to help keep businesses out of patent infringement litigation.

Topical Outline
Session 1
• Overview of Patent Litigation
  • Recent headlines
  • Scope of patent protection
  • Issues the patent-owner has to prove
  • Issues the accused infringer has to prove
• What is the Scope of Discovery?
  • Documents, including e-documents
  • Depositions
  • Third parties (e.g. customers, suppliers)
  • Confidentiality of discovery materials
• Who Decides Liability and Damages?
  • Jury
  • Judge
  • Mediator/Arbitrator

Session 2
• How Long Does it Take from Filing to Trial?
  • District Courts
  • ITC
• How Much Does it Cost?
  • Fees and expenses
  • Contingency fees
  • Recovery of fees and expenses
• Practical Issues in Patent Licensing
  • Exclusivity considerations
  • Other permissible limitations
  • Royalty calculations
• What Changes are on the Horizon?
  • Supreme Court
  • Patent law reform

Instructor: William Cory Spence
Fee $425 .4 CEUs
Principles of ISO 9001, ISO/TS 16949, and AS9100

.35 Hours
I.D.# PD530824ON

This is a highly interactive on-demand course featuring video, demos, and knowledge checks designed to reinforce learning.

Understanding the purpose and intended use of standards, directives and requirements sets the foundation for developing a functional management system. This 35-minute, online short course is intended to present ISO 9001, ISO/TS 16949 and SAE AS9100 as purpose driven management systems that are necessary for companies to survive in our fast-moving economy.

The Principles of ISO 9001, ISO/TS 16949, and AS9100 on-demand course provides those in the automotive and aerospace industries with a high-level overview of these quality management system standards. It is designed to explore the history that lead to the development of the standards. The course also highlights the need for organizations to determine the necessary competence for personnel performing work affecting product quality, provide training or take other actions to satisfy these needs, evaluate the effectiveness of the actions taken, to ensure that personnel are aware of the relevance and importance of their activities and how they contribute to the achievement of the quality objectives, and maintain appropriate records of education, training, skills and experience.

A more in-depth on-demand option for the FMEA topic is in development. Contact Corporate Learning Solutions to discuss availability and learning options that best fit your need.

Learning Objectives
By participating in this on-demand course, students will be able to:
• Recognize the need for international, imposed quality management systems and standards
• Describe the history leading up to the ISO 9001
• Explain why the Automotive and Aerospace industries need specific supplements to the ISO 9001
• Identify key elements of a quality management system incorporated in the quality management standards, including configuration management and continuous improvement
• Describe the Plan, Do, Check, Act process and summarize how it can be applied to all processes to increase production and reduce waste
• Define key terms used with the quality standards and summarize key elements included in sections 1-10 of ISO 9001:2015

Major topics include:
• The Cost of Poor Quality
• History and Development of the ISO 9001, ISO/TS 16949 and AS9100
• Quality Management System Principles and the Process Approach
• Terms and Definitions
• Overview of the Sections in ISO 9001:2015

Is this On-Demand Course for you?
In all three standards, paragraph 6.2.2 states the need for competence, awareness and training. Management and personnel in all departments from sales and marketing to engineering, purchasing, production, customer service, receiving, packaging, storage, shipping, and beyond will benefit from the purpose driven management systems that are necessary to deliver customer satisfaction and survive in the global economy.

What You Will Receive
• 90 days of on line, on-demand single-user access to the .35 hour course
• A printable summary of the key takeaways from each lesson
• Integrated knowledge checks to reinforce key concepts
• Instructor follow-up to your content questions
• Proof of Participation

Instructor: Joseph Sorrentino
Fee $60 There are no CEUs offered for this course.

Explained Web Seminar RePlay

4 Hours
I.D.# PD331617ON

Web Seminar RePlays are captures of the live web seminar. The course sessions are unedited and include interactions between the instructor and live participants. A learning assessment is available at the end of the course to reinforce learning and retention and gauge your understanding of the topic.

In a global economy, aviation, space and defense organizations are presented the challenge of producing and delivering safe and reliable products across a wide range of customer requirements and expectations. In an effort to address diverse quality requirements and expectations while also reducing costs throughout the supply chain, the SAE AS9100 family of standards was developed by international aerospace industry representatives to standardize international aerospace quality management system requirements.
This on-demand course offers insights into the SAE AS9100D:2016 and ISO 9001:2015 significant changes as they adopt the common management system structure. It will include material on the standard's development process including timelines, new Common Management System Structure, AS9100D:2016 and ISO 9001:2015 Requirement Review and reference material for gap analysis and successful implementation.

**Learning Objectives**

Upon completion, the participant should be able to:
- Recognize the impact to new Quality Management Principles on the revision to the standards
- De-mystify the new 10-clause Common Management System structure and understand the impact on your organization
- Grasp the new language like organization and its context, interested parties, documented information, and risk-based thinking
- Realize the Aviation, Space & Defense proposed additions to understand benefits
- Gain an understanding of the SAE AS9100D:2016 and ISO 9001:2015 requirements and intent
- Define the timeline for AS9100D:2016 transition period

**Is this Course for You?**

The course is designed for quality managers, management representatives, auditors, engineers, supply chain managers and other professionals. AQMS Implementers will comprehend SAE AS9100D:2016 requirements for application at your organization. AQMS Internal Consultants will understand the intent to apply value-added implementation of the requirement. AQMS Auditors will comprehend requirements to confidently audit requirements at your organization. AQMS Executives and Management Representatives will better understand how to use AS9100D:2016 requirements to drive cost savings improvement. Individuals wanting an improved AQMS process understanding to integrate AS9100D:2016 requirements into company processes will also benefit.

**Topical Outline**

- Standards Development Process
- New Common Management System Structure and Language
  - Introduction of additions to the standard
  - Impact of new AS9100D and ISO 9001:2015 requirements to your business
  - Context of the Organization
  - Leadership
  - Planning
  - Support
  - Session 2

- Operation
- Performance Evaluation
- Improvement
- Summary
- Techniques to ensure the QMS is effective in meeting customer expectations
- Reference resources for gap analysis and successful implementation

**Instructor:** Buddy Cressionnie  
**Fee:** $425  
**.4 CEUs**

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**Good Laboratory Practices (GLP) Training – CALISO On-Demand Course**

8 Hours  
I.D.# GLP

GLP refers to a Quality Systems of management controls for laboratories and research organizations to ensure the consistency and reliability and reproducibility of results. The original regulatory enforcement was first published by FDA and then a few years later by EPA. It is also outlined in the Organization for Economic Co-operation and Development (OECD) Principles of GLP in 1992 and has since been added to many national regulations. Your company, and all who partake in the daily activities of running a laboratory or a research and testing center, will benefit from this course. This 8-hour GLP (.8 CEU) overview is particularly adapted for training all levels of an organization on the requirements of this standard.

**Major topics include:**

- Scope
- Definitions
- Inspection of a testing facility
- Personnel
- Testing facility management
- Quality assurance unit
- General
- Animal care facilities
ON DEMAND COURSES RESOURCE GUIDE

This SAE/CALISO course is for you if you:
• Want to quickly and efficiently get a comprehensive training of GOOD LABORATORY PRACTICES (GLP)
• Want to improve your CV and career opportunities with qualifications in quality assurance
This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $195.95 0.8 CEUs

ISO 9001 Overview – CALISO On-Demand Course
4 Hours
I.D.# ISO9001OVIEW

ISO 9001 is a quality management standard developed by the International Organization for Standardization (ISO). The ISO 9001 standard is generic and can be used for any organization, whether it provides physical products or services. The requirements must be carefully interpreted to make sense within a particular organization. Developing automotive products is not like producing food products or offering consulting services; yet the ISO 9001 standard, because it is business and management oriented, can be applied to any activity. It is the most widely used quality management standard in the world. This four-hour ISO 9001 overview is particularly adapted for training top management on the high level requirements.

Major topics include:
• General Requirements of ISO 9001
• Management Responsibility
• Resource Management
• Product Realization (summary)
• Measurement, Analysis and Improvement

This SAE/CALISO course is for you if you:
• Want to quickly and efficiently get a comprehensive training of ISO 9001:2008
• Want to improve your CV and career opportunities with qualifications in quality assurance
• Want to upgrade your expertise from auditing ISO 9001:2000 to ISO 9001:2008
This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $195.95 0.8 CEUs

ISO 9001:2008 Training – CALISO On-Demand Course
8 Hours
I.D.# ISO9001TRAINING

ISO 9001 is a quality management standard developed by the International Organization for Standardization (ISO). Your company and all who partake in the daily activities of running the business will benefit from taking ISO 9001 training. This eight-hour ISO 9001 (.8 CEU) overview is particularly adapted for training all levels of an organization on the requirements of this standard.

Major topics include:
• General Requirements of ISO 9001
• ISO 9001 Vocabulary
• Management Responsibility
• Resource Management
• Product Realization
• Measurement, Analysis and Improvement

This SAE/CALISO course is for you if you:
• Want to quickly and efficiently get a comprehensive training of ISO 9001:2008
• Want to improve your CV and career opportunities with qualifications in quality assurance
• Want to upgrade your expertise from ISO 9001:2000 to ISO 9001:2008
This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $229.95 0.8 CEUs

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• Fill out the online quote request at sae.org/corplearning • Email us at Corplearn@sae.org
ISO 9001:2008 Auditor Training – CALISO On-Demand Course

8 Hours
I.D.# ISO9001AUDITOR

ISO 9001 is a quality management standard developed by the International Organization for Standardization (ISO). Your company and all who partake in the daily activities of running the business will benefit from taking ISO 9001 training. The eight-hour (.8 CEU) ISO 9001 Auditor course provides training on the standard itself and on how to lead or conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Major topics include:
- General Requirements of ISO 19011
- Auditing techniques
- QMS Auditing Case Studies

This SAE/CALISO course is for you if you:
- Want to quickly and efficiently learn how to lead an ISO 9001:2008 audit
- Want to quickly and efficiently be trained on ISO 9001 (the standard), and ISO 9000 (the vocabulary for the standard)
- Want to be a lead auditor to conduct internal audits and supplier audits for your company
- Want to improve your CV and career opportunities with qualifications in quality assurance and leading 1st part audits
- Want to upgrade your expertise from auditing ISO 10011-1 to ISO 19011:2002

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and ongoing quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $249.95  0.8 CEUs

ISO 9001:2008 Lead Auditor – CALISO On-Demand Course

22 Hours
I.D.# ISO9001LEADAUDITOR

As described in the previous ISO 9001 Overview description, ISO 9001 is a quality management standard developed by the International Organization for Standardization (ISO). Your company and all who partake in planning, leading and conducting the audit activities of running the business will benefit from taking ISO 14001 Auditor training. The 22-hour (2.2 CEU) ISO 9001 Auditor course provides training on the standard itself and on how to lead or conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Major topics include:
- General Requirements of ISO 9001
- Management Responsibility
- Resource Management
- Product Realization
- Measurement, Analysis and Improvement
- General Requirements of ISO 19011
- Auditing techniques
- QMS Auditing Case Studies

This SAE/CALISO course is for you if you:
- Want to quickly and efficiently learn how to conduct an ISO 9001:2008 audit
- Want to quickly and efficiently be trained on ISO 9001 (the standard), and ISO 9000 (the vocabulary for the standard)
- Want to conduct internal audits and supplier audits for your company
- Want to improve your CV and career opportunities with qualifications in quality assurance and leading 1st part audits
- Want to upgrade your expertise from auditing with ISO 10011-1 to ISO 19011:2002

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and ongoing quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $355.95  2.2 CEUs
ISO 9001:2015 Overview – CALISO
On-Demand Course

4 Hours
I.D.# ISO-9001-2015-OVERVIEW

ISO 9001:2015 is a quality management standard developed by the International Organization for Standardization (ISO). The ISO 9001:2015 standard is generic and can be used for any organization, whether it provides physical products or services. The requirements must be carefully interpreted to make sense within a particular organization. Developing automotive products is not like producing food products or offering consulting services; yet the ISO 9001:2015 standard, because it is business and management oriented can be applied to any activity. It is the most widely used quality management standard in the world.

Major topics include:
• Process Approach
• Risk-based Thinking
• General Requirements of ISO 9001:2015
• Context of the organization
• Leadership
• Planning
• Support
• Performance Evaluation
• Improvement

This SAE/CALISO course is for you if you:
• Want to quickly and efficiently get a comprehensive overview of ISO 9001:2015
• Want to improve your CV and career opportunities with qualifications in ISO 9001
• Want to upgrade your expertise from auditing ISO 9001:2008 to ISO 9001:2015
• Do NOT have time to allocate a full day to take an ISO 9001:2015 overview class
• Want to train more of your staff on auditing economically and without having to immobilize them in a class for a full day

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos at certain stages of the course delivery, and on-going quizzes are incorporated throughout the course to reinforce learning and retention and gauge your understanding of a topic before you move forward. Convenient and portable, this course provides instruction without the expense of travel and time away from the workplace. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes, or in a final exam provided for trainees with a score inferior of 70%. You can take this course using a laptop or PC with an internet connection, at your own pace, and at times convenient to you.

Fee: $199.95 0.4 CEUs

ISO 9001:2015 Training – CALISO
On-Demand Course

10 Hours
I.D.# ISO9001TRAINING

ISO 9001:2015 is a quality management standard developed by the International Organization for Standardization (ISO). The ISO 9001:2015 standard is generic and can be used for any organization, whether it provides physical products or services. The requirements must be carefully interpreted to make sense within a particular organization. Developing automotive products is not like producing food products or offering consulting services; yet the ISO 9001:2015 standard, because it is business and management oriented can be applied to any activity. It is the most widely used quality management standard in the world.

Major topics include:
• Process Approach
• Risk-based Thinking
• General Requirements of ISO 9001:2015
• Section 4. Context of the organization
• Section 5. Leadership
• Section 6. Planning
• Section 7. Support
• Section 9. Performance Evaluation
• Section 10. Improvement

This SAE/CALISO course is for you if you:
• Want to quickly and efficiently get a comprehensive training of ISO 9001:2015
• Want to improve your CV and career opportunities with qualifications in quality assurance
• Want to upgrade your expertise from ISO 9001:2008 to ISO 9001:2015
• Do NOT have time to allocate a 2 full days to take an ISO 9001:2015 class
• Want to train more of your staff on auditing economically and without having to immobilize them in a class for a full day
This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos at certain stages of the course delivery, and on-going quizzes are incorporated throughout the course to reinforce learning and retention and gauge your understanding of a topic before you move forward. Convenient and portable, this course provides instruction without the expense of travel and time away from the workplace. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes, or in a final exam provided for trainees with a score inferior of 70%. You can take this course using a laptop or PC with an internet connection, at your own pace, and at times convenient to you.

Fee: $289.95 0.8 CEUs

ISO 9001:2015 Auditor Training – CALISO On-Demand Course

1.8 Hours
I.D.# ISO-9001-2015-AUDITOR

ISO 9001:2015 is a quality management standard developed by the International Organization for Standardization (ISO). The ISO 9001:2015 standard is generic and can be used for any organization, whether it provides physical products or services. The requirements must be carefully interpreted to make sense within a particular organization. Developing automotive products is not like producing food products or offering consulting services; yet the ISO 9001:2015 standard, because it is business and management oriented can be applied to any activity. It is the most widely used quality management standard in the world.

Major topics include:
• General Requirements of ISO 19011
• Auditing techniques
• QMS Auditing Case Studies

This SAE/CALISO course is for you if you:
• Want to quickly and efficiently learn how to lead an ISO 9001:2015 audit
• Want to quickly and efficiently be trained on ISO 9001:2015 (the standard), and ISO 9000 (the vocabulary for the standard)
• Want to be a lead auditor to conduct internal audits and supplier audits for your company
• Want improve your CV and career opportunities with qualifications in quality assurance and leading first part audits
• Want to upgrade your expertise from auditing ISO 9001:2008 to ISO 9001:2015

Fee: $319.95 0.8 CEUs

ISO 9001:2015 Lead Auditor – CALISO On-Demand Course

32 Hours
I.D.# ISO 9001-2015-LEAD-AUDITOR

ISO 9001:2015 is a quality management standard developed by the International Organization for Standardization (ISO). The ISO 9001:2015 standard is generic and can be used for any organization, whether it provides physical products or services. The requirements must be carefully interpreted to make sense within a particular organization. Developing automotive products is not like producing food products or offering consulting services; yet the ISO 9001:2015 standard, because it is business and management oriented can be applied to any activity. It is the most widely used quality management standard in the world.

Major topics include:
• General Requirements of ISO 9001:2015
• Management Responsibility
• Resource Management
• Product Realization
• Measurement, Analysis and Improvement
• General Requirements of ISO 19011
• Auditing techniques
• QMS Auditing Case Studies
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This SAE/CALISO course is for you if you:

• Want to quickly and efficiently learn how to conduct an ISO 9001:2015 audit
• Want to quickly and efficiently be trained on ISO 9001:2015 (the standard), and ISO 9000 (the vocabulary for the standard)
• Want to conduct internal audits and supplier audits for your company
• Want improve your CV and career opportunities with qualifications in quality assurance and leading 1st part audits
• Do NOT have time to allocate a 2-5 days to take an ISO 9001:2015 Lead Auditor class
• Want to train more of your staff on auditing economically and without having to immobilize them in a class for a full day

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos at certain stages of the course delivery, and on-going quizzes are incorporated throughout the course to reinforce learning and retention and gauge your understanding of a topic before you move forward. Convenient and portable, this course provides instruction without the expense of travel and time away from the workplace. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes, or in a final exam provided for trainees with a score inferior of 70%. You can take this course using a laptop or PC with an internet connection, at your own pace, and at times convenient to you.

Fee: $399.95  2.2 CEUs

ISO 14001:2004 Training – CALISO
On-Demand Course
8 Hours
I.D.#ISO14001

ISO 14001 is an environmental management standard (EMS) developed by the International Organization for Standardization (ISO). The ISO 14001 standard is generic and can be used for any organization, whether it provides physical products or services. The requirements must be carefully interpreted to make sense within a particular organization. Developing automotive products and the environmental impact of this activity is not like producing food products or offering consulting services; yet the ISO 14001 standard, because it is business and management oriented can be applied to any activity. It is the most widely used EMS standard in the world.

Your company and all who partake in the daily activities of running the business will benefit from taking ISO 14001 training. This eight-hour ISO 14001 (.8 CEU) overview is particularly adapted for all members of the organization.

Major topics include:
• General Requirements of ISO 14001
• ISO 14001 Vocabulary
• Environmental Policy
• Planning
• Implementation and Operation
• Checking
• Management Review

This SAE/CALISO course is for you if you:

• Want to quickly and efficiently get a comprehensive training of ISO 14001:2004
• Want to improve your CV and career opportunities with qualifications in EMS
• Do NOT have time to allocate two full days to take an environmental management class
• Want to train more of your staff on auditing economically and without having to immobilize them in a class for a full day

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $219.95  0.8 CEUs

ISO 14001:2004 Auditor Training – CALISO
On-Demand Course
8 Hours
I.D.#ISO14001AUDITOR

ISO 14001 is an environmental management standard (EMS) developed by the International Organization for Standardization (ISO). The ISO 14001 standard is generic and can be used for any organization, whether it provides physical products or services. The requirements must be carefully interpreted to make sense within a particular organization. Developing automotive products and the environmental impact of this activity is not like producing food products or offering consulting services; yet the ISO 14001 standard, because it is business and management oriented can be applied to any activity. It is the most widely used

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EMS standard in the world. Your company and all who partake in the daily activities of running the business will benefit from taking ISO 14001 training. This eight-hour (.8 CEU) ISO 14001 Auditor course provides training on the standards and how to conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Major topics include:
• General Requirements of ISO 19011
• Auditing Techniques
• EMS Auditing Case Studies

This SAE/CALISO course is for you if you:
• Want to quickly and efficiently learn how to lead an ISO 14001:2004 audit
• Want to quickly and efficiently be trained on ISO 14001 (the standard) and ISO 14000 (the vocabulary for the standard)
• Want to be a lead auditor to conduct internal audits and supplier audits for your company
• Want to improve your CV and career opportunities with qualifications in EMS and leading first and second party audits
• Want to upgrade your expertise from auditing with ISO 10011-1 to ISO 19011:2002
• Do NOT have time to allocate two full days to take an ISO 14001 auditor class
• Want to train more of your staff on auditing economically and without having to immobilize them in a class for a full day

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $249.95  .8 CEUs

ISO 14001:2004 Lead Auditor – CALISO On-Demand Course

22 Hours
I.D.#ISO14001LEADAUDITOR

As described in the previous ISO 14001 course description, ISO 14001 is an environmental management standard (EMS) developed by the International Organization for Standardization (ISO). Your company and all who partake in planning, leading and conducting the EMS audit activities of your business and managing its environmental program will benefit from taking ISO 14001 training. The 22-hour (2.2 CEU) ISO 14001 Lead Auditor course is the most comprehensive training on the subject. It provides training on the standard itself but also on how to lead or conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Major topics include:
• General Requirements of ISO 14001
• ISO 14001 Vocabulary
• Environmental Policy
• Planning
• Implementation and Operation
• Checking
• Management Review
• General Requirements of ISO 19011
• Auditing Techniques
• EMS Auditing Case Studies

This SAE/CALISO course is for you if you:
• Want to quickly and efficiently learn how to lead an ISO 14001:2004 audit
• Want to quickly and efficiently be trained on ISO 14001 (the standard), and ISO 14000 (the vocabulary for the standard)
• Want to be a lead auditor to conduct internal audits and supplier audits for your company
• Want to improve your CV and career opportunities with qualifications in EMS and leading first part and second party audits
• Want to upgrade your expertise from auditing with ISO 10011-1 to ISO 19011:2002

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $319.95  2.2 CEUs

ISO 14001:2015 Overview – CALISO On-Demand Course

4 Hours
I.D.#ISO-14001-2015-OVERVIEW

ISO 14001:2015 is an environmental management standard (EMS) developed by the International Organization for Standardization (ISO). The ISO 14001 standard is generic and can be used for any organization, whether it provides physical products or services. The requirements must be carefully interpreted to make sense within a particular organization. Developing automotive products and the
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environmental impact of this activity is not like producing food products or offering consulting services; yet the ISO 14001 standard, because it is business and management oriented can be applied to any activity. It is the most widely used EMS standard in the world.

Your company and all who partake in the daily business activities will benefit from taking ISO 14001:2015 training. This overview course is particularly adapted for training top management on the high level requirements of this standard.

Major topics include:
• General Requirements of ISO 14001:2015
• Section 4. Context of the organization
• Section 5. Leadership
• Section 6. Planning
• Section 7. Support
• Section 9. Performance Evaluation
• Section 10. Improvement

This SAE/CALISO course is for you if you:
• Want to quickly and efficiently get a comprehensive overview of ISO 14001:2015
• Want to improve your CV and career opportunities with qualifications in ISO 14001
• Want to upgrade your expertise from auditing ISO 14001:2008 to ISO 14001:2015
• Do NOT have time to allocate a full day to take an ISO 14001:2015 overview class
• Want to train more of your staff on auditing economically and without having to immobilize them in a class for a full day

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $189.95 .4 CEUs

ISO 14001:2015 Training – CALISO On-Demand Course

10 Hours
I.D. #ISO14001TRAINING

ISO 14001:2015 is an environmental management standard (EMS) developed by the International Organization for Standardization (ISO). The ISO 14001 standard is generic and can be used for any organization, whether it provides physical products or services. The requirements must be carefully interpreted to make sense within a particular organization. Developing automotive products and the environmental impact of this activity is not like producing food products or offering consulting services; yet the ISO 14001 standard, because it is business and management oriented can be applied to any activity. It is the most widely used EMS standard in the world.

Your company and all who partake in the daily activities of running the business will benefit from taking ISO 14001 training. This course is particularly adapted for all members of the organization.

Major topics include:
• General Requirements of ISO 14001
• ISO 14001 Vocabulary
• Environmental Policy
• Planning
• Implementation and Operation
• Checking
• Management Review

This SAE/CALISO course is for you if you:
• Want to quickly and efficiently get a comprehensive training of ISO 14001:2015
• Want to improve your CV and career opportunities with qualifications in EMS
• Do NOT have time to allocate two full days to take an environmental management class
• Want to train more of your staff on auditing economically and without having to immobilize them in a class for a full day

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $289.95 1.0 CEUs

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ISO 14001:2015 Auditor Training – CALISO
On-Demand Course

12 Hours
I.D.#ISO-14001-2015-AUDITOR

ISO 14001:2015 is an environmental management standard (EMS) developed by the International Organization for Standardization (ISO). The ISO 14001 standard is generic and can be used for any organization, whether it provides physical products or services. The requirements must be carefully interpreted to make sense within a particular organization. Developing automotive products and the environmental impact of this activity is not like producing food products or offering consulting services; yet the ISO 14001 standard, because it is business and management oriented can be applied to any activity. It is the most widely used EMS.

Your company and all who partake in the audit activities of your business and managing its environmental program will benefit from taking ISO 14001 training. The ISO 14001 Auditor course is the most comprehensive training on the subject. It provides training on the standard itself but also on how to conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Major topics include:
• General Requirements of ISO 114001
• Auditing techniques
• EMS Auditing Case Studies

This SAE/CALISO course is for you if you:
• Want to quickly and efficiently learn how to lead an ISO 14001:2015 audit
• Want to quickly and efficiently be trained on ISO 14001 (the standard), and ISO 14000 (the vocabulary for the standard)
• Want to be a lead auditor to conduct internal audits and supplier audits for your company
• Want to improve your CV and career opportunities with qualifications in EMS and leading first part and second party audits
• Want to upgrade your expertise from auditing with 19011:2002 to ISO 19011:2011
• Do NOT have time to allocate two days to take an ISO 14001 auditor class
• Want to train more of your staff on auditing economically and without having to immobilize them in a class for a full day

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $309.95 1.2 CEUs

ISO 14001:2015 Lead Auditor – CALISO
On-Demand Course

32 Hours
I.D.#ISO 14001-2015-LEAD-AUDITOR-TRAINING

ISO 14001:2015 is an environmental management standard (EMS) developed by the International Organization for Standardization (ISO). The ISO 14001 standard is generic and can be used for any organization, whether it provides physical products or services. The requirements must be carefully interpreted to make sense within a particular organization. Developing automotive products and the environmental impact of this activity is not like producing food products or offering consulting services; yet the ISO 14001 standard, because it is business and management oriented can be applied to any activity. It is the most widely used EMS.

Your company and all who partake in planning, leading and conducting the EMS audit activities of your business and managing its environmental program will benefit from taking ISO 14001 training. The ISO 14001 Lead Auditor course is the most comprehensive training on the subject. It provides training on the standard itself but also on how to lead or conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Major topics include:
• General Requirements of ISO 14001:2015
• ISO 14001 Vocabulary
• Environmental Policy
• Planning
• Implementation and Operation
• Checking
• Management Review
• General Requirements of ISO 19011
• Auditing Techniques

This SAE/CALISO course is for you if you:
• Want to quickly and efficiently learn how to lead an ISO 14001:2015 audit
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• Want to quickly and efficiently be trained on ISO 14001 (the standard), and ISO 14000 (the vocabulary for the standard)
• Want to be a lead auditor to conduct internal audits and supplier audits for your company
• Want to improve your CV and career opportunities with qualifications in EMS and leading first part and second party audits
• Want to upgrade your expertise from auditing with ISO 19011:2002 to ISO 19011:2011
• Do NOT have time to allocate four days to take an ISO 14001 Lead Auditor class
• Want to train more of your staff on auditing economically and without having to immobilize them in a class for a full day

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $389.95  3.2 CEUs

This SAE/CALISO course is for you if you:
• Want to quickly and efficiently get a comprehensive training of ISO 16949:2009
• Want to improve your CV and career opportunities with qualifications in quality assurance
• Want to upgrade your expertise from QS 9000 to ISO 16949:2009

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $229.95  0.8 CEUs

ISO/TS 16949:2009 Training – CALISO On-Demand Course

8 Hours
I.D.# ISO16949

The ISO/TS16949 is an ISO technical specification for the automotive industry aiming to the development of a quality management system that provides for continual improvement, emphasizing defect prevention and the reduction of variation and waste in the supply chain. The requirements must be carefully interpreted to make sense within a particular organization.

Your company and all who partake in the daily activities of running the business will benefit from taking ISO/TS 16949 training. This eight-hour ISO/TS 16949 (.8 CEU) overview is particularly adapted for training all levels of an organization on the requirements of this standard.

Major topics include:
• General Requirements of ISO 16949
• ISO 16949 Vocabulary
• Management Responsibility
• Resource Management
• Product Realization
• Measurement, Analysis and Improvement

This SAE/CALISO course is for you if you:
• Want to quickly and efficiently learn how to lead an ISO/TS 16949:2009 audit
• Want to quickly and efficiently be trained on ISO/TS 16949 (the standard), and ISO 9000 (the vocabulary for the standard)
• Want to be a lead auditor to conduct internal audits and supplier audits for your company

ISO/TS 16949:2009 Auditor Training – CALISO On-Demand Course

8 Hours
I.D.# ISO16949AUDITOR

The ISO/TS16949 is an ISO technical specification for the automotive industry aiming to the development of a quality management system that provides for continual improvement, emphasizing defect prevention and the reduction of variation and waste in the supply chain. The requirements must be carefully interpreted to make sense within a particular organization.

Your company and all who partake in the QMS and supplier audit activities will benefit from taking ISO/TS 16949 training. The eight-hour (.8 CEU) ISO/TS 16949 Auditor course is the most comprehensive training on the subject. It provides training on the standard itself but also on how to lead or conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Major topics include:
• General Requirements of ISO 19011
• Auditing techniques
• QMS Automotive Auditing Case Studies

This SAE/CALISO course is for you if you:
• Want to quickly and efficiently get a comprehensive training of ISO 16949:2009
• Want to improve your CV and career opportunities with qualifications in quality assurance
• Want to upgrade your expertise from QS 9000 to ISO 16949:2009

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $229.95  0.8 CEUs

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• Want to improve your CV and career opportunities with qualifications in quality assurance and leading 1st part audits
• Want to upgrade your expertise from auditing QS 9000 to ISO/TS 16949:2009
• Want to upgrade your expertise from auditing with ISO 10011-1 to ISO 19011:2002

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $259.95 0.8 CEU

ISO/TS 16949:2009 Lead Auditor Training – CALISO On-Demand Course

22 Hours
I.D.# TS16949LEADAUDITOR

The ISO/TS16949 is an ISO technical specification which forms the requirements or application of ISO 9001 for automotive production and relevant service part organizations. It is essentially ISO 9001 with additional automotive specific requirements and is require by most major automotive manufacturers. Once your company implements processes and procedures that comply with the requirements listed in ISO/TS 16949, you can be audited by a third party organization called a Registrar, which will certify your organization to this standard.

This lead auditor course provides management representatives, QA managers or supervisors and others not only the information needed to conduct an audit for ISO/TS 16949, but also to organize, implement and lead it. All audit teams need a leader, and the body of knowledge of this course covers all of the lead auditing aspects.

Major topics include:
• Statistical Process Control (SPC)
• APQP/CP: Advanced Product Quality Planning and Control Plans
• PPAP: Product Part Approval Process FMEA: Failure Mode and Effects Analysis
• MSA: Measurement Systems Analysis

This SAE/CALISO course is for you if you:
• Want to quickly and efficiently learn how to lead an ISO/TS 16949:2009 audit

Fee: $369.95 2.2 CEUs

ISO 19011:2011 Auditor Training – CALISO On-Demand Course

4 Hours
I.D.#ISO19

ISO 19011 is a guideline developed by the International Organization for Standardization (ISO). The ISO 19011 standard is generic and can be used for auditing any type of management standard: quality, environmental, health and safety and others. Your company and all who partake in the daily activities of running the business will benefit from taking ISO 19011 training for its auditing activities. The four-hour (.4 CEU) ISO 19011 course is the most comprehensive training on the subject. It provides training on the standard itself but also on how to lead or conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Major topics include:
• General Requirements of ISO 19011
• Auditing techniques
• Auditing Case Studies

This SAE/CALISO course is for you if you:
• Want to quickly and efficiently learn how to audit management systems
• Want to be a lead auditor to conduct internal audits and supplier audits for your company
• Want to improve your CV and career opportunities with qualifications in quality assurance and leading 1st part audits
• Want to upgrade your expertise from auditing with ISO 19011 to ISO 19011:2002
ON DEMAND COURSES RESOURCE GUIDE

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $199.95 | .4 CEUs

AS9100D Overview – CALISO On-Demand Course

4 Hours
I.D.# AS9100D-Overview

AS9100D is a quality management standard developed by SAE International. The AS9100D standard is primarily applicable for the aviation, space, and defense industry and incorporates the new clause structure and content of ISO 9001:2015. This standard can also be used in other industry sectors when a quality management system with additional requirements over an ISO 9001 system is needed.

Your company and all who partake in the daily business activities will benefit from taking AS9100D training. This four hour AS9100D overview is particularly adapted for training top management on the high level requirements of this standard.

Participants who complete this course will be able to:

- Understand the high level requirements and intent of this international standard
- Understand the process approach to managing an organization
- Understand how the requirements can be interpreted should be implemented within an organization

Major topics include:

- Process Approach
- Risk-based Thinking
- General Requirements of AS9100D
  - Context of the organization
  - Leadership
  - Planning
  - Support
  - Performance Evaluation
  - Improvement

This SAE/CALISO course is for you if you:

- Want to quickly and efficiently get a comprehensive overview of AS9100D
- Want to improve your CV and career opportunities with qualifications in AS9100D
- Want to upgrade your expertise from auditing AS9100C to AS9100D
- Do NOT have time to allocate a full day to take an AS9100D overview class
- Want to train more of your staff on auditing economically and without having to immobilize them in a class for a full day

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $199.95

AS9100D Training – CALISO On-Demand Course

10 Hours
I.D.# AS9100D

AS9100D is a quality management standard developed by SAE International. The AS9100D standard is primarily applicable for the aviation, space, and defense industry and incorporates the new clause structure and content of ISO 9001:2015. This standard can also be used in other industry sectors when a quality management system with additional requirements over an ISO 9001 system is needed.

Your company and all who partake in the daily activities of running the business will benefit from taking AS9100D training. This 10-hour AS9100D course is particularly adapted for training all levels of an organization on ALL the requirements of this standard.

This standard includes ISO 9001:2015 quality management system requirements and specifies additional aviation, space, and defense industry requirements, definitions, and notes as shown in bold, italic text.

Your company and all who partake in the daily activities of running the business will benefit from taking AS9100D training. This 10-hour AS9100D course is particularly adapted for training all levels of an organization on ALL the requirements of this standard.
ON DEMAND COURSES RESOURCE GUIDE

Participants who complete this course will be able to:
• Understand the high specific requirements and intent of this international standard.
• Understand the process approach to managing an organization and risk-management requirements.
• Understand how the requirements can be interpreted should be implemented within an organization

Major topics include:
• Process Approach
• Risk-based Thinking
• General Requirements of AS9100D
  • Context of the organization
  • Leadership
  • Planning
  • Support
  • Performance Evaluation

Improvement This SAE/CALISO course is for you if you:
• Want to quickly and efficiently get a comprehensive training of AS9100D
• Want to improve your CV and career opportunities with qualifications in quality assurance
• Want to upgrade your expertise from AS9100C to AS9100D
• Do NOT have time to allocate a 2 full days to take an AS9100D class
• Want to train more of your staff on auditing economically and without having to immobilize them in a class for a full day

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $289.95

AS9100D Auditor Training – CALISO On-Demand Course
18 Hours
I.D.# AS9100D-Auditor

AS9100D is a quality management standard developed by SAE International. The AS9100D standard is primarily applicable for the aviation, space, and defense industry and incorporates the new clause structure and content of ISO 9001:2015. This standard can also be used in other industry sectors when a quality management system with additional requirements over an ISO 9001 system is needed.

This standard includes ISO 9001:2015 quality management system requirements and specifies additional aviation, space, and defense industry requirements, definitions, and notes as shown in bold, italic text.

Your company and all who partake in the daily activities of running the business will benefit from taking AS9100D auditor training. The 18-hour Auditor online course is the most effective training on the subject. It provides training on how to conduct internal audits and supplier audits using ISO 19011, the guideline on how to audit management systems, and covers auditing all the requirements of the standard through various case studies.

Participants who complete this course will be able to:
• Master the auditing techniques per ISO 19011, which are used for quality, environmental, and safety management system audits
• Learn how to prepare and conduct an audit
• Be exposed to real auditing case studies covering many industries

Major topics include:
• General Requirements of ISO 19011
• Auditing techniques
• AS9100D Auditing Case Studies

This SAE/CALISO course is for you if you:
• Want to quickly and efficiently learn how to lead an AS9100D audit
• Want to quickly and efficiently be trained on AS9100D (the standard), and ISO 9001:2015.
• Want to be a lead auditor to conduct internal audits and supplier audits for your company
• Want improve your CV and career opportunities with qualifications in quality assurance and leading first part audits
• Want to upgrade your expertise from auditing AS9100C to AS9100D
ON DEMAND COURSES RESOURCE GUIDE

- Want to upgrade your expertise from auditing with ISO 10011-1 to ISO 19011:2011
- Do NOT have time to allocate 2 days to take an AS9100D auditor class
- Want to train more of your staff on auditing economically and without having to immobilize them in a class for 2 days

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $319.95

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AS9100D Lead Auditor Training – CALISO On-Demand Course

32 Hours
I.D.# AS9100D-Lead-Auditor

AS9100D is a quality management standard developed by SAE International. The AS9100D standard is primarily applicable for the aviation, space, and defense industry and incorporates the new clause structure and content of ISO 9001:2015. This standard can also be used in other industry sectors where a quality management system with additional requirements over an ISO 9001 system is needed.

This standard includes ISO 9001:2015 quality management system requirements and specifies additional aviation, space, and defense industry requirements, definitions, and notes as shown in bold, italic text.

Your company and all who partake in planning, leading and conducting the audit activities of running the business will benefit from taking AS9100D Lead Auditor training. The 32-hour AS9100D Auditor course is the most comprehensive training on the subject. It provides training on the standard itself but also on how to lead or conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Participants who complete this course will be able to:
- Understand every requirement of this international standard
- Understand the process approach to managing an organization

Fee: $399.95

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AS9100D Lead Auditor Training – CALISO On-Demand Course

32 Hours
I.D.# AS9100D-Lead-Auditor

AS9100D is a quality management standard developed by SAE International. The AS9100D standard is primarily applicable for the aviation, space, and defense industry and incorporates the new clause structure and content of ISO 9001:2015. This standard can also be used in other industry sectors where a quality management system with additional requirements over an ISO 9001 system is needed.

This standard includes ISO 9001:2015 quality management system requirements and specifies additional aviation, space, and defense industry requirements, definitions, and notes as shown in bold, italic text.

Your company and all who partake in planning, leading and conducting the audit activities of running the business will benefit from taking AS9100D Lead Auditor training. The 32-hour AS9100D Auditor course is the most comprehensive training on the subject. It provides training on the standard itself but also on how to lead or conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Participants who complete this course will be able to:
- Understand every requirement of this international standard
- Understand the process approach to managing an organization
- Understand how the requirements can be interpreted and implemented in various industries
- Master the auditing techniques per ISO 19011, which are used for quality, environmental, and safety management system audits
- Learn how to prepare and lead an audit
- Be exposed to real auditing case studies covering many industries

Major topics include:
- General Requirements of AS9100D
  - Context of the organization
  - Leadership
  - Planning
  - Support
  - Operation
  - Performance Evaluation
  - Improvement
  - General Requirements of ISO 19011
  - Auditing techniques
  - AS9100D Auditing Case Studies

This SAE/CALISO course is for you if you:
- Want to quickly and efficiently learn how to conduct an AS9100D audit
- Want to quickly and efficiently be trained on AS9100D (the standard), and ISO 9001:2015
- Want to conduct internal audits and supplier audits for your company
- Want improve your CV and career opportunities with qualifications in quality assurance and leading 1st part audits
- Want to upgrade your expertise from auditing with ISO 10011-1 to ISO 19011:2011
- Do NOT have time to allocate a 3-5 days to take an AS9100D Lead Auditor class
- Want to train more of your staff on auditing economically and without having to immobilize them in a class for a full day

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $399.95
**Six Sigma Overview – CALISO**

**On-Demand Course**

8 Hours  
I.D.#SIGMA

Six-Sigma is a systematic way to improve a product, process and/or service. This is the ideal course for employees or managers who want to get a basic training on Six-Sigma concepts, methodology and techniques.

Six-Sigma methodology can be used for any size organization, whether it provides physical products (i.e. hardware or software) or services. Developing and maintaining profitable products and services require continuous improvement in numerous key areas such as quality, performance and efficiency. Six-Sigma techniques can help any company achieve these goals.

This is the ideal course for individuals who you want improve their résumé and career opportunities in Six-Sigma, by adding this industry-wide recognized course to the education or training section of your CV.

The course covers Six-Sigma process improvement techniques; it is a stepping stone for Six Sigma Green and Black-belt certifications.

**Major topics include:**

- Six-Sigma, what is it?
- Six-Sigma, why use it?
- International quality standards and Six-Sigma
- Six-Sigma Core Concepts, How to use Six-Sigma
- Six-Sigma application example and Case Study “JFS”
- Another Case Study “BBB”
- Top steps to Six-Sigma
- Sigma Table, Spread Sheet Tips

**This SAE/CALISO course is for you if you:**

- Want to quickly and efficiently become familiar with Six-Sigma to understand and launch Six-Sigma projects as an employee or a manager
- Want to improve your CV and career opportunities with Six-Sigma knowledge and qualifications
- Want to systematically improve the profitability and customer satisfaction of your product or service by improving numerous key areas such as quality, performance and efficiency

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

**Fee:** $159.95  
.8 CEUs

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**MATERIALS:**  
**METALLURGY COURSES**

**Principles of Metallurgy**

4 Hours  
I.D.# PD261322ON

This on-demand course teaches the basic microscopic structures present inside of metals, how these structures and metal composition influence metal strength, and how these structures can be modified using common manufacturing processes to obtain specific mechanical properties. Several examples are presented to demonstrate how common alloying and manufacturing methods are used to modify the microscopic structures and properties of metals. It includes twelve modules followed by a quiz.

**Major topics include:**

- Composition
- Microscopic structures
- Crystal defects
- Diffusion
- Cold Working
- Annealing
- Solid Solution strengthening
- Precipitation Strengthening Heat Treatment
- Steel and Steel Heat Treating

**Is this Metallurgy On-Demand Course for You?**

This course is targeted towards design, manufacturing, and quality engineers, and sales people and purchasing agents with technical backgrounds.

**What You Will Receive**

- 90 days (from date of purchase) of on-demand access to the four hour presentation
- Integrated knowledge checks to reinforce key concepts
- Course workbook (.pdf, downloadable)
- Proof of Participation (Transcript)

**Author:** Industrial Metallurgists, LLC

**Fee:** $225
ON DEMAND COURSES RESOURCE GUIDE

Corrosion of Metals

5 Hours
I.D.# PD261328ON

This online course teaches about corrosion of metals. The physics of corrosion is explored as a background for the discussion of seven common types of corrosion (uniform, galvanic, crevice, pitting, intergranular, stress corrosion cracking, and dealloying). Students will learn why and how corrosion occurs and methods for controlling corrosion. It includes eleven modules followed by a quiz.

Major topics include:
• Introduction to electrochemical corrosion
• Aqueous corrosion
• Uniform corrosion
• Galvanic corrosion
• Crevice corrosion
• Pitting corrosion
• Intergranular corrosion
• Stress corrosion cracking
• Dealloying

Is this Metallurgy On-Demand Course for You?
This course is targeted to design engineers, manufacturing engineers, and quality engineers. It is suggested that, as a prerequisite, you either take our Principles of Metallurgy online course (I.D.# PD261322, page 239) or have basic knowledge of the following topics: grains, grain boundaries, crystal lattice, substitutional solid solution, diffusion, phases, precipitation, precipitation hardening, microstructure, tensile testing.

What You Will Receive
• 90 days of on-demand access (from date of purchase) to the five hour presentation
• Integrated knowledge checks to reinforce key concepts
• Proof of Participation (Transcript)

Author: Industrial Metallurgists, LLC
Fee $330

Failure Analysis of Metals

5 Hours
I.D.# PD261505ON

Quickly getting to the bottom of a metal failure is critical for preventing future failures, keeping customers happy, and keeping manufacturing lines running. This course will teach you how to perform failure analysis of fracture, corrosion, and manufacturing failures.

Major topics include:
• The relationship between failure analysis and root cause analysis
• How to select, collect, handle, and prepare samples for failure analysis
• The background information required to determine failure mechanism and root cause
• The common techniques used for failure analysis and the data obtained
• Which metallurgical analyses are appropriate for specific failures
• How to determine fracture mode based on the appearance of a fracture surface
• How to perform a failure analysis on fracture, corrosion, and manufacturing failures
• The categories of failure root causes for specific failures

Is this Metallurgy On-Demand Course for You?
This course is targeted towards design, manufacturing, supplier quality and quality control engineers, sales people and purchasing agents with technical backgrounds.

What You Will Receive
• 90 days (from date of purchase) of on-demand access to the approximately 5-hour presentation
• Integrated knowledge checks to reinforce key concepts
• Course workbook (.pdf, downloadable)
• Proof of Participation (Transcript)

Author: Industrial Metallurgists, LLC
Fee $330

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Hardness Testing

30 Minutes
I.D.# ON

This on-demand course focuses on Rockwell and Brinell hardness testing and Vickers and Knoop microhardness testing. Participants will learn about how the tests are performed, test sample requirements, test parameter selection, and testing requirements. The course can be completed in 30 minutes.

Major topics include:
- Rockwell hardness testing
- Brinell hardness testing
- Knoop and Vickers microhardness sample preparation and testing

Is this Metallurgy On-Demand Course for You?
This on-demand course is targeted to design, manufacturing, and quality engineers, and sales people and purchasing agents with technical backgrounds.

What You Will Receive
- 90 days (from date of purchase) of on-demand access to the thirty minute presentation
- Integrated knowledge checks to reinforce key concepts
- Course workbook (.pdf, downloadable)
- Proof of Participation (Transcript)

Author: Industrial Metallurgists, LLC
Fee $45

Metallurgy of Precipitation Strengthening

2 Hours
I.D.# PD261329ON

This on-demand course teaches about the microscopic changes that take place in a precipitation strengthened alloy and their effects on the properties of the alloy. The effects of the different heat treating steps (solution treatment, quench, and aging) and heat treating process parameters (solution treatment temperature and time, quench rate, and aging temperature and time) on the alloy microstructure and the effects on alloy strength are discussed. The course is divided into five modules followed by a quiz.

Major topics include:
- Phase diagrams
- Precipitation strengthening heat treatment
- Heat treatment details
- Quality control and course review

Is this Metallurgy On-Demand Course for You?
This course is targeted to design, manufacturing, and quality engineers. It is suggested that, as a prerequisite, you have knowledge of the concepts covered in our Principles of Metallurgy (I.D.# PD261322, page 239) online course.

What You Will Receive
- 90 days (from date of purchase) of on-demand access to the two hour presentation
- Integrated knowledge checks to reinforce key concepts
- Course workbook (.pdf, downloadable)
- Proof of Participation (Transcript)

Author: Industrial Metallurgists, LLC
Fee $140

Metallurgy of Steel Case Hardening

1 Hour
I.D.# PD261333ON

This on-demand course discusses common steel case hardening processes and how they are used to modify the surface layers of steels to obtain specific mechanical properties. Participants will learn about the process parameters and how they affect case composition, depth, microstructure, and properties. The course takes one hour to complete.

Major topics include:
- Carburizing
- Carbonitriding
- Nitriding
- Nitrocarburizing
- Flame hardening; Induction hardening

Is this Metallurgy On-demand Course for You?
This course is targeted to design, manufacturing, and quality engineers, and sales people and purchasing agents with technical backgrounds. It is suggested that, as a prerequisite, you have knowledge of the concepts covered in our Principles of Metallurgy (I.D.# PD261322, page 239) and Metallurgy of Steel: Principles (I.D. PD261326ON, page 242) or knowledge of the concepts covered in those courses.
ON DEMAND COURSES RESOURCE GUIDE

What You Will Receive
- 90 days (from date of purchase) of on-demand access to the one hour presentation
- Integrated knowledge checks to reinforce key concepts
- Course workbook (.pdf, downloadable)
- Proof of Participation (Transcript)

Author: Industrial Metallurgists, LLC
Fee $80

Metallurgy of Steel Through Hardening
1 Hour
I.D.# PD261330ON
This on-demand course teaches about the metallurgy of the following steel through hardening processes: quench and temper, martempering, and austempering. Participants will learn about the effects of heat treating temperature and cooling rate on steel microstructure and properties, and the effects of the interaction between heat treating process parameters and steel composition on through hardened steel microstructure and strength. This course takes one hour to complete.

Major topics include:
- Quench and temper
- Steel hardenability
- Common problems associated with quenching (distortion, cracking, retained austenite)
- Martempering; Austempering

Is this Metallurgy On-demand Course for You?
This course is targeted to design, manufacturing, and quality engineers, and sales people and purchasing agents with technical backgrounds. It is suggested that, as a prerequisite, you have knowledge of the concepts covered in our Metallurgy online course. (I.D.# PD261322, page 239).

What You Will Receive
- 90 days (from date of purchase) of on-demand access to the one hour presentation
- Integrated knowledge checks to reinforce key concepts
- Course workbook (.pdf, downloadable)
- Proof of Participation (Transcript)

Author: Industrial Metallurgists, LLC
Fee $80

Metallurgy of Steel: Principles
3 Hours
I.D.# PD261326ON
This on-demand course teaches the phases and microstructures that form in steels, their effects on steel properties, the microstructure changes that occur when steel is heated and cooled, and the effects of carbon content and cooling rate on the microstructures that form. Also, how to read the iron-carbon phase diagram will be discussed. All this information is applicable to understanding the effects of steel heat treating processes and heat treating process parameters on the microstructure and properties of heat treated plain carbon, low-alloy, and tools steels. The course is divided into six modules followed by a quiz.

Major topics include:
- Steel types and designations
- Metallurgical phases that form in steel and their effects on properties
- Steel phase diagram
- Metallurgical changes in carbon steel during cooling
- Metallurgical changes in carbon steel during heating
- Course Review

Is this Metallurgy On-demand Course for You?
This on-demand course is targeted to design, manufacturing, and quality engineers, and sourcing specialists. It is suggested that, as a prerequisite, you have basic knowledge of solid solution, substitutions, interstitials, diffusion, effects of process temperature and time on diffusion and metallurgical changes, metallurgical phases, grains, grain boundaries, dislocations or the concepts covered in our Metallurgy online course. (I.D.# PD261322, page 239).

What You Will Receive
- 90 days (from date of purchase) of on-demand access to the two hour presentation
- Integrated knowledge checks to reinforce key concepts
- Course workbook (.pdf, downloadable)
- Proof of Participation (Transcript)

Author: Industrial Metallurgists, LLC
Fee $195
ON DEMAND COURSES RESOURCE GUIDE

Tensile Testing
Duration: 30 Minutes
I.D.# PD261308ON
This on-demand course teaches about tensile testing of metals with a focus on how the testing is performed and tensile properties are measured. It includes one module followed by a quiz.

Major Topics Include:
• How a tensile test is performed
• Tensile specimen shape
• Calculation of stress and strain
• Stress and strain curve
• How to determine elastic modulus, yield strength, tensile strength, and elongation from a stress-strain curve

Is this Metallurgy On-demand Course for You?
This course is targeted towards design, manufacturing, supplier quality and quality control engineers, sales people and purchasing agents with technical backgrounds.

What You Will Receive
• 90 days (from date of purchase) of on-demand access to the 25-minute presentation
• Course handbook (downloadable, .pdf’s)
• Integrated knowledge checks to reinforce key concepts
• Proof of Participation (Transcript)

Author: Industrial Metallurgists, LLC
Fee $45

Aluminum Metallurgy
1 Hour
I.D.# PD261734ON
There are a wide variety of wrought aluminum alloys, each developed to provide specific properties. Getting the strength you need in an aluminum alloy requires knowledge of the effects of alloy composition, cold-working, and heat treating on aluminum metallurgy and properties. A good understanding of how aluminum alloys behave and what can be done to modify their properties is critical for being more productive and profitable. The course takes about one hour to complete and consists of one module and a final exam. Also, quizzes and problems give you opportunities to apply the concepts taught.

Major topics include:
• The different families of wrought aluminum alloys
• Composition and strength differences between the alloy families.
• Relationship between metal strength and the microscopic structures that influence strength.
• Effects of cold-working, alloying, and heat treating on aluminum microstructure and strength.
• Aluminum temper designations for cold-worked and precipitation strengthened alloys.

Is this Metallurgy On-demand Course for You?
This course was designed for design, manufacturing, and quality engineers who need to better understand the metallurgy of aluminum alloys in order to make design decisions, evaluate suppliers, and fix quality problems.

What You Will Receive
• 90 days (from date of purchase) of on-demand access to the one hour presentation
• Integrated knowledge checks to reinforce key concepts
• Course handbook (.pdf, downloadable)
• Proof of Participation (Transcript)

Author: Industrial Metallurgists, LLC
Fee $85

Electroplating
3 Hours
I.D.# PD261735ON
Electroplating involves the deposition of thin layers of metal on metal components and metal stock. There are several uses for electrodeposited coatings including cosmetic, corrosion resistance, and wear resistance. Knowledge about electroplating and electroplated coatings is important for product design, preventing and solving quality problems, and evaluating supplier capabilities and quality.

Major topics include:
• Process steps for electroplating and supporting processes
• Different process formats
• Coating properties, features, and defects, and how they are evaluated
• Effects of electroplating process steps on coating properties, features, and defects
• Important coating properties, features, and defects for six different coating uses.
ON DEMAND COURSES RESOURCE GUIDE

- Selecting and specifying electrodeposited coatings
- Evaluating electroplating companies

Is this Metallurgy On-demand Course for You?
If you’re ever involved with metal plating selection, supplier evaluation, and solving quality problems with electroplated metals, then this course is for you.

What You Will Receive
- 90 days (from date of purchase) of on-demand access to the one hour presentation
- Integrated knowledge checks to reinforce key concepts
- Course handbook (.pdf, downloadable)
- Proof of Participation (Transcript)

Author: Industrial Metallurgists, LLC
Fee $225

Learning Objectives
By connecting with this course, participants will be able to:
- Discuss the differences of various acoustic terminologies that are important to solve noise and vibration problems
- Define a relationship between sound pressure, sound power, and sound intensity
- Associate decibel to both sound and vibration
- Prepare effective acoustic specifications encompassing all variables that affect noise and vibration
- Select correct instrumentation for noise and vibration measurements recognizing the challenges of measurements
- Define the source-path-receiver relationship
- Determine the steps of noise and vibration source identification process for a given application
- Employ different noise control options to address specific noise and vibration issues

Is this Web Seminar RePlay for You?
This fundamental course is especially valuable for technical staff, engineers, and managers with limited experience in noise and vibration. It is designed to be suitable for all areas of the mobility industry. An Associate degree in the field of science or technology is recommended; BS degree is preferred.

Topical Outline
Session 1
- Introduction
  - Waves
  - Pressure, power, intensity
  - Frequency
  - Human perception of sound
- Decibels
  - What is decibel
  - Addition and subtraction of decibels
  - Background noise
  - Linear averaging/spatial averaging
- Frequency
  - Frequency Analysis
  - Linear and logarithmic frequency
  - Filters
Session 2
- Human Perception of Sound
  - Equal Loudness contours
  - Frequency weighting of sound
  - Loudness, loudness level, articulation index
- Instrumentation and Facilities
  - Transducers
  - Spectrum analyzers
  - Anechoic/hemi-anechoic room
  - Reverberation room

Acoustic Fundamentals for Solving Noise and Vibration Problems Web Seminar RePlay
6 Hours
I.D.# PD331309ON

Web Seminar RePlays are captures of the live web seminar. The course sessions are unedited and include interactions between the instructor and live participants. A learning assessment is available at the end of the course to reinforce learning and retention and gauge your understanding of the topic.

This course provides an introduction to the characteristics of sound waves, human perception of sound, sound and vibration measurements, measurement facilities, and various noise sources and noise control principles. It will include an overview of sound pressure, power, intensity, decibels, and frequencies. Practical examples will be used to familiarize participants with the acoustic fundamentals for solving noise and vibration problems and the associated solution principles.

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• Fill out the online quote request at sae.org/corplearning • Email us at Corplearn@sae.org
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- Sound power measurements
- Source-path-receiver relationship

Session 3
- Various Noise Sources
  - Product noise
  - Community Noise
  - Industrial noise
  - Vehicle noise
  - Aircraft noise
- Noise Control Principles
  - Sound package materials
  - Absorber, barrier, damper, isolator
  - Mufflers, resonators
  - Active and passive noise control
- Describe how various measurements are made and why they are necessary on a material level, component level, and vehicle level
- Prescribe appropriate sound package materials for specific NVH issues
- Construct proper protocols for combining different sound package materials for different components so that the final vehicle meets the required acoustic target

Is this Course for You?
This course will be especially valuable for those new to the vehicle sound package area and those interested in how absorbers, barriers, and dampers work, how they are different from each other, how they interact with each other in an application, and what one needs to be aware of while making measurements so the results are meaningful. The course is also designed for OEM or supplier engineers and those in roles involved with design, evaluation, trouble-shooting, procuring, releasing, supplying, and/or manufacturing noise control materials and parts for passenger cars and light trucks, heavy trucks, off-highway vehicles, farm machinery, and other transportation systems including aircraft, watercraft and rail transit. An undergraduate degree and familiarity with basic acoustics and vibration, or acoustical materials would be beneficial.

Topical Outline
- Vehicle Noise Sources and Solutions
  - The noise system – sources
  - Ranking noise paths
  - Source-path-receiver relationship
  - The noise control system using sound package materials
- Sound Package Material – Absorber
  - Application
  - Primary function
  - Effect of various parameters
  - How it works
  - How to improve performance
  - Case studies
  - Measurements
- Sound Package Material – Barrier
  - Application
  - Primary function
  - How it works
  - How to improve performance
  - Case studies
  - Measurements
- Sound Package Material – Damper
  - Application
  - Primary function
  - How it works
  - How to improve performance

Vehicle Sound Package Materials Web Seminar RePlay
8 Hours
I.D.# PD331204ON

Web Seminar RePlays are captures of the live web seminar. The course sessions are unedited and include interactions between the instructor and live participants. A learning assessment is available at the end of the course to reinforce learning and retention and gauge your understanding of the topic.

This course offers a detailed understanding of the source – path-receiver relationship for developing appropriate sound package treatments in vehicles, including automobiles, commercial vehicles, and other transportation devices. The course provides a detailed overview of absorption, attenuation (barrier), and damping materials and how to evaluate their performances on material, component, and vehicle level applications. A significant part of course content is the case studies that demonstrate how properly designed sound package materials successfully address vehicle noise issues.

Learning Objectives
By connecting with this course, participants will be able to:
- Identify various descriptors that are used in acoustics while working with sound package materials
- Identify three fundamentally different sound package materials that are used in the industry
- Explain how these materials work and how to improve their performance

Instructor: Pranab Saha
Fee $550 .6 CEUs
ON DEMAND COURSES RESOURCE GUIDE

- Case studies
- Measurements
- Component and Vehicle Level Noise Measurements
  - Why
  - How
  - The need for standards and targets for NVH studies

Case studies
Measurements
Component and Vehicle Level Noise Measurements
  Why
  How
  The need for standards and targets for NVH studies

ON DEMAND COURSES RESOURCE GUIDE

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POWER & PROPULSION: ENGINES

Diesel Engine Technology
13 Hours
I.D.# PD130812ON

This is an electronically delivered seminar featuring full-motion video illustrated with synchronized presentation slides. This course is based on the highly-rated classroom seminar.

As diesel engines become more popular, a fundamental knowledge of diesel technology is critical for anyone involved in the diesel engine support industry. This course explains the fundamental technology of diesel engines, starting with a short but thorough introduction of the diesel combustion cycle, and continuing with aspects of engine design, emission control design, and more. An overview of developing technologies for the future with a comprehensive section on exhaust aftertreatment is also included.

The nearly thirteen hour course is divided into an introduction and eight modules. The instructor makes reference to his book, Diesel Emissions and Their Control, co-authored with W. Addy Majewski and also available from SAE International.

Learning Objectives
By connecting with this course, participants will be able to:
• Summarize the technological advances in modern diesel engines
• Evaluate the sources of emissions from diesel engines and the influence of engine component design on curbing these emissions
• Explain diesel exhaust aftertreatment systems and their effectiveness in reducing emissions

Instructor: Pranab Saha
Fee $640 .8 CEUs

Diesel Engine Noise Control Web Seminar RePlay
4 Hours
I.D.# PD331041ON

Web Seminar RePlays are captures of the live web seminar. The course sessions are unedited and include interactions between the instructor and live participants. A learning assessment is available at the end of the course to reinforce learning and retention and gauge your understanding of the topic.

The Diesel Engine Noise Control Web Seminar RePlay provides an in-depth overview of diesel engine noise including combustion and mechanical noise sources. In addition, the instructor will discuss a system approach to automotive integration including combining sub-systems and components to achieve overall vehicle noise and vibration goals.

Learning Objectives
By connecting with this course, participants will be able to:
• Identify and analyze commonly occurring diesel engine noise sources
• Understand how analytical and experimental techniques can be used to solve diesel noise issues
• Prescribe appropriate noise control analysis and solutions for specific diesel engine NVH issues

Instructor: Magdi Khair
Fee $645 1.3 CEUs

Is this Course for You?
If you are involved in diesel engine support industries such as catalytic converters, lube oils, gaskets, and turbochargers, and if you are not well versed with diesel engines although they play a major role in your career’s survival, this on-demand course is for you.

Topical Outline
• The Case for the Diesel Engine
• The Diesel Combustion Process
• Basic Types of Diesel Engines
• The Diesel Fuel Injection System
• Air Management - Supercharging & Turbocharging
• Emissions Formation in Diesel Engines
• Steps Towards the Modern Diesel Engine
• Emerging Technologies
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Is this Web Seminar RePlay for You?
Those who wish to understand the root causes of many diesel engine noise issues, and how to use this understanding to better diagnose and control diesel engine-related noises.

Topical Outline
Session 1
• The Basics of Diesel Engine Noise
• Combustion Noise Forcing Functions
• Combustion Mode Switching
• Mechanical Forcing Functions in Diesels
• Separating Combustion and Mechanical Noise Sources
• Strategies for Reducing Forcing Functions
Session 2
• Surface Radiated Noise
• Exterior Covers: Radiated Sound and Simulation Modeling
• Gear Train Noise Issues and Countermeasures
• Drive-By Noise Contribution
• Diesel Engine Design Considerations for Low Noise
• Application Noise Issues

Learning Objectives
By connecting with this course, participants will be able to:
• Discuss in detail the basic functioning and component interaction in a modern internal combustion engine, specifically; two and four-stroke cycles as they relate to reciprocating and rotary engine designs.
• Describe the general thermodynamic concepts governing the operation of an internal combustion engine and its various cycles
• Compare the principle operational differences of the various fuels used in internal combustion engines, their availability, and understand the applicability of each
• Discuss the function and operation of all major components and systems within a modern internal combustion engine
• Identify the operational principles behind the timing and working relationships among all internal components, and articulate the importance of this inter-relationship
• Recognize the limitations of the current designs and implementations of the modern internal combustion engine
• Perform a basic assessment and evaluation of new, cutting-edge designs and new powertrain initiatives as they apply to the mobility industry

Is this Course for You?
If you are a powertrain engineer, component supplier, vehicle platform powertrain development specialist, or involved in the application, design and discussion of engines, this on-demand course is for you. It is recommended that participants have an undergraduate engineering degree.

Topical Outline
• Fundamental Operating Procedures
• Engine Technology Development
• Fuel Delivery Systems
• Valve Train
• Component and Event Timing
• Fuels and Combustion
• Ignition
• Emissions and Controls
• Thermodynamics
• Energy Conversion Kinematics and Mechanisms

The Basics of Internal Combustion Engines
10 Hours
I.D.# PD130944ON
This is an electronically delivered seminar featuring full-motion video illustrated with synchronized presentation slides. This course is based on the highly-rated classroom seminar.

In this course, Dr. William Mark McVea covers the most relevant topics related to internal combustion engines - ranging from the chemistry of combustion to the kinematics of modern internal components. You will gain a practical, thorough approach to the basics of most common designs of internal combustion engines as they apply to the gaseous cycles, thermodynamics and heat transfer to the major components, and the design theories that embody these concepts.

The more than ten hour course is broken into ten modules including insights into two- and four-stroke cycles, principle operational differences of various fuels, timing and working relationships among internal components, limitations to current designs, and the evaluation of new designs.

Instructor: Thomas Reinhart
Fee $425 .4 CEUs

The Basics of Internal Combustion Engines
10 Hours
I.D.# PD130944ON
This is an electronically delivered seminar featuring full-motion video illustrated with synchronized presentation slides. This course is based on the highly-rated classroom seminar.

In this course, Dr. William Mark McVea covers the most relevant topics related to internal combustion engines - ranging from the chemistry of combustion to the kinematics of modern internal components. You will gain a practical, thorough approach to the basics of most common designs of internal combustion engines as they apply to the gaseous cycles, thermodynamics and heat transfer to the major components, and the design theories that embody these concepts.

The more than ten hour course is broken into ten modules including insights into two- and four-stroke cycles, principle operational differences of various fuels, timing and working relationships among internal components, limitations to current designs, and the evaluation of new designs.

Instructor: Mark McVea
Fee $565 1.0 CEU
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Introduction to Cooling Airflow Systems
Web Seminar RePlay
12 Hours
I.D.# PD331240ON

Web Seminar RePlays are captures of the live web seminar. The course sessions are unedited and include interactions between the instructor and live participants. A learning assessment is available at the end of the course to reinforce learning and retention and gauge your understanding of the topic.

Vehicle functional requirements, diesel emission regulations, and subsystem thermal limits all have a direct impact on the design of a powertrain cooling airflow system. Severe duty cycles, minimal ram air, fouling, and sometimes unconventional package layouts present unique challenges to the designer. This course introduces many airflow integration issues and vehicle-level trade-offs that effect system performance and drive the design.

The goal is to introduce engineers and managers to the basic principles of diesel cooling airflow systems for commercial and off-road vehicles. Participants will learn about vehicle/product constraints, integration issues, cooling airflow, system resistance, fans, shrouds, radiators, coolers, estimating heat rejection, thermal recirculation, and overall system performance. Basic concepts will be reinforced with examples and a cooling performance calculation of a diesel cooling system.

Learning Objectives
By connecting with this course, participants will be able to:
• Define vehicle requirements and many cooling airflow system integration issues
• Describe heat exchanger sizing considerations, design alternatives, and thermal effectiveness
• List fan/shroud aerodynamic design parameters, guidelines, and installation effects
• Apply the fan laws to evaluate alternative designs
• Calculate fan operating point and airflow using component pressure-loss coefficients
• Estimate engine heat rejection to coolant, including Exhaust Gas Recirculation (EGR)
• Calculate steady-state thermal performance of a diesel cooling airflow system

Is this course for you?
OEM and supplier engineers and managers who are involved with vehicle cooling systems, or who interface with vehicle program management on these issues, will benefit from this seminar. Graduate-level students interested in cooling systems will also find it instructive.

Topical Outline
• Vehicle Perspective
  • Overview Typical Cooling Airflow Systems
  • Design Drivers
  • A Classification of Vehicle Cooling Systems
  • Industrial Air-cooled Heat Exchanger Assemblies
  • Impact of System & Sub-system Requirements
  • Thermal Recirculation
  • Design Challenges
• Key Concepts – System Heat Transfer Equation and Pressure Losses
  • 1st Law of Aerodynamics
  • Radiator Heat Transfer Equation
  • Definition of Standard Air
  • Airflow Terminology and Standard Cubic Feet per Minute (SCFM)
  • Bernoulli’s Equation and Ram Pressure
  • Pressure Loss Coefficient
  • Vehicle Air Flow Restrictions – Flow Energy Losses
  • Construct a System Pressure Loss Curve
• Fan Airflow
  • Fan Classification and Specific Speed
  • Fan Characteristic Curve and System Matching
  • Air Performance Test Chambers (AMCA)
  • Axial Fan Systems, Pusher and Puller
  • Exercise the Fan Laws to Evaluate Design Alternatives
  • Shroud Design Considerations
  • Vehicle Installation Effects – Fan Position, Tip Clearance, Radiator Proximity
• Fan and Ram Airflow Map
  • Ram Airflow
  • Flow Energy Balance Equation
  • Fan Operation with Ram
  • Ram Total-Pressure Recovery
  • Calculate System Loss Curve, Fan Operating Point and Cooling Airflow
• Compact Heat Exchangers
  • Thermal Classification of Heat Exchangers
  • Compact Heat Exchangers in Vehicle Applications
  • Radiator Effectiveness and Louvered Fins
  • Charge Air Coolers, Performance Calculation Against Requirements
  • Air-Side Fouling Study and Heat Exchanger Design Considerations
  • Thermal Accumulation Calculation
• Estimating Powertrain Heat Rejection
  • SAE Dynamometer Gross Power Test Procedures
  • Dynamometer Data on Engine Heat Rejection
  • Brake Mean Effective Pressure (BMEP), A Power Density
  • Specific Heat Rejection (SHR) Characteristic Curve

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Introduction to Powertrain Calibration Engineering Web Seminar RePlay

5 Hours
I.D.# PD331346ON

Web Seminar RePlays are captures of the live web seminar. The course sessions are unedited and include interactions between the instructor and live participants. A learning assessment is available at the end of the course to reinforce learning and retention and gauge your understanding of the topic.

Driven by the need for lower emissions, better fuel economy and improved drive quality, optimized powertrain calibrations are required for the many different vehicle configurations on today’s roadways. While powertrain components such as the internal combustion engine, transmission, and hybrid electric powertrain are somewhat familiar to the automotive industry, the control theory, calibrations and system interactions between these components are a relatively unfamiliar aspect.

This course will introduce participants to the concepts behind optimized powertrain calibrations and how they impact fuel consumption, exhaust emissions, and vehicle performance. Participants will also gain exposure to the role that the calibration plays in the system level interactions of the various powertrain components.

Each participant will be asked to view the recording from the one-hour SAE Vehicle/Powetrain Calibration Engineering: What Is It and Why Is It For You? Telephone/Webcast as a course requirement.

Learning Objectives

By connecting with this course, participants will be able to:

• Describe the role of calibration in powertrain and vehicle performance
• Identify the fundamental requirements that drive powertrain calibration development
• List the major international regulatory agencies
• Identify the driving factors for complexity of powertrain systems
• Identify the powertrain system interactions that are influenced by calibration
• Recognize tools used in the development of powertrain calibrations
• Diagram the high level calibration process flow

Is this Web Seminar RePlay for You?

This course is intended for anyone who would like a better understanding of powertrain calibration and how it influences vehicle performance and drivability. Engineering students with an automotive interest through automotive professionals will gain insight into the calibration process and its system impact. It will also be beneficial to those involved in the specification, design, development, testing and planning of vehicles and powertrains. Product planners and program managers will find the overview aspects helpful.

Prerequisites

Material presented will be practical in nature with basic mathematics used to describe quantitative measures. A background in mechanical or electrical engineering will assist in gaining maximum benefit from the material presented. Experience or training in engine or transmission engineering is helpful, but not essential.

Topical Outline

Session 1
Requirements, Boundary Conditions and Complexity
• Fundamental requirements driving powertrain calibration
  • Regulations
  • Vehicle Requirements
  • Environmental requirements
• Overview of the factors driving complexity in powertrain calibration systems
  • Global requirements
  • Fuels
  • Product hardware
Calibration Functional Objectives
• Overview of some basic powertrain calibration tasks including base engine, transmission, OBD, aftertreatment, vehicle driveability
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- Base Engine Calibrations
  - Steady state models (air charge, exh backpressure, knock thresholds)
  - Single point optimizations (spark, AFR, VVT, EGR, FUP, etc..)
  - Simple transients
- In-vehicle validation of dyno cals
  - Steady state correlation
  - Transient conditions
  - Knock behavior and fuel sensitivity
- Vehicle-specific Calibrations
  - Pedal progression
  - Drive/shift quality
  - Emissions
  - Performance
- Location-Specific Calibrations
  - Customer expectation of “normal” behavior in all climates
  - Hot weather (component protection)
  - Cold Weather (Emissions, startability, drive quality)
- Altitude (Emissions, startability, drive quality, performance)

Session 2
- Systems - How they interact
  - What is a powertrain system?
  - Powertrain subsystem calibration and interactions (engine, aftertreatment, transmission, hybrid, control)
  - Overview of some basic powertrain components and their effects on the overall system
  - Communication between systems and components
  - The calibration engineer’s role in the overall development process as the bridge between hardware and controls
- Calibration Tasks
  - Testing environments for calibration engineers including simulations, engine test cells, powertrain test cells, chassis dynamometer test cells and test track/field testing
  - Tools of the trade - industry standard tools and specialized tools that calibration engineers use
  - Using test data to create a calibration including modeling, optimization and table generation

A Familiarization of Drivetrain Components

5.25 Hours
I.D.# PD130555ON

This is an electronically delivered seminar featuring full-motion video illustrated with synchronized presentation slides. This course is based on the highly-rated classroom seminar.

An efficient, durable, and quiet running drivetrain is as essential to customer satisfaction as styling and interior creature comforts. In this course you will be exposed to various methods that can be used to accomplish this goal. Designed to help you visualize both individual components and the entire drivetrain system - without reference to complicated equations - the course focuses on the terms, functions, nomenclature, operating characteristics and effect on vehicle performance for each of the drivetrain components. Instructor Joseph Palazzolo provides an introduction to the various components of the drivetrain, including the clutch or torque converter, manual or automatic transmission, driveshaft, axle, wheel ends, and brakes.

The course presentation also provides insight into: the structure and function of each component; vehicle performance; and related noise, vibration and harshness issues. You will be equipped to evaluate the space requirements, mounting needs, clearances required, and effect on vehicle performance for each component.

Based on the popular classroom seminar, the five and a quarter hour course is divided into seven modules accompanied by a handbook.

Learning Objectives
By connecting with this course, participants will be able to:
- Discuss both practical and technical aspects of smoothing clutch operation by incorporating cushion and torsional dampers
- Compare different types of transmission synchronizers, automatic transmission torque converters, hydraulic clutch operation and epicyclic gear trains
- Describe the interaction of gear ratios and vehicle performance as related to engine horsepower and torque curves
- Explain phasing and mounting of propeller shafts as related to torsional excitation and secondary couple loads
- Review different types of differentials
- Compare common misconceptions of limited slip devices to their actual performance
- Recognize four-wheel drive systems and the need for an inter-axle differential
- Appraise electronic control of torque through braking and clutching devices
- Evaluate the total drivetrain package as a system

Instructors: Julian Blair, Greg Banish, Talus Park, Chi Binh La
Fee $425 .5 CEUs

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**Is this Course for You?**

This on-demand offering was intended for engineers now working with passenger car, sport utility, truck, bus, industrial, and off-highway vehicles who have had minimal prior experience with the total drivetrain. An engineering undergraduate degree in any discipline would be beneficial.

**Topical Outline**
- Clutches
- Transmission
- Propshaft
- Axle
- Transfer Case
- Wheel Ends
- Brakes

**Instructor:** Joe Palazzolo  
**Fee:** $295  
**.5 CEUs**

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**Fundamentals of Automotive All-Wheel Drive Systems**

4.5 Hours  
I.D.# PD1305560N

This is an electronically delivered seminar featuring full-motion video illustrated with synchronized presentation slides. This course is based on the highly-rated classroom seminar.

This course provides an introduction to the fundamental concepts and evolution of passenger car and light truck 4x4/ all-wheeldrive (AWD) systems including the nomenclature used to describe these systems. Basic power transfer unit and transfer case design parameters, component application to system function, the future of AWD systems, and emerging technologies that may enable future systems are covered.

Based on the popular classroom seminar, the four and a half hour course is divided into eight modules accompanied by a handbook. It is an excellent follow-up to SAE’s *A Familiarization of Drivetrain Components* seminar or on-demand course (which is designed for those who have limited experience with the total drivetrain). See description on facing page.

**Learning Objectives**
- By connecting with this course, participants will be able to: Identify front wheel drive and rear wheel drive vehicle architectures
- Identify part time, full time, and on-demand all-wheel drive systems
- Explain the benefits of all-wheel drive over two-wheel drive
- Quantify all wheel drive traction and mobility benefits
- Describe auxiliary axle disconnect systems
- Explain basic vehicle dynamics performance and the effect of AWD on performance
- Identify couplers vs. biasing devices and their basic function
- Describe the differences between mechanical and electrical implementation in AWD systems
- Describe basic control strategies and logic
- Discuss advanced propulsion concepts and systems

**Is this Course for You?**

This course was designed for engineers (working with passenger cars, light trucks, and SUVs) who need to master AWD components and their functions and effects. Engineers new to the 4WD/AWD field, as well as managers, marketing personnel, purchasing professionals and others interested in all-wheel drive fundamentals, will benefit from this course.

**Topical Outline**
- All-Wheel Drive Systems Overview
- Part-Time Systems
- Full-Time Systems
- Transfer Case Design
- Couplers
- Vehicle NVH
- Emerging Technologies
- All-Wheel Drive Interactions/New Developments

**Instructor:** Joe Palazzolo  
**Fee:** $265  
**.5 CEUs**
Fundamentals of Modern Vehicle Transmissions

14 Hours
I.D.# PD130419ON

This is an electronically delivered seminar featuring full-motion video illustrated with synchronized presentation slides. This course is based on the highly-rated classroom seminar.

In this course, Dr. William Mark McVea details the transmission’s primary functions - to provide drivability characteristics to the vehicle and adaptive connectivity between the engine and the remainder of the fixed function driveline. The discussion then focuses on the latest transmission systems designed to achieve the most efficient engine operation. Current designs, the components and sub-systems used, their functional modes, how they operate, and the inter-relationships are examined. Automatic control, hydro-mechanic design theory and implementation, mechatronics, toroidal transmission functions, and the future of the automatic transmission are discussed. Continuously Variable Transmission (CVT) systems, which represent a fundamental shift in the way power is transmitted from the primary source to the remainder of the driveline, is covered in depth. Based on the popular classroom seminar, the 14 hour course is divided into nine modules, accompanied by a handbook.

Learning Objectives

By connecting with this course, participants will be able to:

- Explain the competing technologies in current use to provide mechanical power transmission within the technical confines of modern vehicle designs
- Discuss the fundamental operational principles of modern vehicle based transmission systems
- Describe in detail the differing characteristics and technical aspects of stepped versus stepless mechanical power transmission systems, their value, practical use, and applicability to stated performance parameters
- Theorize on the practical application of any of the major common designs to a specific application, or performance objective
- Predict and analytically determine the most appropriate system to satisfy a stated operational need
- Review proposed new technology and decide on proof of concept based on the technical merits and technological extensions employed or proposed

Is this Course for You?

This course is for those who wish to become familiar with the operational theories or functional principles of modern vehicle transmission systems. As the material covered is targeted at a number of design and engineering disciplines, you should have a minimum of two years of design experience in the automotive powertrain field, or preferably a B.S. in engineering or related field.

Topical Outline

- Transmission Technology Development
- Transmission Speed Ratios and Operation
- Manual Transmission Power Flow and Components
- Torque Converter
- Automatic Transmission Power Flow and Components
- Holding Members and Hydraulic Control
- Continuously Variable Transmission
- Continuously Variable Transmission Technology
- Technology Review

Instructor: William Mark McVea
Fee $695 1.4 CEUs

Infinitely Variable Transmissions Using a Toroidal Traction Variator Web Seminar RePlay

2 Hours
I.D.# PD331709ON

Web Seminar RePlays are captures of the live web seminar. The course sessions are unedited and include interactions between the instructor and live participants. A learning assessment is available at the end of the course to reinforce learning and retention and gauge your understanding of the topic.

An Infinitely Variable Transmission (IVT) is a subset of a CVT (Continuously Variable Transmission) defined as a device that has a range of ratios of input shaft speed to output shaft speed which includes an Infinite ratio in which the output speed is zero. Typically these devices include both positive and negative ratios on either side of zero resulting in the ability to move forward and reverse from rest without a clutch: IVTs can improve vehicle performance while maintaining or exceeding benchmark functionality and performance. IVTs are a good candidate for future, fuel-efficient vehicles, particularly hybrids and AWDs. An IVT can maintain superb functionality and performance while reducing fleet CO2 levels. No vehicles other than heavy tractors currently use IVT transmissions. A number of companies have looked at implementing IVT but they have failed to find an economical solution with sufficient upside to warrant its introduction, despite the attractive functional benefits. The use of the newly developed Double Roller Full Toroidal Variator - Continuously Variable Transmission (DFTV-CVT) has enabled a
much simpler IVT solution that can be manufactured for potentially a lower cost than other belt or chain style CVT designs and/or multispeed transmissions. The technology presented in this Webinar is based on the combination of a Double Roller Toroidal Traction Drive (DFTV-CVT) with a Planetary gear train (PGT).

This two-hour course will discuss the packaging, functionality, and economics of IVT architecture and expose the positive and negative aspects of IVT. The IVTs discussed use a particular type of CVT called a Double Roller Full Toroidal Variator (DFTV) which is the most compact and efficient CVT technology currently available.

Learning Objectives

By connecting with this course, participants will be able to:
• Describe in principal the physical mechanism involved in traction drives and the functional components of the DFTV-CVT
• Describe and illustrate the IVT mechanical principal using a CVT including hybrid variants
• Identify where the functional attributes of the IVT can be best used in real vehicle applications
• Compare the cost benefits, packaging advantages and design flexibility of the IVT
• Define the control system philosophy required for an IVT
• Develop representative simulation models of real vehicles using an IVT drivetrain, if familiar with simulation software such as Simulink®

Is this Web Seminar RePlay for You?

This course addresses the needs of engineers involved in the selection or design of the most appropriate drivetrain solutions should attend. A cross-section of professionals within OEMs and Tier1 transmission manufacturers, including technical sales people and control engineers, will benefit.

Topical Outline

• Introduction What is an IVT?
  • Packaging, weight and cost advantages
  • Functionality with IVT; off road vehicles and hybrids
• Traction Drives and Toroidal Variators
  • Traction drives
  • Toroidal variators; full, half and double roller; spin and efficiency
  • Steering, clamping and parasitic losses
• “Single Regime IVT”
  • Ratio choices for optimum performance; the importance of CVT ratio spread
  • Recirculating power, geared neutral; how these are managed in an IVT
  • The efficiency “map” of an IVT using the DFTV-CVT
• Direct Over Drive (DOD) as a method of maximizing efficiency at cruise
• Design of a Transmission for a Compact SUV with Off-road Capabilities
  • Functional OEM specification; maximum wheel torque and duty cycle
  • Concept and preliminary design
  • Design validation
• Component Parts of the IVT, associated BOM and transmission costing
• The Method of Control of an IVT and its Performance Characteristics
• Preferred PHEV and MHEV Solutions for an IVTs

Instructors:  Michael Durack
Fee $245 .2 CEUs
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Who Should Attend
This course will be especially valuable for engineers who design, calibrate and/or integrate any common style transmission into the following types of vehicles: passenger cars, light trucks, light duty off-highway vehicles, light duty farm machinery, and military vehicles.

Topical Outline
- OWC Fundamentals in Automatic Transmissions
  - OWC base function
  - Types of OWC’s
- CMD Controllable One Way Clutch
  - Fundamental construction and function
  - Advantages & disadvantages
  - Current use in automatic transmissions
  - Future applications (alignment to electrified powertrains)

Instructor: Michael Doherty
Fee $65 No CEUs are offered for this course

Performance and Use of Polymer Plan Bearings in Transmission Design Web Seminar RePlay
90 Minutes
I.D.# PD3317100N

Web Seminar RePlays are captures of the live web seminar. The course sessions are unedited and include interactions between the instructor and live participants. A learning assessment is available at the end of the course to reinforce learning and retention and gauge your understanding of the topic.

As part of a broad transmission design philosophy, the understanding and application of tribological systems is critical. The number of interacting surfaces within a modern automotive transmission continues to increase, while the demands on the system continue to press the limits of traditional technologies. The understanding of each surface interaction within the greater system becomes increasingly important as each component is asked to do more to benefit the overall system.

This course presents the tribological performance of polymeric plain bearings as related to transmission applications. Will deal with the various wear and damage mechanisms that can occur with a polymer bearing in transmissions. The damage mechanisms discussed will include adhesion, abrasion, fatigue and erosion. A brief discussion of relevant lubrication states, boundary lubrication and fluid film formation, will also be included.

The course will also address specific mechanical design issues associated with using polymer plain bearings within the transmission.

Learning Objectives
By connecting with this course, participants will be able to:
- Describe damage mechanisms of polymer plain bearings and washers in transmissions, including:
  - Adhesion and adhesive friction and wear
  - Abrasion and abrasive wear
  - Fatigue and fatigue wear
  - Cavitation erosion
- Cite differences in lubrication states as they relate to the performance of polymer plain bearings and washers, including boundary and fluid film lubrication
- Identify material solutions to overcome the variety of damage mechanisms
- Discuss mechanical design issues
- Describe the uses of plain bearing surfaces within the transmission and related componentry

Instructor: Michael Doherty or Matthew Steiner
Fee $195 .2 CEUs

Is this Web Seminar RePlay for You?
It would also provide value to equipment designers to equipment designers who specify bearing types, providing a general overview of polymer bearings and their tribological properties.

Topical Outline
- Wear or damage mechanisms
  - Adhesion and adhesive friction and wear
  - Abrasion and abrasive wear
  - Fatigue and fatigue wear
  - Cavitation erosion
- Differences in lubrication states as they relate to the performance of polymer plain bearings and washers
  - Boundary lubrication
  - Fluid film lubrication
- Materials solutions to overcome the variety of damage mechanisms discussed
  - Mechanical design issues
  - Applications review

Instructor: Michael Doherty or Matthew Steiner
Fee $195 .2 CEUs
**Powertrain Controls (PTC) - Ford On-Demand Course**

6 Hours  
I.D. # PD111013ON

The Ford Powertrain Controls (PTC) on-demand course introduces the critical role the powertrain controls system plays in providing excellent vehicle performance, fuel economy, driveability, and emissions. The course describes the powertrain controls system components, including sensors and actuators. The information is presented from a functional, interface diagram, and p-diagram perspective, to enable reliable and robust powertrain operation.

This 6-hour on-demand course is intended to stimulate systems interaction thinking by emphasizing powertrain controls interactions with internal and external interfaces and to help you understand powertrain control systems, prevent late design changes, reduce warranty costs, and improve customer satisfaction.

**Major topics include:**
- Powertrain Controls Overview  
- Powertrain Controls Hardware  
- Powertrain Controls Software/Calibration and Diagnostics  
- Powertrain Controls Reliability and Robustness  
- Powertrain Controls Interfaces  
- Sensors and Actuators  
- Powertrain Controls Modes of Operation

**Is this SAE/Ford On-demand Course for you?**

This course is geared toward powertrain, product development, quality, and manufacturing engineers. It is recommended that you have an engineering degree and experience in the automotive engineering field.

**What You Will Receive**
- 90-days of on-demand access to the six hour course  
- Proof of Participation

Fee $215

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**Powertrain As-Installed Driveline Subsystems (PAIDS) - Ford On-Demand Course**

8 Hours  
I.D. # PD111014ON

Powertrain as-installed subsystems have a common fundamental function to perform in harmony, enabling the engine to power the vehicle and/or accessories. There is a need to avoid issues such as idle roughness and to realize these are system interaction issues. For example, modal alignment affects idle roughness, and improving idle roughness can affect fuel economy.

This 8-hour Ford On-demand Course describes the function and major interfaces of powertrain as-installed driveline subsystems. It also discusses Design Verification System (DVS) metrics/performance requirements for each subsystem and how each subsystem affects other subsystems.

**Major topics include:**
- Introduction to Driveline  
- Drive Axles  
- Driveshafts/Halfshafts  
- Transfer Case/PTU/Coupling/RDU

**Is this SAE/Ford On-demand Course for you?**

This course is geared toward quality, manufacturing, and product development engineers. It is recommended that you have an engineering degree and experience in the automotive engineering field.

**What You Will Receive**
- 90-days of on-demand access to the six hour course  
- Proof of Participation

Fee $275
Powertrain As-Installed Stationary Subsystems (PAISS) - Ford On-Demand Course

12 Hours  
I.D.# PD111015ON

Powertrain as-installed subsystems have a common fundamental function to perform in harmony, enabling the engine to power the vehicle and/or accessories. There is a need to avoid issues such as idle roughness and to realize these are system interaction issues. For example, modal alignment affects idle roughness, and improving idle roughness can affect fuel economy.

This 12-hour Ford On-demand Course discusses hardware design, function, and major interfaces of powertrain as-installed stationary subsystems. It also discusses Design Verification System (DVS) metrics/performance requirements for each subsystem and how each subsystem affects other subsystems.

**Major topics include:**
- Accelerator Controls
- Air Induction
- Engine and Transmission Cooling
- Exhaust
- Fuel
- Powerplant Mounts

**Is this SAE/Ford On-demand Course for you?**
This course is geared toward quality, manufacturing, and product development engineers. It is recommended that you have an engineering degree and experience in the automotive engineering field.

**What You Will Receive**
- Four months of on-demand access to the six hour course
- Proof of Participation

Fee $395

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Powertrain Driveability - Ford On-Demand Course

3 Hours  
I.D.# PD111016ON

Driveability is the result of a system’s interaction between the powertrain, the vehicle, and the customer. Driveability concerns can arise in any mode of operation and have a common factor that all are the result of a change in engine/torque speed. Driveability is a key customer-driven Powertrain attribute. Improving driveability is critical to improving customer satisfaction and competitiveness of vehicles.

All Powertrain Product Development engineers must know how their area of subsystem responsibility could affect vehicle Driveability. This 3-hour Ford On-demand Course will provide knowledge of driveability fundamentals. With this knowledge, you can better determine actions to improve the customer’s perception of driveability.

**Major topics include:**
- The Customer’s Perspective
- Systems and Interfaces that Impact Driveability
- Evaluating a Vehicle’s Driveability Performance

**Is this SAE/Ford On-demand Course for you?**
This course is geared toward quality, manufacturing, and product development engineers. It is recommended that you have an engineering degree and experience in the automotive engineering field.

**What You Will Receive**
- 90-days of on-demand access to the three hour course
- Proof of Participation

Fee $115
**Powertrain Performance Feel - Ford On-Demand Course**

3.5 Hours  
I.D.# PD111017ON

In addition to NVH, Driveability, and Shift Quality, Performance Feel is among the four Powertrain attributes that directly influence customer satisfaction. It is defined in terms of the availability of power to the end customer and is the customer perception of performance that includes the effects of vehicle acceleration, accelerator control characteristics, shift character, and sound quality.

This 3.5-hour Ford On-demand Course is intended to increase the awareness of vehicle Performance Feel issues, target setting process, and the interactions and controls that affect Performance Feel.

**Major topics include:**
- Performance Feel from the Customer’s Perspective
- Performance Feel from an Engineering Perspective
- Metrics and Targets of Performance Feel
- Performance Feel Design Considerations

**Is this SAE/Ford On-demand Course for you?**

This course is geared toward powertrain, product development, quality, and manufacturing engineers. It is recommended that you have an engineering degree and experience in the automotive engineering field.

**What You Will Receive**
- 90-days of on-demand access to the 3.5 hour course
- Proof of Participation

Fee $125

**Catalytic NOx Control Technologies for Diesel and GDI Engines Web Seminar RePlay**

6 Hours  
I.D.# PD331237ON

Web Seminar RePlays are captures of the live web seminar. The course sessions are unedited and include interactions between the instructor and live participants. A learning assessment is available at the end of the course to reinforce learning and retention and gauge your understanding of the topic.

Lean burn engines (diesel and GDI) boast higher fuel economy and cleaner emissions than conventionally tuned engines while producing equivalent power. They employ higher combustion chamber compression ratios, significant air intake swirl and precise lean-metered direct fuel injection. The downfall of lean-burn technology, however, is increased exhaust NOx emissions (due to higher heat and cylinder pressure) and a somewhat narrower RPM power-band (due to slower burn rates of lean mixtures). Removal of NOx from exhausts is a critical need for emission standards and ambient ozone requirements.

This course examines the various catalytic processes for lean burn applications, including Selective Catalytic NOx Reduction (SCR), NOx Trap Technologies (i.e. LNT, NSR), and the combination of SCR, NOx Trap and Hydrocarbon NOx Reduction (LNC). It will focus in on SCR NOx fundamentals, equipping participants with the basic concepts for NOx control and important design parameters for SCR NOx catalyst. The course will examine the system design for SCR in diesel applications including passenger cars and heavy duty trucks, including SCR catalysts, SCR integration with diesel particulate filter, key sensor development catalyst durability issues and urea control.
Learning Objectives
By connecting with this course, participants will be able to:
• Define NOx catalysis and identify key acronyms
• Describe in-use issues
• Cite key elements in NOx catalyst design for diesel applications
• Define SCR design for passenger cars and heavy duty applications
• Identify available sensors for SCR catalyst performance monitoring
• Determine where lean NOx traps may be appropriate versus SCR NOx control

Who Should Attend
This Web Seminar RePlay will be especially valuable for mechanical, metallurgical and chemical engineers, materials scientists, and chemists involved in the design, operation and calibration of a NOx emission control system for both mobile and stationary source applications, such as automobiles, trucks, buses, ships, locomotives, stationary engines, small engines, etc. It will also help the newly hired engineer assigned to an emission control team, the seasoned veteran who just transferred to the emission control group, sales people responsible for emission controls, plant managers concerned about meeting new regulations with catalytic controls, and regulators now involved in transmission technologies. Participants should have a basic familiarity with automotive emissions for gasoline engines, diesel engines or off-road applications.

Topical Outline
Session 1
Lean NOx Catalysis
• NOx reduction catalytic approaches
• Lean NOx reduction fundamentals
• Hydrocarbon NOx reduction (LNC)
• NOx traps technologies (LNT, NSR or NAC)
• SCR Catalytic NOx reduction (ammonia based)
• Combination SCR/NOx traps
Session 2
SCR NOx Catalyst
• SCR NOx catalytic approaches (Vanadia and Zeolite)
• Performance characteristics of SCR NOx catalysts (Vanadia and Zeolite)
• Comparison of commercial issues with lean NOx traps and SCR
Session 3
SCR Catalyst Design Mobile Applications
• Passenger cars
• Heavy duty systems
• Auxiliary equipment design

Instructor: Ronald Heck
Fee $550 .6 CEUs

Fundamentals of Catalytic Converter Integration for Emission Control Web Seminar RePlay
8 Hours
I.D.# PD331142ON

Web Seminar RePlays are captures of the live web seminar. The course sessions are unedited and include interactions between the instructor and live participants. A learning assessment is available at the end of the course to reinforce learning and retention and gauge your understanding of the topic.

This four session course will explore the main elements of the catalytic converter: the catalyst, the honeycomb, and the housing. Session One will cover catalyst fundamentals to equip participants with the basic concepts, important design parameters and main elements of the catalyst, the washcoat and the unitary support. The second session will add discussion on catalyst durability and the effects of in-use on the maintenance of catalyst performance. The third and fourth sessions will explore the ceramic honeycomb as an integral part of emissions control device.

Catalytic emission controls is a key design element of all commercial engines today, whether for autos, trucks, small engines or lawnmowers. Stringent emissions legislation and the advent of low-sulfur fuels have led to new developments to meet the 120,000 vehicle mile durability for passenger cars and 300,000 vehicle mile durability for trucks and buses. Catalytic converter design has become a high priority issue with the new more stringent regulations worldwide.

Participants will be equipped to be conversant in catalysis, the key elements, acronyms, preparation on honeycomb supports, key accelerating aging tests, key performance tests, key issues with in-use, important design parameters and the questions to ask of catalyst suppliers to assist in meeting future emission regulations for all powerplants.

The instructors recommend their book with Robert Farrauto, *Catalytic Air Pollution Control: Commercial Technology, 3rd Edition*, as a supplement to the course content.
Learning Objectives
• Define catalysis and identify catalyst acronyms
• Describe in-use issues
• Question catalyst suppliers
• Interpret basic test procedures for catalyst evaluation and cite key elements in catalyst design
• Define honeycomb substrate, the key properties of honeycomb structure, and the performance parameters in terms of cell dimensions
• Validate performance parameters with measured performance
• Describe test methods relevant to in-use conditions

Who Should Attend
This course will be especially valuable for engineers and others involved in the design, operation and calibration of an emission control system for both mobile and stationary source applications. This includes automobiles, trucks, buses, ships, locomotives, stationary engines, small engines, etc.

This course is designed for mechanical, metallurgical and chemical engineers, materials scientists, and chemists involved in heterogeneous catalysis, who are interested in handling, assembling, and failure analysis of catalytic converters. Participants should have a basic familiarity with automotive emissions for gasoline engines, diesel engines or off-road applications will prove valuable for participants.

This course is designed to cover the entire breath of education and experience backgrounds.

Topical Outline
Session 1 - Catalysis
• Brief historical background
• Fundamentals of catalysis
• Definition of catalyst and the characteristics of catalysis
• Catalytic reactions
• Catalyst preparation, characterization, and durability
• Reaction controlling mechanisms
• Calculating Onboard Energy Storage Needs
Session 2 - Catalyst Durability
• Aging protocols
• Sintering concept and in-use examples
• Masking concept and in-use examples
• Poisoning concept and in-use examples
• Attrition concept and in-use examples
• Consequences of durability on performance
• Charging Systems for Electric Vehicles
Session 3 - Honeycomb Substrates
• Ceramic substrates
• Metallic substrates

• Geometric properties
• Performance parameters
• Physical properties
• Effect of high surface area washcoat
Session 4 - Honeycomb In-Use Durability
• Canning loads and mechanical stresses
• Temperature gradients in transverse direction
• Thermal stresses in washcoated honeycombs
• Allowable stress for lifetime durability

Instructor: Ronald Heck and Suresh T. Gulati
Fee $640 .8 CEUs

Turbocharging for Fuel Economy and Emissions Web Seminar RePlay
4 Hours
I.D.# PD331018ON

Web Seminar RePlays are captures of the live web seminar. The course sessions are unedited and include interactions between the instructor and live participants. A learning assessment is available at the end of the course to reinforce learning and retention and gauge your understanding of the topic.

Turbocharging is already a key part of heavy duty diesel engine technology. However, the need to meet emissions regulations is rapidly driving the use of turbo diesel and turbo gasoline engines for passenger vehicles. Turbocharged diesel engines improve the fuel economy of baseline gasoline engine powered passenger vehicles by 30-50%. Turbocharging is critical for diesel engine performance and for emissions control through a well designed exhaust gas recirculation (EGR) system. In gasoline engines, turbocharging enables downsizing which improves fuel economy by 5-20%.

This Web Seminar RePlay will explore turbocharging for gasoline and diesel (heavy and light duty) engines, including the fundamentals of turbocharging, design features, performance measures, and matching and selection criteria. It will discuss the interaction between turbocharging and engine systems and the impact on performance, fuel economy and emissions. Developments in turbocharging technology such as variable geometry mechanisms, two-stage and sequential (series & parallel) turbocharging, EGR including low pressure loop, high pressure loop and mixed mode systems and novel turbocharging systems will
Learning Objectives

- Identify the basics of how a turbocharger works, how to measure the appropriateness of a turbocharger, and how to select and match a turbocharger to the needs of your powertrain
- Estimate the impact of turbocharging on performance and emissions
- Anticipate potential issues such as packaging, noise, driveability, reliability, and durability
- List the latest developments in turbocharging technology, their impact on engine performance and emissions, and the use of turbocharging world-wide

Who Should Attend

This course will be beneficial to powertrain development engineers, component development engineers, engineering managers, product planners, service engineers, and those developing product strategy. Heavy duty diesel engine development engineers may find the course helpful by increasing their knowledge of turbocharging and EGR systems.

Topical Outline

Session 1
Introduction to Turbocharging
- Fundamentals, Functionality, and Basic Design Features of Turbochargers
- Impact of Turbochargers on Engine Performance, Emissions, and Fuel Economy
- Performance Maps, Selection Criteria, Comparison and Matching of Turbochargers to Engine and Powertrain Needs

Session 2
Advanced Issues and Technology
- Turbocharger Noise, Reliability, and Durability Considerations
- Advanced Technology Developments Including Variable Geometry, EGR Systems, and Multi-Stage Turbocharging
- Worldwide Growth in Application of Turbocharging

Instructor: Kevin Hoag & Roy J. Primus

Fee $425 .4 CEUs
SAFETY AND ACCIDENT RECONSTRUCTION

Includes vehicle impact, accident reconstruction, photogrammetry & forensic photography, occupant safety, and safety standards.

Applying Automotive EDR Data to Traffic Crash Reconstruction

3 Days  
I.D.# C1210

EDR’s are not new, but are becoming more prevalent in part due to a new federal regulation. 49 CFR, Part 563, which affects vehicles produced after September 30, 2012, will result in a standardized and publicly available EDR in 90% of new vehicles. Accident Reconstructionists frequently have trouble reconciling EDR data with other data sources, and improvements in ABS technology result in fewer tire marks visible at the scene of crashes to allow calculation of pre-crash speeds without an EDR.

This course will provide the participant with the skills necessary to analyze EDR data that has already been imaged, apply it to crash reconstruction, and reconcile it with calculations using other data sources. The course will enable the participant to analyze any current and future EDR data set without regard to manufacturer. The class presents the generic analysis step by step, then groups EDR’s into manufacturer-specific families and their data limitations, and works case studies that highlight targeted key learning objectives. The student will also learn key points to satisfy court Frye and Daubert requirements for EDR data to be admissible, and suggest methods to present EDR data that will communicate the data understandably to attorneys and lay juries.

This course has been approved by the Accreditation Commission for Traffic Accident Reconstruction (ACTAR) for 20 Continuing Education Units (CEUs). Upon completion of this seminar, accredited reconstructionists should contact ACTAR, 800-809-3818, to request CEUs. As an ACTAR approved course, the fee for CEUs is reduced to $5.00.

Learning Objectives

By attending this seminar, participants will be able to:

• Describe EDR sensor operation, recording interval and duration, resolution, accuracy, and time latency and articulate the limitations of applying the data to crash analysis
• Calculate min and max speeds prior to loss of control or braking, and at impact based on the last accurate EDR pre-crash speed data point
• Evaluate EDR vs. actual ground speed for specific vehicle operational conditions and vehicle equipment modifications
• Calculate speed at impact and closing speeds by combining EDR Delta V data with normally collected scene and vehicle data such as post crash travel distance, departure angle, drag factor, and vehicle weights
• Apply data to inline rear end, head on, and angular collisions.
• Reconcile EDR data with other physical evidence and combine to narrow speed ranges
• Use time-distance and overlay EDR data on scene maps/diagrams to show where critical driving inputs were made vs. inputs required to avoid collisions

Who Should Attend

This course is a must for anyone involved in the investigation and analysis of passenger car and light truck crashes who needs to understand the types of event data that are available, the limitations of that data, and how to apply it to a collision reconstruction and reconcile it with data from other sources. In addition, this course can be valuable to insurance adjusters and claims managers, and attorneys handling automotive collisions. Engineers designing EDR’s to meet part 563 regulations may also benefit from understanding how the data they store will be used. New analysts requiring training, as well as experienced analysts who require information on changing technology and federal regulations will find this course relevant and timely.
SAFETY AND ACCIDENT RECONSTRUCTION

Prerequisites
An undergraduate degree in mechanical or electrical engineering or a strong technical background is highly recommended. A basic knowledge of college physics (Newton’s laws of motion) and calculus (integrals of acceleration into velocity), and a familiarity with passenger cars and light trucks is expected. Experience or training in crash reconstruction, including acceleration and drag factors, slide-to-stop calculations, and momentum analysis are very helpful, and awareness of critical speed yaw and crush energy calculations will help increase your level of understanding of this material.

Topical Outline

DAY ONE
• Overview
  • Case Study - vision of success
  • Overview - EDR data availability by manufacturer by model and model year
  • 49 CFR Part 563 EDR regulation timing and contents
• EDR Data Analysis
  • Rules of recording and data limitations - Is this recording from my crash, and which of my multiple events is this recording(s) from?
  • Speed data accuracy
  • Speed at impact drills
  • Accelerator pedal release and brake application
  • Using Delta V to obtain closing speed and impact speed
  • Delta V data accuracy

DAY TWO
• GM EDR families - data availability and limitations, and case studies
  • Using Longitudinal Delta V to get speed at impact in angular collisions
  • Using speed data in critical speed yaw single vehicle crashes; transforming speed vs time into speed vs. distance to impact
  • Reconciling EDR data to scene evidence and evaluating uncertainty in inline collisions
  • Multiple events – which event is my recording from?
• Ford EDR families - data availability and limitations, and case studies
  • Ford PCM – evaluating when criminal or negligent behavior occurs, transforming speed vs time data to speed vs distance and overlaying on map to evaluate sight lines
  • Ford ACM – using Delta V in inline collisions and stability control system longitudinal acceleration data to determine real time drag factor

DAY THREE
• Chrysler EDR families - data availability and limitations, and case studies
  • Using acceleration data to calculate Delta V
  • Using yaw angle data to sub-topic
• Toyota EDR families - data availability and limitations, and case studies
  • Using RPM and Delta V to determine speed when actual speed is above data limitation
  • Data latency
• Honda, Mazda, and other manufacturer EDR families (to the extent they are known at the time of the class)
• EDR data admissibility technical foundation

Instructor: Richard R. Ruth
Fee $1745 2.0 CEUs

Driver Distraction from Electronic Devices: Insights and Implications Web Seminar and Web Seminar RePlay

4 Hours
Web Seminar: I.D.# WB1140
Web Seminar RePlay: I.D.# PD331140ON

Although many have an idea of what the term “driver distraction” means, there is no common definition within the research community. Additionally, there are many studies that have investigated the topic, but with varying and sometimes conflicting results. What should be made of these discrepancies?

This four-hour web seminar will provide an overview of driver distraction (predominantly electronic devices): the problem; how to define it; the current state of research and how to critically evaluate that research to make informed decisions; and the effectiveness of state laws and fleet policies to reduce it. The conclusion of the course will summarize strategies, techniques, and technologies that have been shown to be effective in reducing distracted driving from electronic devices.

This course has been approved by the Accreditation Commission for Traffic Accident Reconstruction (ACTAR) for 4 Continuing Education Units (CEUs). Upon completion of this course, accredited reconstructionists should contact ACTAR, 800-809-3818, to request CEUs. As an ACTAR approved course, the fee for CEUs is reduced to $5.00.

Learning Objectives
By connecting with this web seminar, participants will be able to:
• Weigh the extent of the driver distraction problem
• Define driver distraction
• Critically examine the current state of driver distraction research
SAFETY AND ACCIDENT RECONSTRUCTION

- Identify the strengths and limitations of various research approaches that assess driver distraction from electronic devices
- Recognize the difference between various forms of distraction (cognitive, auditory, visual, manual)
- Assess the effectiveness of policy efforts to reduce driver distraction from electronic devices
- Explain that all cell phone “tasks” do not have equal risk
- Determine effective strategies, techniques, and technologies for minimizing distracted driving

Who Should Attend
This course is intended for all those interested in being equipped to critically examine the current state of research in driver distraction. Although the course is aimed at driver distraction from electronic devices, the results pertain to driver distraction in general. Vehicle manufacturers, OEMs, and cell phone providers and manufacturers will be able to use the information presented in this Web Seminar to develop engineering solutions in this area. Government and driving advocate officials will be able to use the information presented in this web seminar to design and deliver informed policy decisions regarding driver distraction. Transportation safety researchers will learn about the latest research in this area as well as future research needs.

Topical Outline
Session 1
- Overview of Driver Distraction Problem
  - Statistics (crashes, injuries, fatalities, monetary burden)
- Forms of Distraction
  - Cognitive
  - Visual
  - Auditory
  - Manual
- Definition of Driver Distraction
- Overview of Methods to Assess Driver Distraction—epidemiological; empirical; naturalistic

Session 2
- Possible Reasons for Discrepancies
  - Driver Choice
  - Self-regulation
  - Arousal
- Effectiveness of Policy Efforts to Reduce Driver Distraction from Electronic Devices
- Research Needs/Next Steps
- Minimizing Distracted Driving from Electronic Devices (what works, what shows promise, what doesn’t work)
- Summary

Instructor: Jeffrey Hickman
Fee $425 .4 CEUs

Injuries, Anatomy, Biomechanics & Federal Regulation

3 Days
I.D.# 85049

Safety continues to be one of the most important factors in motor vehicle design, manufacture and marketing. This seminar provides a comprehensive overview of these critical automotive safety considerations: injury and anatomy; human tolerance and biomechanics; occupant protection; testing; and federal legislation. The knowledge shared at this seminar will enable attendees to be more aware of safety considerations and to better understand and interact with safety experts.

This course has been approved by the Accreditation Commission for Traffic Accident Reconstruction (ACTAR) for 18 Continuing Education Units (CEUs). Upon completion of this seminar, accredited reconstructionists should contact ACTAR, 800-809-3818, to request CEUs. As an ACTAR approved course, the fee for CEUs is reduced to $5.00.

Learning Objectives
By attending in this seminar, participants will be able to:
- Recognize the significance of various injuries, how to rank order and quantitatively compare their severity, and how to access overall severity of multiple injuries.
- Assess the significance of various test results, know their basis and how to interpret them.
- Identify the biomechanical and legal basis of safety regulations and their changes (especially FMVSS 208 and 214).
- Describe the different measuring capabilities of various test dummies including Hybrid III test dummies.
- Contrast the difference between impact and deceleration injuries for various body regions and explain the “third collision,” which takes place within the vehicle.

Who Should Attend
This seminar is designed for all professionals - technical or managerial - who are involved either directly or indirectly with vehicle safety performance. An engineering undergraduate degree in any discipline would be beneficial.

Topical Outline
- Introduction & Background
- Next Generation Restraint Systems
- Injury Scales -- Abbreviated Injury Scale (AIS); Injury Severity Score (ISS); Trauma Score; Harm; Injury Priority Rating (IPR), Functional Capacity Index (FCI)
- Diagnostic Images of Injuries -- Plain Film X-rays, CT, MRI
SAFETY AND ACCIDENT RECONSTRUCTION

• The Role of Alcohol
• Anatomy, Injuries and Tolerance Parameters (By Body Region) -- Head & Neck; Spine; Chest; Abdomen; Pelvis and Lower Extremities
• Test Devices: Basic Differences and Measuring Capabilities for Front and Side Impact Tests
• FMVSS 201, 208, 214 and NCAP and LINCAP -- Current & Proposed Injury Criteria and their Biomechanical Basis
• Regulatory Process -- Federal Rulemaking Process and NHTSA -- Legal Authorizations and Restrictions
• Assessing Pre-existing Conditions and Previous Injury
• Older Drivers - Special Needs

Instructor: Jeffrey A. Pike
Fee $1825 2.0 CEUs

Photogrammetry and Analysis of Digital Media

3 Days
I.D.# C1712

Photographs and video recordings of vehicle crashes and accident sites are more prevalent than ever, with dash mounted cameras, surveillance footage, and personal cell phones now ubiquitous. The information contained in these pictures and video provide critical information to understanding how crashes occurred, and in analyzing physical evidence. This course teaches the theory and techniques for getting the most out of digital media, including correctly processing raw video and photographs, correcting for lens distortion, and using photogrammetric techniques to convert the information in digital media to usable scaled three-dimensional data. Hands-on training using actual case studies and a variety of software titles such as 3D Max, Photomelder and PTLens, will introduce the students to the latest techniques.

Learning Objectives

By attending in this seminar, participants will be able to:
• Remove lens distortion from photographs and video
• Utilize the latest techniques in photogrammetry software
• Accurately locate roadway evidence using photogrammetry
• Determine crush measurements from photogrammetry
• Create photogrammetry-based point clouds
• Analyze video footage for object positioning and timing
• Effectively present your findings in court

Who Should Attend

This course is geared toward individuals interested in video and photographic analysis, including engineers, accident reconstructionists and investigators, and law enforcement. Individuals working in the field of autonomous vehicles and remote sensing will also find the concepts presented relevant since the photogrammetry principles taught in the course are the same used in the cameras and sensors installed on vehicles.

Topical Outline

• Overview of Photogrammetry
• Use in Accident Reconstruction
  • Police use at accident sites
  • Locating scene evidence – no longer physically visible
  • Determining vehicle damage – from photographs alone
  • Photo scanning - scene and vehicles
  • Image projection (visualization, texturing, striation analysis)
  • Video analysis (speed, positions)
  • Video tracking and motion capture
  • Crash test documentation and analysis
  • Visualization – 3D animation (Orienting viewer)
• Types and Methods of Photogrammetry
  • Aerial / Oblique
  • Close-range
  • Stere-o-Photogrammetry
  • Analogue (Grid)
  • Structure from Motion (SFM)
• Software Packages
  • Hands-on Workshop: Eyeball Photogrammetry Method – Scene Diagram
    • Review available photographs, aerial resources, and photo analysis
  • Hands-on Workshop: Photo Rectification (Grid Photogrammetry)
    • Known distance for scale, photo divisions (grid), diagram with evidence placements, compare results
  • Photogrammetry: Formal Methods – Scene
    • Review available photographs, lens distortion removal, effects on accident reconstruction, EXIF data, software
  • Hands-on Workshop: Lens Distortion Removal – library based, manual, straight line and point cloud methods
• On-site Photogrammetry
  • Plot out police matrix on site – inform inspection
  • Hands-on workshop: reverse camera projection – photo grid for reference and line of sight methods
• Camera Matching Photogrammetry (Scene)
  • Hands-on workshop: 3D Studio Max (Autodesk) – photograph analysis; lens distortion removal; import: scan data/survey, photographs; solve for three virtual cameras; results/comparison
  • PFTrack – import: scan data/survey; photograph; solve for camera location; results/comparison
• Video Analysis
SAFETY AND ACCIDENT RECONSTRUCTION

- Video tracking – static and moving camera
- Speed analysis – 2D planar tracking; landmark, line-of-sight analysis
- Photogrammetry: Formal Methods – Vehicle
  - Hands on workshop: PhotoModeler – photograph analysis; lens distortion removal; import photographs; process recognizable features; obtain accurate 3D models or scan data; output, and align; compare results
  - Camera matching photogrammetry
- Photogrammetry: Alternative Methods
  - Target based photogrammetry (Rhino Photo)
  - Hands-on workshop: photo scanning (VisualSFM) – coverage, scale; photograph vehicle; process in VisualSFM; align to 3D model for comparison; accident scene example
- Photogrammetric Technology Applications
  - Image projection - nighttime visibility; texturing (camera projections); striation analysis
- Admissibility
  - Range of uncertainty determination
  - References

Instructor: William Neale and Toby Terpstra
$1795 2.0 CEUs

Project, Accident, and Forensic Photography

I.D.# C1729

Many technical projects, most vehicle and component testing, and all accident reconstructions, product failure analyses, and other forensic investigations, require photographic documentation. Roadway evidence disappears, tested or wrecked vehicles are repaired or permanently altered, and components are tested to failure. Oftentimes, photographs are the only evidence that remains of a wreck or of subjects before or during tests. Making consistently good images during any inspection is a critical part of the evaluation process.

Anyone involved in these technical pursuits must be able to create professional images regardless of the lighting or physical conditions. Photographs should not be “okay” or “close enough” any more than calculations or analysis should be. If the project is important enough for accurate calculations, it is important enough for accurate photographs.

After testing and analysis is complete, results must be presented in court, to boards, management, or peer groups, or in reports and technical papers. This course will provide the skills necessary to consistently produce high-quality photographs for any purpose.

Learning Objectives

By attending in this seminar, participants will be able to:
- Consistently produce quality photographs
- Create complete and meaningful photographic record of any project, accident, or testing
- Ascertain what equipment works, and why
- Describe the photographic process used, from equipment through post-processing (necessary for many court proceedings and peer-reviewed papers)
- Develop a consistent methodology for post-processing and distribution of images

Who Should Attend

This course is designed for individuals who must take photographs as part of their field of work. This may include accident reconstructionists, product failure analysts, forensic scientists and engineers, testing and development engineers, human factors experts, biomechanical and biomedical experts, police agencies, government agencies, and anyone needing to illustrate technical papers or books. Individuals should have some familiarity with taking photographs within their field of work.

Topical Outline

- Why Your Photography Skills Matter
  - Lights off demo (there’s always enough light)
- Camera Fundamentals
  - Camera formats (advantages/disadvantages)
  - DSLR vs. point-and-shoot vs. cell phone
  - Full frame vs. crop sensor
  - Raw vs. JPEG
  - Camera settings
    - White balance: when to manually set, when to use Auto
    - Sharpening
    - Color profile
  - Exposure (aperture, shutter speed, ISO)
  - Aperture: depth of field (DOF); backgrounds/foregrounds
  - Shutter speed: freeze or blur moving subjects; eliminate camera shake
  - ISO: reduce noise while keeping reasonable shutter speed
  - Digital noise
  - Reciprocity: how they all interact
  - Histograms: using in-camera
- Focus
  - Manual vs. autofocus
  - DOF: where to focus
  - Live View: when and how to use
SAFETY AND ACCIDENT RECONSTRUCTION

- Composition
  - Extraneous, distracting, or obstructing elements—foreground, sides, or background; waiting for traffic or people to move
  - Level camera (consistency, irregular sites)
  - Dead space
  - Fill frame
  - Include reference elements, if applicable
  - Parallax errors
  - Light and shadow
  - Lens choices
    - Zoom, prime, fixed, macro
    - Angle of view (natural, compression, distortion)
- Flash Fundamentals
  - Exposing for flash
    - TTL vs. manual (e.g., tire w/shiny rim, seat belt tongue)
  - On vs. off-camera flash
  - Flash accessories & modifiers
  - Macro
- Video
  - DSLR, p&s, camcorder, phone, drone
  - Sound
  - Camera – stationary; moving
- Equipment That Works
  - Polarizer
  - Camera support: tripod, monopod, ground pod, bean bag, windshield mount
  - Ladder, pole, or drone for high viewpoint; tethering
  - Camera cases, bags, belt systems, strap
  - Remote release
  - Batteries: camera, flash, accessories
  - Flashlight: head lamp, focus assist, equipment at night
    - Side lighting
    - Effect on color temperature
  - Camera, lens, & equipment cleaning
- Close-up and Macro Photography
  - Specialized equipment
    - Ring flash
    - Macro tripod or ground pod
    - Close-up lenses
    - Macro focusing rail
    - Focusing
    - Micro photography
- Photographing Outdoors
  - Accident sites
    - Overall establishing shots
    - Close detail shots
    - TPE to locate sun angles
    - Sequences to show sight distance
    - Sequences to show vehicle or pedestrian movements
    - Equipment: polarizer and monopod
    - Vehicles
  - Wide plus detail shots
  - Equipment: polarizer plus fill flash
  - Components and broken pieces
  - Temporarily label potentially ambiguous subjects (LR, A2RI, etc.)
- Weather
  - Wet reflections and glare
  - Fog limiting sight distance
  - Wet streaks across vehicle evidence
  - Snow, hail, etc.
- Night photography
  - Ambient (visibility)
  - Flash, flood, or painting with light (show evidence)
  - Ambient & headlight blooming
  - Documenting conditions as seen
  - Tethering
- Photographing Indoors
  - Ambient light likely not enough
  - White balance
  - Tripod
  - Supplemental light
    - Flash
    - LED
    - Work lights: heat, color temperature
    - Light modifiers
    - Light stands
    - Effects of windows, doors
- Photographing Testing
  - Documenting equipment, facility, and test subjects (before and after tests)
  - Vehicle and component testing: document vehicle, test equipment, dynamic tests
    - Rollover & truck braking examples
  - Chem lab testing: sample area before, sample being removed, sample area after, sample itself
  - Mechanical lab testing: test subject before and after, including pieces, if applicable
- Post-Processing Workflow
  - Develop a consistent methodology: varying workflow is less defensible
  - Calibrate monitor: for color, for night photography
  - Download images
  - Sort - Delete out of focus, bad exposure, duplicates; group similar subjects ("derandomize")
  - Rename photos (here’s how I do it)
    - File number + sequential number
    - Add descriptor if helpful (LF, A2RO, etc., if not labeled in photo)
  - Back up files
  - Image resolution (screen vs. printing)
  - Optimizing Images
  - Noise reduction
SAFETY AND ACCIDENT RECONSTRUCTION

• Sharpening for screen or print
• Lens correction
• Exposure, shadows, highlights, clarity
• Resizing and saving - NOT PDFs!
• Distributing Images
  • Online file sharing sites (Dropbox, ShareFile, etc.)
  • Physical storage (hard drives, thumb or jump drives, CD/DVD)
• Printing for deposition or trial exhibits
• Reading and Interpreting EXIF Data
• Camera and focal length
• Date original photo made
• Special Topics
  • Panoramas
  • Tripod-mounted, handheld, drone
  • Taking overlapping images
  • Stitching in post
  • Photographing travel routes from vehicle
  • Photographing sight distance traffic patterns
  • Photographing for photogrammetry
• Adjusting photos from other sources
  • Extracting detail from night photos
  • Pattern matching (tire track over body)
  • Creating photo exhibits
• Reading and Interpreting EXIF Data
  • Camera and focal length
  • Date original photo made
• Special Topics
  • Panoramas
  • Tripod-mounted, handheld, drone
  • Taking overlapping images
  • Stitching in post
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  • Stitching in post
  • Photographing travel routes from vehicle
  • Photographing sight distance traffic patterns
  • Photographing for photogrammetry
• Adjusting photos from other sources
  • Extracting detail from night photos
  • Pattern matching (tire track over body)
  • Creating photo exhibits

This course is currently in development. Contact SAE Corporate Learning Solutions to learn more about the course and availability.

Reconstruction and Analysis of Rollover Crashes of Light Vehicles

1 Day
I.D.# C1502

For automotive engineers involved in crash reconstruction and analysis, a knowledge of basic accident reconstruction principles and techniques is essential, but often insufficient to answer all of the questions posed by design engineers, regulators, and lawyers. This seminar takes participants beyond the basics of accident reconstruction to physical models and analysis techniques that are unique to the reconstruction of single-vehicle rollover crashes.

The seminar begins by discussing the common characteristics and phases of single-vehicle rollover crashes and giving an overview of the test procedures and data available for developing analysis techniques. The seminar then introduces participants to common types of physical evidence deposited on the roadway and the vehicle during a rollover crash. Participants then learn how to use this physical evidence to reconstruct the motion the vehicle experienced during the crash. Finally, the course introduces the techniques and methods available for analyzing each phase of a single-vehicle rollover crash. This course draws heavily on rollover testing from the literature that has utilized automated steering control and uses these tests to determine the rate of error of common rollover reconstruction techniques.

Students will receive a 200-page book on rollover reconstruction that includes a table summarizing the rate of error of the techniques.

This course has been approved by the Accreditation Commission for Traffic Accident Reconstruction (ACTAR) for 7 Continuing Education Units (CEUs). Upon completion of this seminar, accredited reconstructionists should contact ACTAR, 800-809-3818, to request CEUs. As an ACTAR approved course, the fee for CEUs is reduced to $5.00.

Learning Objectives

By attending in this seminar, participants will be able to:
• Name common characteristics and phases of rollover crashes
• Describe common rollover test procedures and the data they offer for reconstruction
• Identify and document common types of physical evidence from rollover crashes
• Use physical evidence to reconstruct the motion of a vehicle involved in a rollover crash
• Estimate the rate at which a vehicle will decelerate during each phase of a rollover crash
• Calculate the speed a vehicle was traveling during each phase of a rollover crash
• Determine what steering and braking inputs a driver utilized before a rollover
• Quantify the forces applied to a vehicle when it impacts the ground during a rollover
• Analyze the trajectory of an occupant that was ejected during a rollover
• Quantify the rate of error of common reconstruction techniques for rollover

Who Should Attend

This course is designed for accident reconstructionists and engineers. Individuals with a strong background in crash reconstruction, but new to or inexperienced in the specialized area of rollover crash reconstruction, will benefit the most from the course material. Many of the techniques will also be applicable to other crash types, and will therefore also benefit anyone looking to deepen their understanding of crash reconstruction.
SAFETY AND ACCIDENT RECONSTRUCTION

Prerequisites
An undergraduate engineering degree or a strong background in crash reconstruction is recommended. A basic knowledge of college algebra, college physics, and familiarity with common analysis techniques used in crash reconstruction will be assumed.

Topical Outline
• Types of Rollover Crashes and Rollover Statistics
• General Characteristics of Rollover Crashes
  • Test Methods and characteristics; field relevance
• Physical Evidence from Rollover Crashes
  • Scene evidence and documentation - photogrammetry to locate evidence
  • Vehicle evidence and documentation
• Analysis Methods – Rollover Phase
  • Average deceleration rates - dependence on surface and vehicle type?
  • Non-constant deceleration models
  • Evaluating roll motion from physical evidence - glass; scratch patterns; rim gouges
  • Typical rollover characteristics - # of rolls v. rollover distance; typical roll velocity curves
  • Roof-to-ground impact model - testing and validation
  • Simulation - PC-crash; HVE; validation considerations of simulation software
• Analysis Methods – Trip Phase
  • Physical evidence
  • Analytical models: equations - static stability factor, increasing the complexity and accuracy; estimating the center of gravity height; estimating the roll moment of inertia; trip duration
  • Simulation: PC-crash; HVE; validation considerations of simulation software
• Analysis Methods – Pre-Trip Phase (Loss-of-Control)
  • Tire marks
  • Striations and their meaning - uncertainty and sensitivity analysis
  • Calculating speed loss
  • Is the critical speed equation applicable?
  • Testing - validation of striation analysis; validation of speed loss equations

Instructor: Nathan Rose & Gray Beauchamp
Fee $810 .7 CEUs

Reconstruction and Analysis of Motorcycle Crashes
1 Day
I.D.# C1506

The reconstruction and analysis of motorcycle crashes requires a specialized set of skills and knowledge beyond those required for typical four wheel vehicles. This seminar takes participants beyond the basics of crash reconstruction to physical models and analysis techniques that are unique to the reconstruction of motorcycle crashes, providing learners with a comprehensive summary of applicable reconstruction techniques. In addition, case studies will be utilized throughout the course to further explore crash causation, configuration, kinematics, dynamics, and handling characteristics, focusing on pre-crash, impact and post impact analysis.

This course has been approved by the Accreditation Commission for Traffic Accident Reconstruction (ACTAR) for 7 Continuing Education Units (CEUs). Upon completion of this seminar, accredited reconstructionists should contact ACTAR, 800-809-3818, to request CEUs. As an ACTAR approved course, the fee for CEUs is reduced to $5.00

Learning Objectives
By attending in this seminar, participants will be able to:
• Identify motorcycle crash causation from field studies
• Identify pertinent engineering design parameters affecting motorcycle dynamics
• Describe motorcycle motions both in plane and cornering
• Describe common characteristics and phases of motorcycle crashes
• Identify, document, and analyze common types of vehicle and roadway evidence pertinent to motorcycle crashes
• Use physical evidence to reconstruct the motion of a motorcycle involved in a crash
• Estimate the rate at which a motorcycle decelerates during each phase of a crash
• Calculate the speed a motorcycle travels during each phase of a crash sequence
• Evaluate the steering and braking inputs a rider used before a crash
• Identify factors leading to a single vehicle motorcycle crash

Who Should Attend
This course is designed for engineers or other professionals with a strong background in crash reconstruction, but new to or inexperienced in the specialized area of motorcycle crash reconstruction.
SAFETY AND ACCIDENT RECONSTRUCTION

Prerequisites
An undergraduate engineering degree or a strong background in crash reconstruction is recommended. A basic knowledge of college algebra, college physics, and familiarity with common analysis techniques used in crash reconstruction will be assumed.

Topical Outline
• Introduction
• Motorcycle Crash Characteristics
  • CDC Data, GES / NASS, NHTSA data, Hurt Report, Thai Report, MAIDS Report
• Motorcycle Performance and Design
  • Motorcycle types – dirt, sport, touring, cruiser
  • Configuration - engine types, frame types, rake / trail, fork offset, C.G. location, wheel radius, suspension travel, clearance, technologies: ABS/TCS/ESC, tire types - multi-compound, multi-surface (DOT), knobbie, sport, touring
  • Rectilinear Motion - steady state motion, aerodynamic forces, braking / accelerating
  • Cornering - countersteer, lean angle, steady state, understeer/oversteer, roll motion, gyroscopic effects
• Motorcycle Inspection
  • Damage, mechanical, and tire documentation
• Scene Information
  • Scene inspection and evidence, tire marks, roadway evidence
• Analysis Methodology - Motorcycle Single Vehicle Crashes
  • Terrain effects (edges, potholes, ridges)
  • Instabilities - high side crashes, kick back (lift off roadway), chattering, low side crashes, weave/wobble
  • Rider inputs leading to crashes
• Analysis Methodologies – Pre-Crash Phase
  • Front braking, rear braking, overbraking, sliding
• Analysis Methodology - Motorcycle Crash Phase
  • Motorcycle crash tests - ISO 13232, UCLA (Severy), IMMA, JARI, SAE, KEVA
  • Crash configuration
  • Crash partner energy calculation; narrow object crash analysis of vehicles
  • Motorcycle crash energy calculation
  • Component evaluation and/or testing
  • Computer simulation – SMAC, PC-Crash
• Analysis Methodology - Motorcycle Post-Crash Phase
  • Motorcycle trajectory, sliding vs tumbling, sliding characteristics

Instructor: Stein Husher
Fee $810 .8 CEUs

NEW! SAE ACCIDENT RECONSTRUCTION CERTIFICATE PROGRAM
Watch for the certificate icon to indicate course titles that are part of an SAE multi-course certificate program.
Become more proficient in the practice of vehicle crash/accident reconstruction by successfully completing this certificate program from SAE. Required courses guide you through crash reconstruction methods, vehicle dynamics, and event data recorder (EDR) technology. Then select three electives that suit your individual technical interest area. Completing the SAE Accident Reconstruction Certificate Program grants you eight credits towards the SAE/Kettering University 20-credit Certificate in Automotive Systems or Kettering’s 40-credit M.S. in Mechanical Engineering. Visit training.sae.org/collegecredit for more information. View the list of required and elective courses and more information on enrolling in this SAE certificate program-training.sae.org/credentialing/certificate/accident.htm

Side Impact Occupant Safety and CAE
2 Days
I.D.# C0717
Side impact crashes account for approximately twenty-six percent of all motor vehicle fatal crashes, second only to frontal crashes, according to a report by the National Highway Transportation and Safety Administration (NHTSA). While car companies and suppliers continue to develop new technologies that make vehicles safer, NHTSA rolled out updated safety regulations (FMVSS 214) based on new research studies, making vehicle safety design more and more complex.

This seminar is designed to familiarize participants with the engineering principles behind vehicle and restraint designs for occupant safety. Students will learn the mechanics of side crashes and how vehicle structures, restraint systems, and interiors affect occupant safety. Students will also be exposed to system, subsystem and component level CAE and testing tools used in the simulation of side impacts. Accident crash statistics, biomechanics, government regulations and public domain frontal safety tests will also be covered. A combination of hands-on activities, including computer simulations, discussion, and lecture are used throughout the course. A camera that takes slow-motion movies at up to 1,000 frames per second is employed to capture the miniature Side Impact Crash Demo Test kit on day one, which enables the registrants to thoroughly analyze the crash impact.
SAFETY AND ACCIDENT RECONSTRUCTION

This course has been approved by the Accreditation Commission for Traffic Accident Reconstruction (ACTAR) for 12 Continuing Education Units (CEUs). Upon completion of this seminar, accredited reconstructionists should contact ACTAR, 800-809-3818, to request CEUs. As an ACTAR approved course, the fee for CEUs is reduced to $5.00

Learning Objectives
By attending this seminar, attendees will be able to:
• Explain side impact and how the vehicle structure, door trim and side airbags affect occupant responses
• Describe different dummy types and what injury metrics are used to evaluate occupant injuries
• Interpret FMVSS 214 regulations and public domain safety evaluations such as LINCAP and IIHS safety rating systems
• Describe system, sub-system and component level CAE and testing tools that are used to assist in design decisions
• Evaluate the relative effect of door intrusion and restraint system characteristics
• Select correct data filtering to process crash test data

Who Should Attend
This course is designed for engineers who are new to the field of occupant protection in side impacts as well as those individuals who require knowledge regarding IIHS side impact ratings and the FMVSS 214 regulation. This course will also be of interest to engineers who deal with side impact issues or are involved in designs of side impact related components, such as airbags, door trim, side impact bolsters, door structures and body structures.

Prerequisites
An undergraduate engineering degree or a strong technical background is highly recommended. Participants should have a basic working knowledge of Microsoft Excel.

Topical Outline
DAY ONE
• Vehicle Crash Safety Introduction
  • Crash injury and fatality data from the U.S.
  • Distribution of different crash types
  • Active safety and passive safety
  • Trend of crash safety ratings
• Vehicle Side Impact Test Modes
  • Moving deformable barrier impact
  • Pole impact
• Biomechanics
• Test Dummies and Injury Metrics
  • SID/HIII; SID IIs & SID IIs-FRG
  • ES-2 & ES-2re
  • BioSID & WorldSID
• U.S. Regulatory Requirements
  • FMVSS 214, 201, 301
• U.S. Public Domain Tests and Performance Ratings
  • LINCAP
  • IIHS
• European Regulatory Requirements
• Euro-NCAP and Performance Ratings in Other Markets
• Test Data Processing
  • Filtering and SAE J211 guidelines
  • HIC, TTI
  • Numerical integration, differentiation, occupant relative travel
  • Hands-on in computer lab: test data processing
• Hands-on Computer Exercises
  • Simulations Using Simplified Models
  • Crash Data Processing

DAY TWO
• Side Impact Mechanics
  • Vehicle structure
  • Door trim
  • Thoracic and pelvic bolsters
  • Inflatable devices for impact protection
• Restraint System for Side Impact
  • Thorax bag
  • Shoulder bag
  • Thorax-head combo bag
  • Thorax-pelvis combo bag
  • Seat mounted and door mounted side airbags
  • Inflatable curtain
  • Inflatable shoulder belt / lap belt
• Crash Sensors
  • G-based sensors; Pressure sensors
• Vehicle Crash Computer Modeling (CAE)
  • Vehicle CAE model
  • Occupant CAE model
  • Crash Barrier CAE models
• Component and Sub-system Crash Development Tools
  • Sled tests
  • Sub-system level FEA
  • Madymo for airbag development
• Vehicle Level Crash Development and Test Data Analysis
  • Barrier test
  • Crash vehicle re-build
  • Surrogate vehicle test
  • Full vehicle FEA analysis
  • Test data analysis
• Design Optimization and Robustness
  • DOE used in component test, HYGE sled and CAE
  • Optimization in CAE
  • Robust design using CAE

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• Hands-on Project Using Miniature Test Kit
  • The effect of vehicle stiffness
  • The effect of door trim design, restraint system
• Summary

Instructor: Stephen Kang & Zhibing Deng
Fee $1445 1.3 CEUs

Vehicle Crash Reconstruction: Principles and Technology

3 Days
I.D.# C1728

Crash reconstruction utilizes principles of physics and empirical data to analyze the physical, electronic, video, audio, and testimonial evidence from a crash to determine how and why the crash occurred. This course will cover basic principles and approaches to accident reconstruction (breaking the analysis down into phases, for instance). Methods of evidence documentation will be covered. Since different crash types produce different evidence types and call for different analysis methods, physical evidence, empirical data, and analysis method for the following crash types will be covered: in-line and intersection collisions (planar impact mechanics and crush analysis), pedestrian collisions, motorcycle crashes, rollover crashes, and heavy truck crashes. Analysis methods will also be presented for electronic data from event data recorders and for video. Finally, the course will cover photogrammetry, simulation, and uncertainty analysis. Each topic will be covered to a level of detail that will be useful for practicing accident reconstructionists and that will prepare the students to dive into each topic in more detail either through their own research or through SAE’s other course offerings. Classroom activities will provide students an opportunity to have hands-on experience with crash evidence. Attendees of this course will receive a copy of the Vehicle Accident Analysis and Reconstruction Methods, published by SAE International, 2011.

Learning Objectives

By attending this seminar, attendees will be able to:
• Describe the basic evidence documentation techniques
• Recognize the different types of evidence produced by the different collision types
• Describe the basic mechanics of collision
• Summarize the principles of planar impact mechanics and crush analysis
• Describe the forms of analysis applicable to each collision type
• Summarize the empirical data available in the literature for each collision type

Who Should Attend

This course is well-suited for individuals just beginning to work in the area of crash reconstruction as well as persons already in the field who want to establish a firmer foundation in current crash reconstruction technology.

Topical Outline

DAY ONE
• General Principles of Crash Reconstruction
  • NHTSA 9-cell matrix
  • Types of evidence
  • Goals in reconstructing a crash
• Evidence Documentation and Photogrammetry
  • Basic photography
  • Priority photos
  • Scanners/drones
• Acceleration, Braking, and Friction
  • Measuring/estimating friction
  • Vehicle braking performance
  • Acceleration performance
  • Identifying tire marks/causation
• Inline Collisions (Momentum and Crush Analysis)
  • Conservation of momentum
  • Crush analysis
• Intersection Collisions (Planar Impact Mechanics and Simulation)
  • Planar impact mechanics
  • Crush analysis
DAY TWO
• Intersection Collisions (Planar Impact Mechanics and Simulation)
  • Planar impact mechanics
  • Crush analysis
• Motorcycle Crash Reconstruction
  • Physical evidence from motorcycle crashes
  • Braking, cornering, and swerving
  • Motorcycle crashes on curves
  • Motorcycle crashes with other vehicles
• Pedestrian Crash Reconstruction
  • Physical evidence from pedestrian crashes
  • Empirical speed-throw distance relationships
  • Theoretical modeling
  • Simulation
• Rollover Crash Reconstruction
  • Physical evidence from rollover crashes
  • Loss-of-control phase
  • Trip phase
  • Rollover phase
DAY THREE
• Rollover Crash Reconstruction
  • Physical evidence from rollover crashes
SAFETY AND ACCIDENT RECONSTRUCTION

- Loss-of-control phase
- Trip phase
- Rollover phase
- EDR Data Analysis
  - Analyzing pre-crash data
  - Analyzing Delta-V data
  - Utilizing EDR data in a reconstruction analysis
- Heavy Truck Crash Reconstruction
  - Physical evidence from heavy truck crashes
  - Brake force and deceleration rate calculations
  - Heavy truck acceleration
  - Heavy truck maneuvering capabilities
  - Heavy truck event data recorders
- Video Analysis
- Simulation

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<tr>
<th>Instructor:</th>
<th>Nathan Rose and Wesley Grimes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fee $1875</td>
<td>2.0 CEUs</td>
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Vehicle Frontal Crash Occupant Safety and CAE

2 Days
I.D.# CO621

Car companies and suppliers continue to develop new technologies that make vehicles safer and regulatory agencies continue to update safety regulations based on new research studies, making vehicle safety design more and more complex. This seminar covers the mechanics of frontal crashes and how vehicle structures, vehicle restraint systems, and vehicle interiors affect occupant safety. It also describes details of how CAE tools work in the simulation of frontal crashes. The goal of the course is to familiarize participants with engineering principles behind vehicle and restraint designs for occupant safety. Accident crash statistics, biomechanics, government regulations and public domain frontal safety tests will be reviewed briefly. Students will also be exposed to Madymo, one of the major occupant CAE tools. The basic inner workings of the tool, such as rigid body dynamics, joints, contact, airbag and seatbelt modeling, and modeling techniques will be shared with the class. The class also offers participants opportunities to do hands-on computer analysis as well as simplified hands-on crash tests, where students can learn first-hand how vehicle pulses and restraint design affect occupant response. A camera that takes slow-motion movies at up to 1,000 frames per second is employed to capture the miniature Side Impact Crash Demo Test kit, which enables the registrants to thoroughly analyze the crash impact.

Learning Objectives
By attending this seminar, participants will be able to:
- Explain frontal crashes and how vehicle structure and restraint systems affect occupant responses
- Describe how restraint components function in crashes and protect occupants
- Carry out calculations of injury metrics using test or CAE results as input
- Describe the occupant CAE tool, Madymo, and how it works
- Explain assumptions and limitations of CAE models
- Evaluate the relative effect of crash pulse, and restraint system characteristics
- Analyze and evaluate crash pulses
- Describe FMVSS 208 and NCAP requirements and metrics
- Explain the use of different dummies and their limitations

Who Should Attend
This course is designed for engineers who are either new to the field of automotive safety or familiar with only certain aspects of automotive safety. It can help engineers, for example, who design a specific component in a vehicle to understand how it works in vehicle crashes, how its characteristics affect occupant response and how it relates to other components in the vehicle.

Prerequisites
An undergraduate engineering degree or a strong technical background is highly recommended. Participants are expected to have a basic working knowledge of Microsoft Excel.

Topical Outline
DAY ONE
- Vehicle Crash Safety Introduction
  - U.S. crash injury and fatality data
  - Distribution of different crash types
  - Active and passive safety
- Vehicle Frontal Crash Modes
  - Frontal rigid, offset deformable and angular barriers
  - Out of position tests, driver and passenger
  - HYGE and Servo sled tests
  - Component tests
- Biomechanics - Human Anatomy and AIS Injury Scale
- Brief Overview of Frontal Test Dummies and Injury Metrics
- Frontal Crash Mechanics
  - Crash pulse, front loaded, rear loaded
  - Class Project using Excel: calculate vehicle velocity and crush from pulse; get maximum crush, time to zero velocity; pulse comparison, front-loaded and rear loaded pulses
  - Intrusions
  - Occupant to restraint gaps and restraint characteristics
  - Belted vs. unbelted occupant
  - Class project: determining occupant responses
  - Airbag quickness and stiffness
  - Belt slack, pretension, EMR
  - Class project: Determining the best restraint characteristics
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• Driver vs. passenger
• Typical crash event
• Class project: determining the optimal pulse shape
• 5th percentile female submarining
• Crash Sensor - Airbag & Pretensioner Firing & Non-firing Conditions; Sensor Tests

DAY TWO
• Brief Review of U.S. and European Regulations and Public Domain Safety Ratings
• Numerical Data Processing
  • Filtering and SAE J211 guidelines
  • HIC, Nij, Cumdur, V*C calculations
  • Numerical integration, differentiation, occupant relative travel
• Vehicle Crash Computer Modeling (CAE)
  • Vehicle structure CAE, finite element method
  • Occupant CAE, rigid body dynamics
  • CAE assumptions and limitations
• DABLIT - Component Test for Driver Airbag
• DOE and Optimization
• Restraint System
  • Airbag, inflator, single & dual stage
  • Crash sensor, Restraint Control Module (RCM)
  • Seatbelt, D-rings
  • Retractors, torsion bars
  • Buckle and retractor pretensioners
  • Steering column stroke
  • Steering wheel lower and upper rims
  • Knee bolster
• Real World Crashes - Safety for the Aging Population; Crash Severity Distribution

Instructor: Stephen Kang
Fee $1395 1.3 CEUs
SAFETY AND ACCIDENT RECONSTRUCTION

RELATED TRAINING SOLUTIONS
Some of our courses apply to more than one technology category. Consider these related courses described in other sections of this resource guide.

Tire Forensic Analysis
This seminar provides a detailed description of tire failure modes, their potential causes, identification, and the sometimes subtle nuances that go along with determination of tire failure.
Read more about this course on page 6.

Tire and Wheel Safety Issues
In this seminar engineering fundamentals are discussed and illustrated with numerous practical examples and case studies of current public interest.
Read more about this course on page 7.

Basic Tire Mechanics and Inspection
This course provides an introduction to basic tire mechanics, including materials, sidewall stampings, pressure, tread patterns, tire inspection and basic tire failure identification of passenger and light truck tires.
Read more about this course on page 2.

Product Liability and The Engineer
The concept of safety and reliability has been altered from a purely engineering/manufacturing concept to a legal/manufacturing approach. This new approach requires an understanding of legal concepts as related to the manufacturing and design process.
Read more about this course on page 120.

The Role of the Expert Witness in Product Liability Litigation
This seminar will address the critical issues that every person who may be, has been, or is, an expert witness must understand to assist both the attorney and the product manufacturer, regardless of which side the expert serves.
Read more about this course on page 121.

Review the Cybersecurity courses on pages 34-38.
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Michael F. Albright is co-founder and General Manager of SignalX Technologies LLC, a firm specializing in NVH engineering and custom test & measurement application development. His past positions include Business Development Manager for the NVH consulting group of LMS North America, Management and Project Engineering positions at the Roush Anatrol Division of Roush Industries, Inc, and Civilian engineering for the U.S. Navy. With experience predominantly in the automotive industry, Mr. Albright has addressed a very diverse range of noise and vibration control issues including powertrain NVH, vehicle NVH, brake noise, engine accessory noise, driveline NVH, test procedure and facility development, test/CAE hybrid simulation methods, as well as a host of manufacturing quality issues. Mr. Albright holds a B.S. in mechanical engineering from University of Cincinnati and an M.S. in mechanical engineering from Purdue University.

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Igor Anilovich is currently a Diesel OBD II and AECD Leader in the General Motors Powertrain Engineering Group where he focuses on OBD II design and emission control strategy compliance for diesel engine applications. Prior to that, Dr. Anilovich was a Technical Specialist for Diesel Exhaust Gas Sensors Diagnostics. Dr. Anilovich was also a Control Design Engineer with responsibility for new concepts development for OBD II compliant diagnostics for gas engine applications. Dr. Anilovich won the 2008 “Boss” Kettering Award. He is a DFSS Black Belt and SAE member. Dr. Anilovich is an author of more than thirty patents, multiple publications and research reports. Dr. Anilovich has an M.S. from the Aviation University in Kharkov, Ukraine and a Ph.D. from the Automobile and Road Construction University in Kharkov, Ukraine.

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Dr. Ewa A. Bardasz is a Fellow at The Lubrizol Corporation, where she is currently responsible for overseeing technical activities related to lubricating novel combustion hardware, aftertreatment systems and emissions. She is experienced in the areas of crankcase lubrication, corrosion inhibition, engine testing and exhaust emissions control. Dr. Bardasz holds over 25 patents, has published multiple technical and scientific papers, authored chapters for technical books and is a frequent invited speaker at conferences throughout the U.S. and Europe. She is the recipient of the SAE International 2002 Award for Research on Automotive Lubricants, and 2009 SAE International Environmental Excellence in Transportation Award. Dr. Bardasz is a Fellow of SAE International and a Fellow of the Society of Tribologists and Lubrication Engineers (STLE) where she is also on the Board of Directors. Dr. Bardasz obtained a M.Sc. in Chemical Engineering from Warsaw Technical University and a PhD in Chemical Engineering from Case Institute of Technology.

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Simon J. Baseley was the Director of Engineering Strategy and Program Management within the Intelligent Hydraulic Drive Group at Bosch Rexroth Corporation until he retired in July 2011. He currently works part time at the University of Michigan as a Visiting Research Investigator in the Automotive Lab. Mr. Baseley was also a Director of the Intelligent Hydraulic Drive Products for the Dana Corporation, where he worked to develop and promote applications for hydraulic drive systems for vehicles. Prior to that, he was the Director of Advanced Engineering for Hobourn Automotive Ltd. where he formulated and executed new hydraulic pump applications and directed the applied research initiatives in fluid flow and noise suppression. Mr. Baseley also has extensive experience within the aerospace industry, previously serving as Chief Design Engineer for Rolls-Royce Ltd. An active member of SAE International, Mr. Baseley has written several papers on noise related research and hydraulic hybrid systems. He holds eight patents related to hydraulic pumps and hybrid systems. Mr. Baseley, formally educated in the U.K., received a B.S. in Mechanical Engineering from the University of Nottingham and a M.S. in Aircraft Propulsion from Cranfield University.

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Mr. Beauchamp is a Principal Engineer focusing on vehicular accident reconstruction at Kineticorp, LLC. He has been working and conducting research in the field of accident reconstruction since 2003. Mr. Beauchamp has published numerous technical papers and articles related to accident reconstruction. The majority of his research has focused on the various phases of single vehicle loss-of-control crashes including controllability following tire disablation, tire mark interpretation, vehicle trip dynamics and rollover dynamics. Much of his work has involved full scale vehicle testing. Mr. Beauchamp holds a B.S. and M.S. in Mechanical Engineering and is a Professional Engineer in the state of Colorado.

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Blair, Julian
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Dr. Bolourchi is currently a staff research engineer II with Nexteer Automotive Innovation Center where he designs algorithms for advanced chassis systems. Farhad helped develop Delphi’s first electric power steering system, for which he received the company’s highest technical award, the “Boss Kettering”. Dr. Bolourchi previously worked for Hughes Aircraft Company and gained valuable experience in both missile systems controls and automotive applications. He was also a part time faculty member at the University of California - Davis and Sacramento State University. Farhad received GM’s President Honors award in 1998, and was inducted to Delphi’s Hall of Fame in 1999. He has numerous publications and patents related to control systems and automotive applications. Dr. Bolourchi has a B.S. in Mechanical Engineering from Northeastern University, a M.S. in Mechanical Engineering and a Ph.D in Nonlinear Control Systems from the University of California - Davis.

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Mr. Dawson has over 35 years of experience in Quality and Reliability engineering. President and CEO of Quality-One International since 1986, Mr. Dawson has previously held engineering and training positions at Ford Motor Company, and Wickes Manufacturing. As CEO of Quality-One, Mr. Dawson has consulted with hundreds of companies and trained thousands of quality and engineering professionals in Failure Mode and Effects and Analysis (FMEA) and Advanced Product Quality Planning (APQP). He periodically teaches these and other related quality and reliability courses for several colleges and universities in the US, Canada, and Australia and speaks at engineering related functions. Mr. Dawson has written and collaborated on several technical books and manuals including “Murphy’s Law Overruled (FMEA in Design, Process and Service)”, Ford Design Institute FMEA Handbook and AIAG Effective Error Proofing CQI-1B. He has participated, written and presented numerous technical papers at ASQ, ASM and other professional organizations. Mr. Dawson has a B.S. in Metallurgical Engineering from Penn State University and is a Certified Quality Engineer (CQE), Certified Reliability Engineer (CRE) and is a Master Black Belt in the practice of Six Sigma.

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**Doherty, Michael**
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Michael Durack is currently Technology Director and Managing Director of Ultimate Transmissions. He was educated as an Architect but quickly moved into the role of Contractor and construction systems and building materials innovator. Much of his working life has been spent in South East Asia delivering large scale low and medium cost housing projects and the machinery and systems associated with the delivery of these projects. Towards the beginning of this century, he specialized in the development of building materials manufacturing equipment. This led to specific involvement in the development of more energy efficient variable speed industrial drives. He used the experience associated with the design and manufacture of industrial drives to develop a type of mechanical CVT that has direct application to the automotive industry. Michael has published a large number of technical papers on the subject of traction drives and was awarded the best paper at the 2014 FISITA conference in Maastricht.

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INSTRUCTOR BIOGRAPHIES

Giapponi, Thomas
Mr. Giapponi’s professional career spans the Armstrong Rubber Company and Pirelli North America in the capacities of Tire Design Engineer, Manager Medium/Heavy Truck Tires, Manager Light Truck and Passenger Car Tire Engineering, Director of Tire Engineering and Director of Tire Testing. He directed Pirelli’s North American R&D and Quality as the Director of R&D, Technical Director and Director of Quality in the market. In 2001 Mr. Giapponi started TRGtech Tire Consulting LLC which performs tire forensic investigations, tire patent defense, and tire forensic training. Mr. Giapponi received his Bachelor of Science in Engineering from Purdue University and is a registered P.E. in Connecticut.

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Geoff Goddard is Professor in Motorsport Engineering Design and Head of the Vehicle Engineering Research Group in the School of Technology at Oxford Brookes University in the UK. Following a position in the gas turbine industry as a Rolls Royce University Apprentice, he joined Cosworth Engineering in 1970 and was later promoted to Chief Designer by Keith Duckworth. The engines he designed made the Cosworth name synonymous with winning including the F1 World Championship as well as World Sportscar, World Touring Car, and World Rallycar championships. In 1995, he joined TWR as Director of Engine Design responsible for the design and development of engines for clients including Aston Martin DB7, Volvo, Ducati, Renault, SAAB, Audi, GM, Ford, Nissan, and the Oldsmobile Aurora. While working in these companies, he led the open design-led structure favoured by Duckworth, which allowed a free-flow of information across the boundaries of all technical areas, enabling design engineers to expand their knowledge and vision at an incredible pace. This was demonstrated by their winning results, making Cosworth the best post-graduate university in the world. By joining Oxford Brookes University, he brought some of this vision to their engineering courses and helped initiate new MSc courses in Racing Engine Design and Motorsport Engineering. He has also underpinned PhD research programmes for F1 clients and industrial programmes covering advanced combustion research into future fuels, nano-particle additives, and various championship winning racing programmes. Geoff’s external activities include Director of Geoff Goddard Engines Ltd consulting on engines, Ambassador for EEMS, the British Government’s Energy Efficient Motor Sport body, and co-chair for the SAE International Motorsport Conference Engine and Drivetrain Panels.

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Grimes, Wesley
Wesley Grimes is President of Collision Engineering Associates, a firm specializing in accident reconstruction analysis involving motor vehicles. He has been in the field of accident reconstruction since 1981. Mr. Grimes served for many years on the SAE International Accident Investigation Practices committee and was a co-organizer of the technical paper sessions on accident reconstruction for 10 years, receiving the Forest R. McFarland Award from SAE International. He received his Bachelor of Science in Mechanical Engineering from Arizona State University.

Gulati, Suresh
Dr. Suresh Gulati was a Research Fellow in the Science and Technology Division of Corning Inc. where he specialized in the behavior of glass, glass-ceramics and ceramics subjected to mechanical and thermal loads, their fatigue and fracture properties and their long-term reliability. He is a member of American Men and Women of Science and Who’s Who in Technology Today. Dr. Gulati is the author of over 200 publications in the area of ceramic catalyst supports, fiber optics, liquid crystal display glasses, cathode ray tubes, space windows, automotive windshields, and stepper lenses made from high purity fused silica. Before joining Corning, he held positions with Cornell University, the University of Colorado, and Continental Can Company. Dr. Gulati has a Ph.D. in applied mechanics from the University of Colorado, an M.S. in mechanical engineering from Illinois Tech and a B.S. in mechanical engineering from the University of Bombay, India.

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Dr. Jody Hall is currently the Vice President, Automotive Market for the Steel Market Development Institute. Prior to that she was the Technical Integration Engineer for the Body Manufacturing Engineering Center at General Motors in North America where she was responsible for new steel applications and specifications for all stamped steel body components. Jody’s experiences in manufacturing at General Motors ranged from research and development of new materials and manufacturing processes to solving production problems. Her background includes engine and transmission components, body sheet metal, stamping die design and construction, plant floor data management, and manufacturing strategic planning. She was also GM’s manufacturing representative to the Auto/Steel Partnership Joint Policy Council for fourteen years. Dr. Hall is the recipient of numerous professional awards including the University of Michigan College of Engineering Alumni Merit Award in 2007, the Auto/Steel Partnership Instrumental Change Award in 2007, the GM Die Engineering Services Award for Leadership in 2005, the USCAR Special Recognition Award for Outstanding Contributions in 2004, and the GM Chairman’s Honors Award in 2001. Dr. Hall has a B.S. in Materials & Metallurgical Engineering, and a M.S. and Ph.D. in Materials Science and Engineering from the University of Michigan.

Hall, Thomas J.
Thomas J. Hall currently owns and manages MaxG Technology LLC, a technical consulting and training company, specializing in Vehicle Braking and Stability technology for the transportation industry. Prior, he was the Chief Engineer for Global Brake Systems - General Motors for the Robert Bosch Chassis Systems Division. He also served as the Engineering Manager for System Design and Validation at ITT Automotive, Continental Teves. His experience also includes development of ABS, TCS and Stability Control Systems, responsibility for application of system engineering principles and process to the brake industry and development and promotion of brake system proposals and advance braking technologies. Mr. Hall has a B.S. in mechanical engineering from the University of Michigan and a Master of Science in Finance from Walsh College.

Haughey, Bill
Bill Haughey is a respected consultant and instructor in the areas of Failure Modes Effects Analysis, Design for Manufacturability and Assembly, Design Review Based on Failure Modes, Design Review Based on Test Results, and other GD3 methodologies. He is a current member of the issuing committee of the SAE International J1739 FMEA standard, SAE International Automotive Quality and Process Improvement Committee; the SAE International Automotive Electronic Systems Reliability Standards Committee; and the AIAG FMEA Fourth Edition Recommended Practice Committee. Mr. Haughey was recently approved to lead the development of a new SAE International DRBFM
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Recommended Practice (J2886). Mr. Haughey formerly worked for GM, where he held various managerial, manufacturing, and engineering positions including Process Lead and Supervisor for FMEA and DFM/A. While at GM, Mr. Haughey also supported Tatsuhiko Yoshimura in the global implementation of the GD3 (DRBFM) methodology. Yoshimura considers Mr. Haughey to be a subject matter expert in the GD3 methodologies, including DRBFM and DRBTR. Mr. Haughey received a B.S. degree from the University of Michigan and M.S from Central Michigan University, and has the following certifications: Black Belt in GD3 (DRBFM and DRBTR); Master Design for Manufacturability and Assembly Engineer; and Certified Internal Auditor.

Heck, Ronald
Dr. Ron Heck is currently an independent consultant. Prior to that, Ron was a research manager responsible for developing catalyst technology for Engelhard Corporation. He has worked on the development of catalytic processes in SCR NOx, NSCR NOx, automotive catalyst, diesel catalyst, PremAir™ catalyst systems, hydrogenation technology, ozone abatement, volatile organic compound abatement, ammonia oxidation, chemical feedstock purification and chemical synthesis. Ron is a member of American Men and Women of Science and Who’s Who in Technology Today. He is an SAE International Fellow and a recipient of the SAE International Forest R. McFarland. He was a co-instructor for courses for SAE International in automotive emission control catalysis and diesel emission control catalysis. He was a member of the Scientific Advisory Board of the Strategic Environmental R&D Program for environmental studies in the Department of Defense. Ron has been involved in over 80 publications in commercial applications of catalysts and holds 36 U.S. patents on catalytic processes. He is the co-author of the book with Dr. Farrarro entitled Catalytic Air Pollution Control: Commercial Technology and is the former co-editor of the NewsBrief section of Applied Catalysis B: Environmental. Ron and his former research team from Engelhard received the 2004 Thomas Alva Edison Patent Award from R&D Council of New Jersey for the invention of close coupled catalyst technology for ultra low emission gasoline vehicles. Ron received his B.S. in Chemical Engineering and his Ph.D. from the University of Maryland.

Hickman, Jeffrey
Dr. Jeffrey Hickman is a Group Leader at the Virginia Tech Transportation Institute. His primary areas of research include community-wide applications of behavior-based safety, self-management, and organizational culture change techniques, assessing driver behavior, fatigue, work/rest cycles, and driver distraction in commercial motor operations. These research projects include competitive research awards from the FMCSA, NHTSA, Mine Health and Safety Administration, National Transportation Research Center, Inc., Transportation Research Board, Canadian Council of Motor Transport Administrators, and the AAA Foundation for Traffic Safety. He has over 60 presentations, 30 scientific publications and technical reports, scientific reviews for the National Institute for Occupational Safety and Health, and currently serves as a reviewer for the Journal of Occupational Health Psychology, Accident Analysis and Prevention, and Journal of Organizational Behavior Management. Dr. Hickman is also the President of Hickman Management Solutions. He has significant experience in the design, delivery, and implementation of targeted solutions for organizations looking to improve safety, productivity, and performance.

Hoag, Kevin
Kevin Hoag is an Institute Engineer in the Engine, Emissions, and Vehicle Research Division at Southwest Research Institute, and has more than 35 years of engineering experience in diesel and spark-ignition engine development. Before joining Southwest Research he held engineering management positions with Cummins, Inc., and was most recently Associate Director of the Engine Research Center at the University of Wisconsin. He continues to teach in Wisconsin’s Master of Engineering in Engine Systems program. Kevin holds bachelors and masters degrees in mechanical engineering from the University of Wisconsin. He is the author of two books, Skill Development for Engineers (IEE Press, 2001), and Vehicular Engine Design (Springer-Verlag, 2005, 2015).

Hoff, Craig J.
Dr. Craig J. Hoff is an Associate Professor of Mechanical Engineering at Kettering University, teaching the areas of thermal and mechanical design, with applications in automotive engineering and biomedical engineering. His research interests include loop heat pipes, electronic and vehicle thermal management, and alternative automotive powertrains. Dr. Hoff is the faculty advisor to the Kettering Formula SAE racecar team and is the Chair of SAE International’s Scholarship Committee. He is the co-author, with Dr. Gregory Davis, of the text Introduction to Automotive Powertrains.

Husher, Stein
Stein E. Husher is currently a principal scientist engaged in crash reconstruction at KEVA Engineering, LLC. He has been working and conducting research in the field of Accidental Reconstruction for over 30 years. An avid street motorcycle rider himself, Mr. Husher has reconstructed hundreds of motorcycle crashes. He has published numerous technical papers related to accident reconstruction, including motorcycle crashes and serves on SAE International and ISO committees. He holds a Bachelor’s degree in Mathematics and a Master’s degree in Mechanical Engineering.

Jiao, Jianzhong
Dr. Jianzhong Jiao is an internationally recognized expert for LEDs and lighting technology development, products design, testing, standards, and regulations. He is an independent consultant in the areas of LEDs and lighting technology, product, and business strategies, standards, regulations and compliances, civil and intellectual property litigations, and technology investments. He is the past Chair of the SAE International Lighting Committee, past Chair of NGLIA, past Chair of NEMA SSL Section Technical Committee, and current Chair or active member of the committees in SAE International, IES, ANSI, NEMA, UL, ASABE, CIE-USA, IEEE, JEDEC, and SEMI. He is an Organizer and Chair for the SAE World Congress, member of the Organizing Committee and Chair of SPIE SSL Symposium, member of the Technical Panel of Strategies in Light (SIL). Dr. Jiao also teaches seminars and short courses for SAE International, SPIE, SIL, and Light Fair International. He also served as an adjunct professor teaching physics and electrical engineering courses at Purdue University and Lawrence Technological University. Dr. Jiao holds a Ph.D. degree in Electrical Engineering from Northwestern University, a M.S. degree in Applied Physics, and a B.S. degree in Mechanical Engineering. He is titled to 9 U.S. Patents and has over 40 technical papers and magazine articles, and given numerous invited presentations to international events. Dr. Jiao is an SAE International Fellow, a Senior Member of SPIE, and has received multiple industry awards.

Johnston, Paul
Paul Johnston is Senior Director of Compression and Braking at Meritor WABCO and is responsible for application engineering, product planning and new product development. Previously at ArvinMeritor, Johnston was Senior Director of the North American Foundation Brake Business Unit and Worldwide Director of Product Engineering for the CVS Worldwide Braking Division. He has over 38 years of experience in commercial vehicle air and hydraulic braking systems and products. A member of SAE International, Mr. Johnston was the recipient of the 2007 SAE International Award for Outstanding Technical Committee Service. Mr. Johnston is active in the Truck & Bus Council, Truck & Bus Brake Committee, and related subcommittees to develop new brake products
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Kipers, Kenneth
Dr. Kenneth Kipers has over 25 years of experience in additive synthesis, fuels, formulation, field testing, and customer service, is a Certified Lubrication Specialist and is currently involved in the consulting and training field specializing in fuels and lubricants. He is an adjunct professor at Richland College in Dallas and an instructor for Dale Carnegie courses, as well. Dr. Kipers has been an expert witness in many cases involving gasoline, diesel, and aviation fuels. He is also an active member of ACS, SAE International, and STLE. Dr. Kipers received a B.S. from San Diego State University and a Ph.D. in physical organic chemistry from the University of California-Los Angeles.

Kun, Robert (Skip)
Mr. Kuhn currently manages a technical consultancy for a variety of clients including automotive OEM’s and their Tier suppliers. His experience includes single failures, multiple failures, class action suits, and individual engine operational and reliability issues. Prior to becoming a consultant, Mr. Kuhn worked for both Ford and Chrysler in a variety of positions that included engine testing and development, fleet testing of prototype engines, vehicle chassis and engine packaging, and overall vehicle platform development including engine systems. He holds a B.S. in Mechanical Engineering from Carnegie Mellon University and an M.S. in Automotive Systems Engineering from the University of Michigan Dearborn and is also a licensed Professional Engineer in the State of Michigan.

Kurowski, Paul
Dr. Paul Kurowski is a professor in the Department of Mechanical and Materials Engineering at the University of Western Ontario in London, Ontario. His teaching experience includes finite element analysis, machine design, mechanics of materials, kinematics and dynamics of machines, mechanical vibration and product development. He is also the President of Design Generator Inc., a consulting firm specializing in product development, design analysis and training in Computer Aided Engineering methods. Dr. Kurowski has published multiple technical papers and taught professional development seminars for SAE International, the American Society of Mechanical Engineers, the Association of Professional Engineers of Ontario, the Parametric Technology Corp. (PTC), Rand Worldwide, SolidWorks Corp. and other companies and professional organizations. He contributes regularly to several engineering publications focusing on the implementation of CAE methods into the product development process. He is a member of SAE International and the Association of Professional Engineers of Ontario. Mr. Kurowski obtained his M.Sc. and Ph.D. in Applied Mechanics from Warsaw Technical University and completed postdoctoral work at Kyoto University.

La, Chi Binh
Chi Binh La is the Business Unit Director, Gasoline and Alternative Fuels, with IAV Inc. He has over 15 years of experience in engine development covering NVH, mechanical development and calibration, as well as analysis and simulation. In 2012, he joined IAV where he is responsible for the strategic vision and profitable growth of the business unit. Technically the business unit is responsible for the development of gasoline and alternative fueled engines including base engine calibration to vehicle drivability, emissions and OBD. Chi Binh holds a Bachelor’s...
Degree in Mechanical Engineering from University of Waterloo and a Master’s Degree in Engine Systems from University of Wisconsin.

**Leaphart, Eldon**
Eldon Leaphart is currently a Principal Engineer with Carr Engineering Inc. in Houston, Texas. In this position, his responsibilities include performing investigations to determine causes, conditions, and circumstances of defect allegations related to all forms of embedded system design. Mr. Leaphart has over 30 years of experience working in the area of chassis system development on both controlled suspension and controlled brake product lines, previously with GM, Delphi Corporation and BWI Group Inc. During this tenure, he held various engineering roles in the areas of algorithm, failsafe, diagnostics, test, embedded systems software development and engineering management. Mr. Leaphart has authored several technical publications, is the recipient of two GM Boss Kettering awards and named on several patents related to electronic brake controls. He is a member of the ISO TC22/SC32/WG16 on Functional Safety for ISO 26262. Mr. Leaphart is a current member of SAE International and holds BSEE and MSEE degrees from The Ohio State University.

**Lundstrom, Richard**
Dr. Richard Lundstrom is an independent research and project engineer specializing in dynamic system engineering, automotive chassis development, and application of the science of improvement. He formerly taught Chassis Design, Systems Analysis and Mechanical Control Systems at Kettering University, where he also previously served as team leader for the annual Kettering Industry Symposium. In addition, Dr. Lundstrom taught several mechanical engineering courses, developed Vehicle Dynamics and Thermal System Design courses, and founded and directed the Vehicle Dynamics Lab at Lawrence Tech. He worked as a product engineer with Ford Motor Company and developed and taught a Fundamentals of Vehicle Design course. Dr. Lundstrom is a member of SAE International, ASME, ASQ, ASEE and SCCA. He received a B.S. in Mechanical Engineering from the University of Illinois, a M.S. from the University of Michigan and a Ph.D. from Oakland University.

**Mago, Angelo E.**
Angelo Mago is senior consultant and owner of ATM Consulting, Inc., which provides customized training and consulting services to a varied design and manufacturing supplier community in the areas of quality assurance, quality control, design engineering, document management, and customer service and improvement methods. He has over 25 years of experience in product design, quality assurance, project management working in DOD in the M1 Abrams and Bradley Program Management offices and as the Senior Supplier Quality Engineer for GM Truck Group responsible for NAO and off-shore supplier ISO qualification, product development, and PPAP qualification and approval. Through ATM Consulting, Mr. Mago has played a lead role in establishing a PM and APOP environment for both large and small companies. He is a recipient of the SAE International Forest R. McFarland Award for distinction in professional development/education. He has a B.S. in Mechanical Engineering from Florida Institute of Technology.

**Malburg, Mark**
Dr. Malburg is the president of Digital Metrology Solutions, Inc where he provides dimensional and surface metrology consultation and develops analysis and control algorithms, software and custom instrumentation. He is also the president and chief software architect of Verified Technologies – the creators of the award-winning BrakeView™ system for the measurement of rotating components and is an adjunct associate professor of engineering at the University of North Carolina at Charlotte. He is currently a member of the ASME B46.1 “Surface Texture” standards committee, a member of the B89 committees for “Roundness”, “Straightness” and Flatness”, and is a United States Subject Matter Expert for several ISO committees under ISO/TC213 for surface and form metrology. Dr. Mark Malburg holds a B.S. and M.S. in Mechanical Engineering from Michigan Technological University. His graduate work at Michigan Tech addressed the characterization of plateau-honed surfaces and the approach he developed was later adopted as an International Standard. He completed his Ph.D. at the University of Warwick researching problems in instrument correlation in surface metrology applications.

**Mantravadi, Samuel**
Dr. Samuel Mantravadi is a Research Engineer at the Embedded, Commercial and Sensors Office of Assured Information Security, Inc. Since joining AIS, Dr. Mantravadi has been applying his knowledge of sensor systems and embedded development to address cybersecurity challenges when connecting processors and networking directly to sensors including medical devices, automobiles, aircraft systems, and other sensor systems. He has a unique combination of experience in embedded software development, testing, reverse engineering and sensor systems along with a strong background in research for the United States Air Force. During his Air Force career, he served in three different directorates of the Air Force Research Laboratory, working on sensor technology development programs for Directed Energy, Basic Research (AFOSR) and the Center for Rapid Innovation. Dr. Mantravadi has published four referred journal and conference papers. He holds an MS in Electrical Engineering from Wright State University and a PhD from the Air Force Institute of Technology.

**Masiak, James**
James Masiak has more than 32 years of experience in product and process development and implementation of business processes for General Motors. Activities include the implementation of an enhanced engineering product cost management process within GM North America, the alignment of cross-functional organizational initiatives, and development of an engineering resource allocation plan for GM Regions. Mr. Masiak was also responsible for the development and implementation of Global Engineering and Business Strategies across General Motors International Operations. His initial assignments at GM included vehicle and component testing & analyses, product development & management and strategic planning and benchmarking. He has recently applied the Innovation Corps Business Model Canvas methodology in assisting college and private sector startups. Mr. Masiak received his B.S. in Mechanical Engineering from Wayne State University, his M.S. in Mechanical Engineering from the Massachusetts Institute of Technology, and his M.B.A. from the Michigan State University Executive Management Program.

**Masoudi, Mansour**
Dr. Mansour Masoudi is the founder of Emissol LLC, an emission control (aftertreatment) company specializing in various automotive powertrain technologies, Research and Development (R&D) with a core specialty in emission reduction and aftertreatment technologies. Throughout his career, he has carried out various responsibilities working on gasoline and Diesel emission control components and systems, including substrate and catalyst technologies, spray injection (fuel, DEF), aftertreatment system design and optimization, testing and validation. He formerly held technology, product and R&D responsibilities at Corning Inc. (Senior Product Engineer), Delphi Corp. (Staff Project Engineer), Bosch Diesel Systems (Senior Engineer), Bosch Emission Systems (Manager, Aftertreatment Systems) and at Paccar (Manager, Advanced Powertrain Technology). He has a Ph.D. in Mechanical and Aerospace engineering, M.S. in Mechanical Engineering and MS. in management. Dr. Masoudi is the Editor-in-Chief of the journal “Emission Control Science and Technology”.

**Masoudi, Mansour**
Dr. Mansour Masoudi is the founder of Emissol LLC, an emission control (aftertreatment) company specializing in various automotive powertrain technologies, Research and Development (R&D) with a core specialty in emission reduction and aftertreatment technologies. Throughout his career, he has carried out various responsibilities working on gasoline and Diesel emission control components and systems, including substrate and catalyst technologies, spray injection (fuel, DEF), aftertreatment system design and optimization, testing and validation. He formerly held technology, product and R&D responsibilities at Corning Inc. (Senior Product Engineer), Delphi Corp. (Staff Project Engineer), Bosch Diesel Systems (Senior Engineer), Bosch Emission Systems (Manager, Aftertreatment Systems) and at Paccar (Manager, Advanced Powertrain Technology). He has a Ph.D. in Mechanical and Aerospace engineering, M.S. in Mechanical Engineering and MS. in management. Dr. Masoudi is the Editor-in-Chief of the journal “Emission Control Science and Technology”. 
Matthews, Ronald D.
Professor Ron Matthews, currently serving as a member of the SAE International Board of Directors, is Head of the General Motors Foundation Engines Research Laboratory on the campus of the University of Texas at Austin. He has been actively involved in engine research for 35 years, including engine control systems since the initial introduction of on-board computers. Dr. Matthews, a Fellow of SAE International, founded the Formula SAE competition in 1981 and has been the Faculty Advisor for a Formula SAE team each year since. He has been author or co-author on over 200 technical papers and reports, mostly in the field of engines.

McVea, William Mark
Dr. William Mark McVea, P.E., is currently Chief Technology Officer for Torvec, Inc., an industry leader in the design and development of patented powertrain engineering technology used primarily in the automotive industry. He is also President and Principal Engineer of KBE+, Inc. where Dr. McVea and his team design and develop complete powertrains for automotive and off-highway vehicles. His prior positions include Professor of Vehicle Dynamics and Powertrain Sciences in the Mechanical Engineering Department at the Rochester Institute of Technology and adjunct professor at Purdue University in their Automotive Sciences Department. He was also formerly a manager of the CAE group within a tier-one powertrain supplier to global automotive markets, a consulting engineer in vehicle dynamics with Gear Consultants, Inc., and a project manager of traction systems for off-highway vehicles with Clark-Hurth International. Dr. McVea has published extensively on the topics of transmission systems, automated design assistant systems, knowledge systems and knowledge based engineering in general. He also holds or is listed as co-inventor on numerous patents related to mechanical power transmissions. Dr. McVea holds a B.S. in Mechanical Engineering from the Rochester Institute of Technology, a Ph.D. in Design Engineering from Purdue University and is a licensed Professional Engineer.

Micklow, Gerald J.
Gerald Micklow, Ph.D. PE is currently a full professor of Engineering at East Carolina University and is a licensed engineer in the state of North Carolina. For nearly three decades, Dr. Micklow has been actively involved in the design and evaluation of advanced power producing systems. Dr. Micklow’s research over the years has been heavily funded by NASA, the National Science Foundation, the Department of Energy, the Federal Aviation Administration, Argonne National Labs and others with the majority of the work being related to fuel injection and low pollutant emission combustion systems for aircraft and on-road and off-road automotive/trucking/machinery applications. Dr. Micklow has received numerous awards from NASA including being inducted into the NASA/U.S. Space Foundation Innovative Technology Hall of Fame in 2000 and receiving the NASA Space Act Award for work performed on the Space Shuttle in 2002. In addition, Dr. Micklow’s industry experience includes eight years of designing advanced aircraft and missile configurations where he maintained top-secret security clearances. With over 60 engineering publications, Dr. Micklow received both a B.S. and M.S. in Aerospace Engineering from Pennsylvania State University and a Ph.D. in Mechanical Engineering from Virginia Polytechnic Institute and State University.

Miller, Joseph D.
Since 2005, Joe Miller has served as the chairman of the United States Technical Advisory Group to ISO TC22/SG5/WG16, which is developing ISO 26262: Road Vehicles - Functional Safety. This was recognized by the SAE Technical Standards Board Outstanding Contribution Award. He is the Chief Engineer of Systems Safety at TRW Automotive responsible for the systems safety process. Prior to this, he has managed systems engineering, manufacturing planning, and program control for electric steering. He has also engineered communication, avionics, infrared, and radar systems, as well as and thick and thin film components. Joe has 20 US patents, a Master of Engineering (EE) and a Master of Business Administration.

Neale, William
William Neale is the Director of Visualization at Kineticorp, LLC, a Denver-based forensic engineering and visualization firm. Prior to joining Kineticorp, he was Director of Animation at Knott Laboratory, another forensic engineering and reconstruction firm. Throughout his career, the daily focus of his professional activities has been on video analysis, photogrammetry, videogrammetry, computer modeling, and visualization. William has authored and presented over 25 peer-reviewed, technical articles related to video analysis, photogrammetry, and reconstruction and has testified throughout the country in Federal and State courts. Some of the high-profile cases he has worked on include the collapse of the Dallas Cowboys Practice facility in Dallas, Texas, the special effects accident that occurred in the blockbuster film Transformers 3 “Dark of the Moon” and the reconstruction of the Princess Diana accident which has been featured on The Discovery Channel. Mr. Neale’s work was also recently featured on TNTs Cold Justice. Mr. Neale received the 2006 SAE International Arch T. Cowell award for his research in video tracking and photogrammetry and received funding for research in this field from DriveCam – The Driver Science Company, Ford Motor Company, The Milwaukee Brewers, and The National Football League (NFL). Mr. Neale received Bachelor of Arts and Master of Architecture degrees from Washington University in St. Louis, where he studied photography, videography, and computer visualization.

Oliver, Michael J.
Michael J. Oliver is Vice President of Electrical / EMC Engineering at MAJR Products Corporation, where he is responsible for customer EMC design and consulting and new product development. He is also the company’s ISO-9001:2000 management representative. An expert in EMI/RFI shielding technology, he has experience in electronics, military shelter electrical systems, and high power antenna/radome design. His experience also includes the design and testing of aerospace antennas, shielding of military shelter electrical systems, and discrete EMC shielding components. Mr. Oliver has expertise in open and anechoic chamber radiated testing to military standards and has utilized various antennas and radiated test systems. In addition, he has written numerous technical papers and publications on electromagnetic shielding components, product testing and design, and military antenna/radome test methodology standards. Mr. Oliver is the founder and currently serves as Chairman of the IEEE Pittsburgh EMC Chapter. He is Co-Chairman of the SAE International AE4 Electromagnetic Compatibility Committee, and a member of the IEEE EMC Standards Coordination Committee (SACCom). Mr. Oliver has three patents (one pending) on EMC shielding-thermal management devices and he received a B.S. in Electrical Engineering Technology from Gannon University.

Palazzolo, Joseph
Joe Palazzolo is Chief Engineer – eDrive Systems at GKN Driveline. He is responsible for managing the mechanical design and development of new automotive gearboxes, torque transfer devices, concepts, and industrialization into production applications. His prior professional experience spans the majority of vehicle powertrain systems, including overall chassis design and validation, all-wheel systems design and development, power transfer unit and transfer case design, and torque management device development. Joe has been privileged to contribute while working at Carron and Company, Visteon Corporation, Warn Industries, Magna Powertrain, and Ford Motor Company. Mr. Palazzolo maintains the ASE certified Master Technician and Undercar Specialist certifications, has chaired the SAE International All-Wheel Drive Standards Committee, and has been an active SAE International member since 1990. Mr. Palazzolo was a recipient of the SAE International Forest R. McFarland
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Award for distinction in professional development and education in 2007. In 2010, he achieved the SAE Master Instructor designation and continues to maintain this in his three seminars that he has been teaching globally since 1999. In 2013, his technical and professional accomplishments to the industry were recognized by reaching the membership grade of SAE International Fellow. Mr. Palazzolo is the award winning author of High-Performance Differentials, Axles & Drivelines in 2009. In 2013, he furthered his authoring with his second text on How to Rebuild the Ford 8.8 and 9 inch Axles. He is the author of three chapters featured in the Automotive Engineering Encyclopedia released in 2014. He has designed, built, campaigned and supported various race cars and teams for both professional and amateur racing organizations. His scope of work has been inclusive of the entire vehicle but also focused on competitive, high-performance drivetrain systems. He holds a Bachelors degree in Mechanical Engineering from Cleveland State University and a Masters degree in Automotive Engineering from Lawrence Technological University. He has received numerous patents for his work and creativity in advancing mobility systems.

Park, Talus
Talus Park is the Calibration Skill Team Leader at AVL Powertrain Engineering based in Plymouth, Michigan. He is responsible for diesel and gasoline engine calibration, transmission calibration as well as certification services throughout North America. His team is focused on utilizing innovative tools and methods to deliver high quality calibration projects with maximum efficiency. Mr. Park has over twelve years of experience in the transportation industry focused on calibration. He earned both his Bachelor’s and Master’s degrees in mechanical engineering from West Virginia University.

Pawloski, Kurt
Curt Pawloski is President/Senior Consultant for Integral Operations, Inc. He has over 30 years of experience in project management, geometric dimensioning and tolerancing, process and quality improvement, problem solving, and quality system development and implementation. Mr. Pawloski has helped auto industry OEMs and numerous supplier organizations prepare or improve their Quality Systems, facilitated the writing of quality procedures and work instructions, and consulted on implementation of quality systems. In addition, he was the leader of a team to develop a comprehensive Project Management training and certification system for Volkswagen’s IT function. Mr. Pawloski is an Adjunct Faculty Member at Oakland Community College, Delta College, and Midlands Technical College. He is a board member and past member of the year for the Saginaw Valley Section of the American Society for Quality. He has a B.S.ChE from the University of Michigan, a Graduate Certificate in Hazardous Materials Management/Chemical Engineering from Wayne State University, and an M.B.A. from Wayne State University.

Pfeifer, Michael
Michael Pfeifer is President of Industrial Metallurgists, LLC and is a consultant in failure analysis and metallurgy. Previously, he worked for 13 years at Motorola as a manufacturing engineer in an integrated circuit factory and as a design/quality/cost reduction engineer for automotive electronics. At Motorola, Mike learned and applied the engineering techniques required to design and manufacture great products. He is author of the book, Materials Enabled Designs: The Materials Engineering Perspective to Product Design and Manufacturing, which discusses how to make design and manufacturing decisions in order to optimize the materials used in a product so that the product meets performance, reliability, and cost requirements. Mike received a B.S. and M.S. in Metallurgical Engineering from University of Illinois and a Ph.D. in Materials Science and Engineering from Northwestern University.

Placenti, Vincent
Mr. Placenti is Senior Manager at Robert Bosch LLC in Farmington Hills, Michigan and is responsible for Diesel Fuel Injection Hydraulic Systems Integration for North American diesel-engine applications. This encompasses simulation, adaptation and testing of high-speed, high-pressure fuel injection systems, concentrating on Common-Rail systems, both solenoid-valve and Piezo. Included is research of alternate fuels for diesel engine applications. Experienced in all types of diesel fuel injection and various gasoline systems, Mr. Placenti is a contributing author to the Springer Handbook for Mechanical Engineers. Mr. Placenti holds a B.S. in Mechanical Engineering and has been with Bosch for over thirty years, seven of which were at the Bosch Headquarters for Diesel Fuel Injection in Stuttgart, Germany.

Pike, Jeffrey A.
Jeffrey A. Pike is President, Biomechanics Consulting, Inc. and Adjunct Professor, Biomedical Engineering, Wayne State University. He previously held the position of Senior Technical Specialist, Occupant Injury/Biomechanics, Ford Motor Company, from which he recently retired. He has extensive professional experience in biomechanics, injury mechanisms and causation, occupant protection, testing, regulatory requirements and regulatory process and medical records review. Mr. Pike has organized and presented at numerous technical forums, including sessions at two White House Conferences as well as SAE International Symposia on Vehicle Rollovers, Occupant Protection and Lower Limb Injuries. He has also taught SAE International regulatory and forensics seminar for 21 years and has been a guest lecturer at MIT, the Medical College of Wisconsin, the University of Michigan, Harvard Medical School and the University of Virginia. Mr. Pike is an SAE International Fellow and received the SAE Forest R. McFarland Award in 2004 for his contributions to professional development activities. His publications include technical books, papers and textbooks and principal author of two textbooks published by SAE International—Automotive Safety: Anatomy, Injury, Testing and Regulation and Neck Injury: The Use of X-Rays, CT’s and MRI’s to Study Crash-Related Injury Mechanisms. His educational background includes studies at Polytechnic Institute of Brooklyn, New York University and the University of Michigan.

Pinch, William
Bill is currently an industry consultant for chassis and suspension systems and components. He is retired from General Motors Company where he held the position of Global Suspension Subsystem Leader in the Chassis Group. He has also held the position of Engineering Group Manager for Steering, Suspension and Structures. Bill has extensive experience with passenger cars, light trucks and off-road vehicles. Previously, he worked for AMC/Jeep/Renault as a Senior Steering and Suspension Design Engineer. Bill holds a B.S.E. in Mechanical Engineering and M.S.E. in Materials, Properties and Processes from the University of Michigan.

Porter, Alexander (Alex) J.
Alexander J. Porter is the Chief Engineer for Programs, Performance, and Durability for Intertek, and has been with the company since 1992. Since 1996, he has been developing accelerated testing methods for mechanical components and systems. Mr. Porter has three patents relating to accelerated testing equipment and has authored over 40 articles and technical papers on accelerated testing. Alex is the author of the book Accelerated Testing and Validation, Elsevier 2004. His work in the past has included implementation of FEA in a laboratory setting and development of a thermal management system for an advanced data acquisition package developed by NASA’s Drydon Flight Research Facility. Alex is a member of SAE International and IEEE. He holds a B.S. in aircraft engineering and an M.S. in mechanical engineering, both from Western Michigan University.
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Potts, Gerald R.
Dr. Potts is the Principal in GRP Consulting specializing in tire and vehicle dynamics and is an Adjunct Professor of Mechanical Engineering at the University of Akron, teaching tire and vehicle dynamics. Previously he worked for Firestone Research as a Research Scientist working on tire dynamics and developing a new Dynamics Research Laboratory and MTS Systems Corporation as Manager of Tire/Wheel Systems and headed the Flat-Trac™ test system development team. He also initiated the development of indoor tire wear test machines. Dr. Potts also served as an Associate Professor of Mechanical Engineering at the General Motors Institute (now Kettering University) teaching classes in vehicle dynamics, chassis engineering, vibrations, and instrumentation. He has also owned his own businesses where he developed tire test system controls and tire rolling resistance test machines and a laboratory high-speed uniformity tire test machine, as well as vehicle safety test systems for vehicle crash tests and component strength tests for major tire and vehicle companies around the world. Dr. Potts earned a Bachelor of Science degree in Mechanical Engineering from Wichita State University and Master’s and Ph.D. degrees in Mechanical Engineering from Kansas State University.

Primus, Roy J.
Roy J. Primus is a Senior Principal Engineer in the Combustion Systems Organization at the General Electric Global Research Center. Prior to joining GE Global Research, Mr. Primus was an Executive Director at the Technical Center of Cummins, Inc. He has been conducting reciprocating engine research and development for over 35 years. Mr. Primus’ areas of expertise include diesel engine performance development, emissions control, thermodynamic system modeling and air handling system design and analysis. He holds a Master of Science degree in Mechanical Engineering and a Bachelor of Science degree in Mathematics from Rose-Hulman Institute of Technology. He has authored over 25 technical publications and holds 25 patents on reciprocating engine systems and technology. Mr. Primus is a Fellow of SAE International and an Assistant Adjunct Professor for the University of Wisconsin Master of Engineering in Engine Systems distance learning program.

Quarto, Mark
Dr. Mark Quarto is currently the Chief Technology Officer (CTO) for Quarto Technical Services where he is responsible for the design/development of diagnostic test equipment and software, technical education and training programs, and technology innovations focused on hybrid and electric vehicle propulsion and energy management systems. Dr. Quarto previously worked within the General Motors Company as an Engineer and Engineering Group Manager in Advanced Powertrain Technology Systems / Global Aftermarket Engineering where he was responsible for the management and development of control and diagnostics systems and service solutions for the Chevrolet Volt, Fuel Cell, Two-Mode Hybrid, Parallel Hybrid Truck (PHT), Evi Electric Vehicle, S10 Electric Truck, and Alternative Fuel Systems Programs. He also served as the Service Training Development Manager and Resident Service School Instructor. Mark began his automotive career as a technician at both dealership and aftermarket facilities. In addition to his accomplishments and experiences while working at General Motors, Mark has served as a Chief Engineer, Senior Consultant, Author, and Subject Matter expert in Hybrid, Electric, and Fuel Cell Technologies. Dr. Quarto has a Bachelor’s Degree in Electrical Engineering from LaSalle University specializing in Power Electronics; a Bachelor’s Degree in Automotive Technology from Ferris State University; Master’s Degree in Technical Education from Ferris State University specializing in electric and hybrid propulsion systems; and a Doctorate in Technical Education from Nova Southeastern University, specializing in designing and developing learning systems for hybrid/electric vehicles and high voltage energy and propulsion systems.

Quigley, Jon M.
Jon M. Quigley, PMP CFTL, is a principal and founding member of Value Transformation, a product development training and cost improvement organization established in 2009. He has nearly three decades of product development and manufacturing experience, ranging from embedded hardware and software through verification and project management. Jon has won awards such as the Volvo-5P Technical Award in 2005 and the 2006 Volvo Technology Award. He has secured seven US patents and a number of international patents. These patents range from human machine interfaces to telemetry systems and drivers aides. Jon is on the Western Carolina University Masters of Project Management Advisory Board as well as Forsyth Technical Community College Advisory Board. He has also been a guest lecturer on Project Management at Wake Forest University’s Charlotte NC campus and teaches Project Management classes at City University of Seattle via distance learning. Jon also is an expert at ITMPI (IT Metrics and Productivity Institute), is part of the PM2Go experts (The Standish Group), has given webinars at The Project Management Institute and has spoken before PMI Chapters across North Carolina and parts of Virginia. Jon has membership in ASQ, SAE, AIAG and PMI (holding Project Management Professional Certification). Jon also has the CFTL certification from ISTQB. He has authored, co-authored and contributed to a list of books and publications, including the SAE book Project Management for Automotive Engineers: A Field Guide. Jon has an Engineering Degree from the University of North Carolina at Charlotte, and two Master’s Degrees from City University of Seattle.

Rakouth, Ph.D., Heri
Heri Rakouth, Ph.D., is Manager, Technology Exploration at the Innovation and Technology Office (ITO) of Delphi Corp. in Troy, MI. In this capacity, he coordinates technology innovation activities across three out of the five divisions of Delphi. He spearheaded cross-divisional efforts that have led to the build of the telematics business development team for the aftermarket and the launch of the V2X proof of concept project currently implemented for the Land Transport Authority of Singapore. Dr. Rakouth has about 30 years experience in both aerospace/defense telecommunications and automotive electronics industries. He has held various responsibilities at Thomson CSF/Thales and Renault in France as product engineer and technical manager before joining Delphi in 1996. Dr. Rakouth is also an adjunct professor at Oakland University teaching undergraduate and graduate classes in Power Electronics and Wireless Communications. Dr. Rakouth has published over 20 IEEE or equivalent technical papers and tens of classified and non-classified reports. He holds several U.S. and European patents. He holds MS and PhD degrees in Electrical Engineering, from the University of Pierre and Marie Curie (UPMC) of Paris (1979 and 1982) along with an MBA from Saginaw Valley State University (1999) and an MS in Manufacturing Management from Kettering University (2000).

Ranganathan, Raj P.
Dr. Raj Ranganathan is well known for his expertise in heat transfer. Prior to his current position, he was a Director at CD-Adapco. In addition, Dr. Ranganathan worked for General Motors and Caterpillar in the U.S. primarily in gasoline and diesel engines. He received GM’s highest award for innovation, the 2007 Boss Kettering Award. He has been associated with SAE International for 20 years and received the SAR Forest R. McFarland Award in 2006. Raj has co-authored over 40 papers, patents, patents pending and proprietary research reports. Dr. Ranganathan received both a M.S. and Ph.D. in Mechanical Engineering with specialization in the area of heat transfer from Purdue University.

Reddy, Sam
Dr. Reddy is an independent consultant specializing in fuel vaporization and evaporative emission control. Sam retired from General Motors R&D Center in 2009. He has 35 years of experience in fuels and fuel vapor emission control research and development. He holds twenty-eight U.S.
Reinhart, Thomas
Thomas Reinhart is a Program Manager for NVH in the Engine, Emissions, and Vehicle Research division of Southwest Research Institute. Previous roles include Senior Manager for NVH at Visteon Chassis Systems, where Mr. Reinhart was responsible for the NVH analysis and development of axles, driveshafts, and power steering systems. From 2001 to 2004, he was NVH Program Manager at Roush Industries, Inc. where he was responsible for NVH testing and development of diesel and gasoline engines, as well as transmissions, axles and accessories. Diesel fuel system noise was a special focus of this work. Prior to Roush, he was Director of Noise & Vibration Technology at Cummins, Inc. Mr. Reinhart has been involved in solving noise and vibration issues in engines, as well as in a wide variety of engine applications, including pickup trucks, heavy duty trucks, construction equipment, and marine. Mr. Reinhart has developed noise reduction features for diesel engines, four of which have been patented. He has published 15 technical papers on Powertrain NVH topics. Mr. Reinhart received his B.S. and M.S. in mechanical engineering from Purdue University. He also spent a year studying automotive engineering at the Technical University of Hannover, Germany. His master’s thesis focused on the application of acoustic intensity measurements to diesel engines.

Rose, Nathan
Mr. Rose is currently a Director and Principal Engineer focusing on vehicular accident reconstruction at Kineticorp, LLC, a Denver-based forensic engineering firm that he helped found in 2005. He has been working and conducting research in the field of accident reconstruction for more than 18 years. Mr. Rose has reconstructed hundreds of rollover crashes, conducted extensive research and testing related to rollover crashes and has published numerous articles and technical papers, of which ten have been published by SAE International. He holds a B.S. in Civil Engineering and a M.S. in Mechanical Engineering.

Ross, Phillip J.
Phillip J. Ross is President of Quality Services International, Inc., a consulting firm specializing in quality and statistical training. He has accumulated over 4500 hours of classroom instruction teaching courses in quality, design tools, and manufacturing processes and problem solving in the United States, Great Britain, Holland, Japan, and Singapore. Prior to his consulting business, Mr. Ross worked for General Motors in automotive powertrain design and development and automobile manufacturing and assembly. He first worked with Allison Transmission Division in product design/development and then with Saturn Corporation in the manufacturing and assembly aspects. Mr. Ross was involved in the design phase of many transmission components and systems, developed statistical/quality methods and training, and performed process development. He also performed process development for lost foam casting, painting, molding, and others while at Saturn. Mr. Ross is the author of the book Taguchi Techniques for Quality Engineering which has sold over 35,000 copies worldwide, has had articles published in Quality Progress by ASQC and in Target by AME and is the holder of three patents on product design. Mr. Ross received a B.S. in mechanical engineering from General Motors Institute, and is an ASQ Fellow and Certified Quality Engineer.

Ruth, Richard R.
Mr. Ruth is currently president of Ruth Consulting LLC which specializes in passenger car and light truck Event Data Recorders and restraint systems performance in crashes. He has 10 published papers on EDR accuracy and assists civil attorneys and prosecutors in Frye and Daubert hearings to get EDR data admitted in court. He has taught over 30 classes in EDR imaging and data analysis to law enforcement and private reconstructionists, and is a regular speaker at national and regional crash reconstruction conferences. He is a beta tester for new releases of the Bosch Crash Data Retrieval system. Mr. Ruth is a member of the SAE J1698 Event Data Recorder Committee, and a member of ISO’s EDR related TC22/SC12/WG7, and a former member of the ASTM 4150 group that developed an EDR procedure. Prior to consulting, Mr. Ruth worked 33 years for Ford Motor Company, and during his last 10 years managed the engineers who did field investigations of safety system performance in real world crashes including EDR imaging and analysis, and championed the release of Ford EDR data to the Bosch Crash Data Retrieval system, personally writing some of the data limitations. He handled law enforcement requests for EDR readout assistance, was a member of Ford’s EDR policy committee, was Ford’s representative to the SAE EDR standards committee, and helped shape Ford and Auto Alliance responses to NHTSA on Part 563 EDR legislation. Mr. Ruth has a B.S.in Electrical Engineering from Michigan Technological University and an M.B.A. from the University of Michigan Ross Business School, and is a registered professional engineer.

Saha, Pranab
Pranab Saha is the principal consultant and co-founder of Kolano and Saha Engineers, Inc., an independent professional engineering and consulting company in acoustics, noise and vibration control. A well-known authority on automotive noise control and body interior systems, Dr. Saha has directed and participated nationally and internationally in numerous advanced noise control engineering programs and training seminars for various OEMs and suppliers in India, Mexico, and USA. Dr. Saha is currently the Chair of the SAE International Engineering Meetings Board, a Professional Development Instructor, and the Lead Faculty Member of the SAE International Vehicle Interior Noise Academy. He is also the past-chairman of the SAE International Acoustical Materials Committee and has helped develop several standards in acoustics. Dr. Saha is an active member of ASA, ASME, ESD, INCE, NSPE, SAE International, and a contributing editor of Sound and Vibration publication. He has presented technical papers, organized and chaired numerous technical sessions sponsored by SAE and other professional organizations. Dr. Saha has also won several awards presented by SAE International and the Michigan Society of Professional Engineers (MSPE) and has been named an SAE Master Instructor. Dr. Saha holds a B.S. in Mechanical Engineering from the University of Calcutta, a M.S. in Engineering Sciences from the University of Florida and a Ph.D. in Mechanical Engineering (Acoustics Specialty) from the Georgia Institute of Technology.

Schmid, Steven R.
Dr. Schmid is a Professor at the University of Notre Dame, where he conducts research and teaches courses in manufacturing, metal forming, tribology and design. Prior to joining academia, Dr. Schmid was a project engineer at Triodynamic, Inc., a consulting firm specializing in machine and manufacturing/product consulting with a special emphasis on safety. As such, he has visited hundreds of manufacturing facilities as diverse as sugar cane plants in Hawaii to battery factories in Vermont, and has been a consultant to industry and government. He is a past recipient of the Society of Manufacturing Engineers John T. Parsons Outstanding Young Manufacturing Engineer Award, has won numerous teaching awards, and was named a Kaneb Center Teaching Faculty Fellow at the University of Notre Dame in 2003. Dr. Schmid is a graduate of the Illinois Institute of Technology and Northwestern University. In 2012-2013, Dr. Schmid was the first Academic Fellow at the Advanced Manufacturing National Program Office, where he helped design the National Network for Manufacturing Innovation. He is the co-author (with S. Kalpakjian) of the world’s most popular manufacturing textbook, which has been translated into many languages including German, Japanese,
Korean, Chinese (Mandarin), Italian, and Spanish. He is President of the North American Manufacturing Research Institute of the Society of Manufacturing Engineers (NAMRI/SME).

**Seyboldt, Charles F.**
Mr. Charles Seyboldt has degrees in Mechanical Engineering and Law. He has over 15 years of experience in the transportation industry, having engineering responsibilities covering a broad range of product and manufacturing technologies. He is a registered Professional Engineer and a registered patent agent.

**Sittsamer, Murray**
Murray Sittsamer of The Luminous Group has over 26 years’ experience in operations management, strategic planning, new process launches, financial analysis, quality systems and process improvement. During the past 12 years, Murray has focused his work on supporting automotive OEMs and suppliers with their quality and productivity improvement efforts, especially in the areas of Advanced Product Quality Planning (APQP), Failure Mode and Effects Analysis (FMEA), variation reduction and Problem Solving. Before entering the consulting field in 1994, Murray served as director of distribution support and quality systems for Geiman Sciences. While there, he led a successful 15-month effort to obtain ISO 9000 quality system registration and had the role of project manager for a highly publicized groundwater contamination dispute. Murray holds a Master of Science in Industrial Administration from Carnegie Mellon University. He earned his undergraduate degree in industrial engineering from the University of Pittsburgh.

**Sorrentino, Joseph**
For nearly three decades, Joseph Sorrentino has been instrumental in implementing successful quality management systems for commercial companies, military and aerospace contractors, and government agencies throughout the U.S. As president and CEO of Lean Quality Systems, Inc., Sorrentino specializes in implementing new standard methods for the corporate sector and has successfully worked with more than 25 corporations in the southern California area alone. A retired U.S. Navy quality assurance specialist, Sorrentino is certified as a level III examiner for visual, magnetic particle, dye penetrant, and ultrasonic inspections. He began his career as a quality management professional in the U.S. Navy, initially as chief petty officer, level III NAVSEA examiner/quality assurance division officer and spent eight years as a GS1910 quality specialist.

**Speirs, Robert G.**
Robert Speirs is Associate Professor of Plastics Programs at Ferris State Univ. Additionally, Speirs instructs many plastics engineering technology seminars covering material selection, product design and advanced plastics processing. Along with his vast teaching experience, Speirs brings practical industrial experience from his work with Baxter Travenol Laboratories and Dow Chemical. Speirs also has taught continuing education seminars in injection molding, mold design and injection molding troubleshooting for molders throughout North America and in Singapore and Hong Kong.

**Spence, William Cory**
As the founding partner of Spence PC, Mr. Spence assists individual and business clients in obtaining their best possible outcome in contentious legal matters. He has experience in litigation, arbitration, and mediation involving all areas of intellectual property law. He has litigated claims in both state and federal courts throughout the United States. Additionally, Mr. Spence has experience with patent monetization strategies and complex, international patent infringement litigation involving multiple parties and jurisdictions, including Asia. He is a registered patent attorney and published author and frequent speaker on patent monetization and other intellectual property issues. Mr. Spence is a graduate of the University of Notre Dame, where he obtained separate Bachelor of Science Degrees in Chemical Engineering and Biophysics (“Physics in Medicine”), and a graduate of the University of Houston Law Center. Prior to forming Spence PC, Mr. Spence spent twelve years practicing law with Kirkland & Ellis LLP in Chicago, IL and Tokyo, Japan.

**Steiner, Matthew**
Matt Steiner is the Applications Engineering Leader for the Automotive Segment at GGB Bearing Technology. He holds a BSME from Kettering University and has spent 10+ years in component design and systems engineering. The applications engineering team at GGB is responsible for the implementation of tribological solutions within customer products and the identification of key market needs and technological opportunities.

**Tao, Xiaojian**
Dr. Xiaojian Tao is Manager of Advanced Fuel Delivery and Contamination Research at the Southwest Research Institute (SwRI). His work primarily focuses on automotive fuel delivery systems and system contamination sensitivity. Dr. Tao has conducted extensive testing and research on fuel and component compatibility for OEM auto-makers and also assisted in developing key life testing procedures for fuel pumps, fuel delivery modules and many other associated components. With the help of his staff, he developed a prototype electronic controlled variable valve lifting mechanism and a fast acting fuel injection system for flexible fuels. Dr. Tao has assisted the automobile industry in revising existing fuel delivery procedures and establishing new ones. He has also successfully established mathematical models for these fuel delivery systems using nonlinear stochastic system theory. He then utilized these models to investigate the physics essentials of the interactions among contaminants, additive packages, fuels and fuel delivery system components. Dr. Tao has authored and co-authored numerous technical publications in related fields. He is a graduate of the Mechanical and Aerospace Engineering Department at Oklahoma State University.

**Terpstra, Toby**
Toby Terpstra is a senior staff member of the visualization department at Kineticorp, a forensic engineering and visualization company. Toby specializes in photogrammetry, 3D digitization, computer modeling, and animation. He has experience in the latest 3D computer animation techniques and associated technologies. Mr. Terpstra regularly contributes to related industries, having published with and given presentations to the Acoustical Society of America, the Association for Crime Reconstruction, as well as SAE International. He has a degree in Applied Science from Westwood College of Technology.

**Timmis, Eric**
Eric Timmis is the owner of BusinessIsAContactSport.com, a training and consulting company dedicated to business process improvement, focusing on value and quality management implementation, program/project management training, and the integration of strategic...
INSTRUCTOR BIOGRAPHIES

partnership relationships between departments and organizations. Mr. Timmis has over thirty years of diversified experience across several industries, which includes the delivery of value engineering facilitation services to Ford Motor Co. and its supplier community and training for Eaton Corporation’s. Product Development Group. He is also a recognized speaker at various national conferences. Eric received a B.S.c. in Civil Engineering from the University of Birmingham in England and is a member of the Institution of Civil Engineers.

Vadnais, Thomas
Tom’s engineering career began as a tire development engineer at BF Goodrich and later as a consultant in tire failure analysis and vehicle accident reconstruction for SEA Limited. He has continued as a consulting engineer in those fields to this date, and added forensic photography as an area of expertise. A long-time Nikon shooter with a passion for photography, Tom became an early adopter of digital photography and promptly divested himself of all vestiges of film photography. Tom took every course or workshop he could find on digital capture, post-processing, and digital printing, as he mastered each part of the process. As a long-time professional engineering consultant, professional photographer, and photography instructor, Tom is uniquely suited to teach both the fundamentals of digital photography and the specific practical use of photography in technical projects, accidents, and forensics. He is a registered professional mechanical engineer, and has been an SAE member since 1980. Tom was active throughout the life of SAE’s AIRP (Accident Investigation and Reconstruction Practices) group, including a stint as the chairman of the heavy truck forum group.

Vakili, Mohammad
Mr. Vakili is currently a consultant in the friction material industry. Throughout his career he has held numerous positions including the Vice President of Technology & International for Fritec; Director & VP of Technical Services in the friction material industries and various related industries including Wagner Automotive, HKM, ITT, and Continental. He has traveled extensively around the world and visited most “who’s who” of the friction manufacturing industries in order to select the most suitable products for a given OE or OES application. Mr. Vakili recently was a co-publisher of a research work on Automotive Wheel Dust Evaluation & Testing with Ford Motor Co. and Link Engineering. He has been a speaker and chairperson at the Brake Colloquium, FMSI, and BMC and has taught a course in “Friction Material Topics” for Continental Automotive System employees in the U.S. and Europe. A member of AIChe and SAE. Mr. Vakili has a B.S. and M.S. in Chemical Engineering from the University of Massachusetts.

Van Gilder, John
John Van Gilder is currently a Technical Fellow, OBD II Development, in the General Motors Powertrain Group where he is responsible for implementing statistical techniques in OBD design, model based on-board diagnostic design, development of OBD requirements for new powertrain systems, and in-use assessment of OBD systems. Prior to that, Mr. Van Gilder was a Product Assurance Engineer at Delphi where he focused on improving design and manufacturing process reliability, including implementation of quality tools such as design of experiments, quality function deployment, statistical process control, etc. for spark plugs and exhaust oxygen sensors. Mr. Van Gilder was also a Commissioned Officer in the United States Navy working in materials research and development. He has organized and presented at numerous SAE OBD and Powertrain Controls technical meetings. Mr. Van Gilder has a B.S.E. in Engineering Physics from the University of Michigan, a M.S. E. in Nuclear Engineering from the Bettis Atomic Power Laboratory and a M.S.E. in Reliability Engineering from Kettering University and is a Professional Engineer in the state of Michigan.

Walker, Jr., James
James Walker, Jr. is currently a Principal Engineer specializing in chassis, brake, and electronic brake control systems at Carr Engineering, Inc. His prior professional experience includes brake control system development, design, release, and application engineering at Kelsey-Hayes, Saturn Corporation, General Motors, Bosch, Ford Motor Company, and Delphi. Mr. Walker created scR motorsports consulting in 1997, and subsequently competed in seven years of SCCA Club Racing in the Showroom Stock and Improved Touring categories. Through scR motorsports, he has been actively serving as an industry advisor to Kettering University in the fields of brake system design and brake control systems. Since 2001, he has served as a brake control system consultant for StopTech, a manufacturer of high-performance racing brake systems. In addition to providing freelance material to multiple automotive publications focusing on chassis and brake technology, Mr. Walker is the author of the book High-Performance Brake Systems: Design, Selection, and Installation. In 2005, he was presented with the SAE International Forest R. McFarland Award for distinction in professional development and education and in 2010 he was designated an SAE Master Instructor. He obtained his B.S.M.E. in 1994 from GMI Engineering & Management Institute.

Walker, R. W. (Bill)
Bill Walker is the owner and principal engineer at Walker Technical Services where he provide consulting services in design, testing, and certification for manufacturers and operators of aerospace and mobile equipment throughout North America, Europe, and Asia. Mr. Walker has almost four decades of experience in test engineering, regulatory compliance engineering, and product safety engineering. Mr. Walker previously held the position of Manager of Safety and Compliance at John Deere Forestry, Inc., where he oversaw safety engineering, regulatory compliance, product liability management, intellectual property management, and standards development activities for the world-wide manufacturer of advanced forestry equipment. Additionally, Mr. Walker held the positions of Manager of Testing at Diamond Aircraft Industries, Director of Engineering, Manager of Flight Testing, and Test Engineer at Eurocopter Canada, Ltd. He is currently a member of the SAE International MTC4 (forestry machinery), ISO TC23/SC15 (Forestry Machinery), TC23/SC3 (Safety and comfort of the operator), and TC23/SC14 (Operator Controls, Operations Symbols and other displays, and Operator Manuals). He has also served on Canadian Standards Association Technical Committees on Mobile Forestry Machines and Rollover Protective Structures. Mr. Walker received a B.Sc. Aerospace Engineering from Northrop University and M.A.Sc. in Aerospace Engineering from the University of Toronto Institute for Aerospace Studies.

Walter, Eric
Eric Walter is a Software Developer at HEM Data Corporation. He has over 4 years of experience programming data acquisition and analysis software and has been the lead engineer on software including CAN analysis, J939/OBD database editing, data transfer, and online fleet management. His programming expertise is in Microsoft .NET, technical web-design, and mobile iOS development. Mr. Walter has a B.S. in Computer Science from the University of Michigan.

Walter, Richard
Richard Walter is the President and Founder of HEM Data Corporation. A pioneer in PC-based data acquisition and analysis, he has acquired data from in-vehicle networks since they were mandated in 1996. Mr. Walter previously worked at the Bendix Research Laboratories where he was awarded five patents for automotive inventions and gained valuable testing experience. He taught at Lawrence Technological University and has conducted numerous seminars and training sessions. He has had several articles and papers published in engineering journals including
Dr. David Ward is Senior Technical Manager, Functional Safety at HORIBA MIRA. In this role, he provides leadership in development and independent assessment of automotive electronic system safety, reliability and cybersecurity. Since joining HORIBA MIRA in the 1990s, Dr. Ward has been instrumental in industry activities to develop standards and guidance for automotive functional safety, beginning with the pioneering MISRA “Guidelines for Development of Vehicle Based Software” in 1994 and more recently as the UK Principal Expert to ISO/TC22/SC32/WG8 “Road Vehicles – Functional Safety”, which develops ISO 26262. Dr. Ward is an active contributor to the automotive industry’s first standard for cybersecurity SAE J3061. In recognition of his contribution to standardization in functional safety, he was awarded the Institute of Mechanical Engineers Award for Risk Reduction in 2013. Dr. Ward holds an MA degree in Natural Science from the University of Cambridge, a Ph.D. in Electrical Engineering from the University of Nottingham, UK and holds appointments as a Visiting Professor in Functional Safety at Coventry University, UK and in Engineering Design at the University of Leicester, UK.

Wooderson, Paul

Paul Wooderson, MEng CEng MIET, is Senior Functional Safety/Cyber Security Engineer at HORIBA MIRA Ltd, currently responsible for cybersecurity research and development. He is a Chartered Engineer with 16 years’ experience in embedded systems security in the automotive and smartcard domains. Paul’s experience includes threat analysis and risk assessment, security evaluation of cryptographic hardware and software, secure design techniques and security certification. Paul is a UK Expert to the ISO/SAE joint working group developing the international standard ISO/SAE AWI 21434 “Road Vehicles – Cybersecurity Engineering”, and is also a member of the SAE Task Forces on Vehicle Electrical Hardware Security and Cybersecurity Assurance Testing.

Woodside, Kenneth B.

Ken Woodside is a senior consultant with The Luminous Group. His consulting experience has focused on assisting organizations improve their ability to operate more effectively and efficiently while meeting customer needs and expectations. He is particularly experienced in designing and implementing interventions that focus on developing creative bottom line strategies, increasing productivity and improving production effectiveness. These interventions have included senior management and line personnel in the process of developing and implementing change strategies including restructuring, lean manufacturing, quality improvement, and customer / supplier relations. Ken was part of a long term consulting experience to install process control at a major metal stamping and assembly plant that provided the foundation for QS-9000 certification. Ken has a Bachelors Degree in Finance and a Masters Degree in Social Psychology, both from Boston University. He earned his Doctorate Degree in Organization Development and Psychology from United University in Dayton Ohio.

Zachos, Mark

Mark Zachos is currently an adjunct professor at the University of Michigan. He is the President of Dearborn Group, Inc. and has more than twenty years of networking experience. Mr. Zachos participates in many SAE and ISO multiplexing committees, including the following: J1850, J1939, J2284, J2411, and J2367. He holds a B.S. and an M.S. in engineering from the University of Michigan.
Zielinski, Kevin
Kevin Zielinski currently owns and operates Red Cedar Media LLC, a training and corporate communications consulting, design, development and delivery company based in Michigan. Previously, Kevin was Senior Applications Specialist for EDS (including General Motors/EDS and Hewlett Packard/EDS) specializing in technical training delivery, training consulting, courseware design and development, and e-Learning. He has designed, developed and delivered over 40 lecture- and web-based courses attended by General Motors and EDS employees worldwide. Mr. Zielinski has also served as Adjunct Professor for the Wayne State University College of Engineering and WSU/Focus:Hope for many years. His areas of expertise include: e-Learning design and development, Quality Tools and Methods (Design of Six Sigma, Robust Engineering, Design of Experiments (DOE), Statistical Tolerancing and GD&T); Design for Manufacturing and Assembly (DFMA); Engineering Economics; and Plant Floor Throughput Improvement. He has been an instructor for SAE International Professional Development since 1990, and is a recipient of the SAE Forest R. McFarland Award (April 2005). He holds a bachelor’s and master’s degree in engineering from Wayne State University.

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January 2018

Live Online
Jan 10-19 New! Design for Additive Manufacturing: Towards End-Part Production – I.D.# WB1705
Jan 10-19 Vehicle Sound Package Materials – I.D.# WB1204
Jan 22-26 New! FEA Beyond Basics: Nonlinear Analysis– I.D.# WB1725
Jan 22-Feb 2 Design of Experiments (DOE) for Engineers– I.D.# WB0932

Kirkland, WA, USA - MicroTek - Seattle
Jan 30-31 Design Review Workshop– I.D.# C1306

February 2018

Troy, MI, USA - SAE International Troy Office
Feb 12-13 Control Systems Simplified – I.D.# C0525
Feb 21-22 New! Fundamentals of Vehicle Suspension Design – I.D.# C1618
Feb 28-Mar 1 A Familiarization of Drivetrain Components – I.D.# 98024

Live Online
Feb 5-9 New! FEA Beyond Basics: Thermal Analysis– I.D.# WB1726
Feb 19-Mar 7 Fundamentals of Geometric Dimensioning & Tolerancing (GD&T) – I.D.# WB0933

Livonia, MI, USA - Effective Training Inc. (ETI)
Feb 12-13 The Role of the Expert Witness in Product Liability Litigation – I.D.# 92054
Feb 13-15 Fundamentals of GD&T 2009 3-day– I.D.# ETI151

Herndon, VA, USA - MicroTek - Herndon (Dulles)
Feb 26-27 Introduction to Highly Automated Vehicles – I.D.# C1603

Durham, NC, USA - National Business Training (Raleigh)
Feb 12-13 The Basics of Internal Combustion Engines– I.D.# C0103

March 2018

Troy, MI, USA - SAE International Troy Office
Mar 2 Fundamentals of Automotive All-Wheel Drive Systems – I.D.# C0305
Mar 12-13 Practical NVH Signal Processing Methods– I.D.# C0431
Mar 14-16 Fundamentals of Steering Systems – I.D.# C0716
Mar 19-21 Advanced Vehicle Dynamics for Passenger Cars and Light Trucks – I.D.# C0415
Mar 19-21 Gasoline Direct Injection (GDI) Engines– I.D.# C1009
Mar 19-21 New! Transmission Engineering Academy – I.D.# ACAD11
Mar 22-23 Modern Fluids for Internal Combustion Engines – I.D.# C0704
Mar 22 Introduction to Brake Noise, Vibration, and Harshness – I.D.# C1337
Mar 23 Brake Noise Problem Resolution – I.D.# C0831
Mar 26-27 Engine Failure Investigation and Analysis – I.D.# C1344
Mar 27-28 Diesel Engine Technology – I.D.# 93014
Mar 26 New! High Voltage Vehicle Safety Systems and PPE – I.D.# C1732
Mar 27-29 Hybrid and Electric Vehicle Systems – I.D.# C1504
# Professional Development Schedule

## Live Online

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<td>Acoustic Fundamentals for Solving Noise and Vibration Problems – I.D.# WB1309</td>
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<td>Mar 20-22</td>
<td>Introduction to Powertrain Calibration Engineering – I.D.# WB1346</td>
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## Lombard, IL, USA - MicroTek - Chicago Metro

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<tr>
<td>Mar 6-7</td>
<td>Introduction to Commercial and Off-Road Vehicle Cooling Airflow Systems – I.D.# C0738</td>
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</tr>
</tbody>
</table>

## Herndon, VA, USA - MicroTek - Herndon (Dulles)

<table>
<thead>
<tr>
<th>Date</th>
<th>Course</th>
<th>ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar 19-21</td>
<td>Injuries, Anatomy, Biomechanics &amp; Federal Regulation – I.D.# 85049</td>
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</table>

## Livonia, Michigan, USA - Effective Training Inc. (ETI)

<table>
<thead>
<tr>
<th>Date</th>
<th>Course</th>
<th>ID</th>
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</thead>
<tbody>
<tr>
<td>Mar 20-21</td>
<td>Advanced Concepts of GD&amp;T 1994 2-day – I.D.# ET2411</td>
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<tr>
<td>Mar 26</td>
<td>Fundamentals of Shielding Design for EMC Compliance – I.D.# C0835</td>
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## April 2018

### Troy, MI, USA - SAE International Troy Office

<table>
<thead>
<tr>
<th>Date</th>
<th>Course</th>
<th>ID</th>
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</thead>
<tbody>
<tr>
<td>Apr 3</td>
<td>Principled Negotiation – I.D.# C1602</td>
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<tr>
<td>Apr 4-6</td>
<td>Managing Engineering &amp; Technical Professionals – I.D.# C0608</td>
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<tr>
<td>Apr 16</td>
<td>Basic Tire Mechanics and Inspection – I.D.# C1423</td>
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<tr>
<td>Apr 17-18</td>
<td>Tire Forensic Analysis – I.D.# C1424</td>
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### Troy, MI, USA - SAE International Troy Office

#### In Conjunction with the WCX™: SAE World Congress Experience

<table>
<thead>
<tr>
<th>Date</th>
<th>Course</th>
<th>ID</th>
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</thead>
<tbody>
<tr>
<td>Apr 9-11</td>
<td>Principles of Cost and Finance for Engineers – I.D.# C0828</td>
<td></td>
</tr>
<tr>
<td>Apr 12-13</td>
<td>Leading High Performance Teams – I.D.# C0410</td>
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</table>

## Live Online

<table>
<thead>
<tr>
<th>Date</th>
<th>Course</th>
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<tbody>
<tr>
<td>Apr 3-5</td>
<td>Driver Distraction from Electronic Devices: Insights and Implications – I.D.# WB1140</td>
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<tr>
<td>Apr</td>
<td>Patent Litigation in the U.S.: What You Need to Know – I.D.# WB0940</td>
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<tr>
<td>Apr 17-24</td>
<td>Catalytic NOx Control Technologies for Diesel and GDI Engines – I.D.# WB1237</td>
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<tr>
<td>Apr 17-May 1</td>
<td>New! Materials Degradation in Mechanical Design: Wear, Corrosion, Fatigue and their Interactions – I.D.# WB1722</td>
<td></td>
</tr>
<tr>
<td>Apr 18-27</td>
<td>Root Cause Problem Solving: Methods and Tools – I.D.# WB0931</td>
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### Livonia, VA, USA - Effective Training Inc. (ETI)

<table>
<thead>
<tr>
<th>Date</th>
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<tbody>
<tr>
<td>Apr 10-11</td>
<td>Product Liability and The Engineer – I.D.# 82001</td>
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<tr>
<td>Apr 16-17</td>
<td>Fundamentals of GD&amp;T for Inspectors 2-day – I.D.# ET2053</td>
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<tr>
<td>Apr 24-25</td>
<td>New! Critical Concepts of Tolerance Stacks – I.D.# C1701</td>
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### Pontiac, MI, USA - LHPU Campus

<table>
<thead>
<tr>
<th>Date</th>
<th>Course</th>
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<tbody>
<tr>
<td>Apr 2-6</td>
<td>New! Gasoline Engine Calibration Engineering Academy – I.D.# ACAD10</td>
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### Appleton, WI, USA - FVTC Public Safety Training Center

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<thead>
<tr>
<th>Date</th>
<th>Course</th>
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<tbody>
<tr>
<td>Apr 30-May 3</td>
<td>Accessing and Interpreting Heavy Vehicle Event Data Recorders – I.D.# C1022</td>
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### El Segundo, CA, USA - MicroTek - El Segundo

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<tr>
<th>Date</th>
<th>Course</th>
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### Detroit, MI, USA - Cobo Center

#### Held In Conjunction with the WCX™: SAE World Congress Experience

<table>
<thead>
<tr>
<th>Date</th>
<th>Course</th>
<th>ID</th>
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<tbody>
<tr>
<td>Apr 9-10</td>
<td>Automotive Lighting: Design and Technology – I.D.# C0202</td>
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<tr>
<td>Apr 9-10</td>
<td>Introduction to Brake Control Systems: ABS, TCS, and ESC – I.D.# C0315</td>
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<tr>
<td>Apr 9-10</td>
<td>Introduction to Highly Automated Vehicles – I.D.# C1603</td>
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<tr>
<td>Apr 9-10</td>
<td>New! Fundamentals of Vehicle Suspension Design – I.D.# C1618</td>
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<tr>
<td>Apr 9-10</td>
<td>Evaporative and Refueling Emission Control – I.D.# C0928</td>
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<tr>
<td>Apr 11</td>
<td>New! ADAS Application: Automatic Emergency Braking – I.D.# C1704</td>
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<tr>
<td>Apr 12</td>
<td>Automotive Lighting: Testing and Requirements – I.D.# C0618</td>
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<tr>
<td>Apr 12-13</td>
<td>Design of Experiments - Basic Simplified Taguchi – I.D.# C0231</td>
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<tr>
<td>Apr 12-13</td>
<td>Introduction to Failure Mode and Effects Analysis for Product and Process – I.D.# C1201</td>
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<tr>
<td>Apr 12-13</td>
<td>Advanced Diesel Particulate Filtration Systems – I.D.# C0502</td>
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For the most up-to-date live learning schedule, training.sae.org/calendar/
PROFESSIONAL DEVELOPMENT SCHEDULE

Apr 12-13  New! Introduction to Radar for Automotive Applications – I.D.# C1627
Apr 13    Emissions-Related OBD Systems: A Design Overview – I.D.# C0708
Apr 13    Automotive Lighting: LED Applications – I.D.# C0727
Apr 13    Reconstruction and Analysis of Motorcycle Crashes – I.D.# C1506

May 2018

Troy, MI, USA - SAE International Troy Office

May 1    Surface Texture: Specification and Control – I.D.# C1110
May 2-3  Introduction to Hybrid and Electric Vehicle Battery Systems – I.D.# 0626
May 3-4  Improving Fuel Efficiency with Engine Oils – I.D.# C0914
May 4    Safe Handling of High Voltage Battery Systems – I.D.# C1019
May 9    Exhaust Flow Performance and Pressure Drop of Exhaust Components and Systems – I.D.# C0235
May 10-11 Material Selection and Testing for Plastics – I.D.# C0134
May 10-11 Sound Package Materials for Vehicle Noise Control – I.D.# 92032
May 14-16 Combustion and Emissions for Engineers – I.D.# 97011
May 14-18 Engineering Management Academy – I.D.# ACAD09
May 22-23 Powertrain Selection for Fuel Economy and Acceleration Performance – I.D.# C0243
May 24-25 Side Impact Occupant Safety and CAE – I.D.# C0717

Live Online

May 8-15  Brake System Balance for Passenger Cars and Light Trucks – I.D.# WB1413
May 14-25 Finite Element Analysis for Design Engineers – I.D.# WB1241
May 29-Jun 1 New! FEA Beyond Basics: Nonlinear Analysis – I.D.# WB1725

Greer, SC, USA - BMW Performance Center

May 21-23  Applied Vehicle Dynamics – I.D.# C0414

Livonia, Michigan, USA - Effective Training Inc. (ETI)

May 1-2  New! ISO Geometric Tolerancing 2-day – I.D.# ET7103
May 15-17 Fundamentals for GD&T 2009 3-day – I.D.# ET1151

May 22-23  Functional Gaging and Measurement 2-day – I.D.# ET8200

Pontiac, MI, USA - LHPU Campus

May 14-18  New! Gasoline Engine Calibration Engineering Academy – I.D.# ACAD10

June 2018

Troy, MI, USA - SAE International Troy Office

Jun 4    Diesel Engine Technology Engineering Academy – I.D.# ACAD03
Jun 6    The Tire as a Vehicle Component – I.D.# C0101
Jun 7    Tire and Wheel Safety Issues – I.D.# C0102
Jun 11-13 Advanced Vehicle Dynamics for Passenger Cars and Light Trucks – I.D.# C0415
Jun 15    Reconstruction and Analysis of Rollover Crashes of Light Vehicles – I.D.# C1502
Jun 18-19 Engineering Project Management – I.D.# 99003
Jun 18-20 Applying Automotive EDR Data to Traffic Crash Reconstruction – I.D.# C1210
Jun 20-21 Leading High Performance Teams – I.D.# C0410
Jun 26    New! ADAS Application: Automatic Emergency Braking – I.D.# C1704

Live Online

Jun 4-8  Introduction to Design Review Based on Failure Modes (DRBFM) – I.D.# WB1047
Jun 4-8  New! FEA Beyond Basics: Thermal Analysis – I.D.# WB1047
Jun 11-22 Vibration Analysis Using Finite Element Analysis (FEA) – I.D.# WB1401
PROFESSIONAL DEVELOPMENT SCHEDULE

Livonia, MI, USA - Effective Training Inc. (ETI)
Jun 5-6  Applications of GD&T 2-day – I.D.# ET2512

July 2018

Troy, MI, USA - SAE International Troy Office
Jul 16-17  Robust Design – I.D.# C1231
Jul 16-17  Managing Programs and Associated Risks – I.D.# C0409
Jul 23-24  New! Introduction to Radar for Automotive Applications – I.D.# C1627

El Segundo, CA, USA - MicroTek - El Segundo
Jul 23-24  Introduction to Highly Automated Vehicles – I.D.# C1603

Live Online
Jul 11-20  Tolerance Stack-up Fundamentals – I.D.# C0842

El Segundo, CA, USA - MicroTek - El Segundo
Jul 23-24  Introduction to Highly Automated Vehicles – I.D.# C1603

August 2018

Troy, MI, USA - SAE International Troy Office
Aug 1-2  Vehicle Frontal Crash Occupant Safety and CAE – I.D.# C0621
Aug 1-3  Principles of Cost and Finance for Engineers – I.D.# C0828
Aug 6-8  Fundamentals of Modern Vehicle Transmissions – I.D.# 99018
Aug 6-8  Vehicle Dynamics for Passenger Cars and Light Trucks – I.D.# 99020
Aug 6-8  Gasoline Direct Injection (GDI) Engines – I.D.# C1009
Aug 9-10  Fundamentals of Gear Design and Application – I.D.# C0223
Aug 14-15  Selective Catalytic Reduction for Diesel Engines – I.D.# C0913
Aug 15  Common Rail Diesel Fuel Injection – I.D.# C0920
Aug 15-17  Weibull-Log Normal Analysis Workshop – I.D.# 86034
Aug 22-23  New! Fundamentals of Vehicle Suspension Design – I.D.# C1618
Aug 22-23  Design for Manufacture and Assembly (DFM/DFA) – I.D.# C0418
Aug 27-29  Managing Engineering & Technical Professionals - I.D.# C0608
Aug 30  Principled Negotiation – I.D.# C1602

Live Online
Aug 21-30  Vehicle Sound Package Materials – I.D.# WB1204
Aug 27-29  Introduction to Powertrain Calibration Engineering – I.D.# WB1346

Livonia, Michigan, USA - Effective Training Inc. (ETI)
Aug 7-9  Fundamentals of GD&T 2009 3-day – I.D.# ET1151

Lombard, IL, USA - MicroTek - Chicago Metro
Aug 14-15  Introduction to Commercial and Off-Road Vehicle Cooling Airflow Systems – I.D.# C0738

Greenville, SC, USA - MicroTek - Greenville
Aug 9-10  Engine Failure Investigation and Analysis – I.D.# C1344

Herndon, VA, USA - MicroTek - Herndon (Dulles)
Aug 6-8  New! Vehicle Crash Reconstruction: Principles and Technology – I.D.# C1728

September 2018

Troy, MI, USA - SAE International Troy Office
Sep 11-12  Exhaust Gas Recirculation (EGR) for Diesel Engines – I.D.# C1214
Sep 12-13  Control Systems Simplified – I.D.# C0525
Sep 17-19  Fundamentals of Steering Systems – I.D.# C0716
Sep 24-25  A Familiarization of Drivetrain Components – I.D.# 98024
Sep 24-26  Hybrid and Electric Vehicle Systems – I.D.# C1504
Sep 26  Fundamentals of Automotive All-Wheel Drive Systems – I.D.# C0305
Sep 27  New! High Voltage Vehicle Safety Systems and PPE – I.D.# C1732
Sep 27-28  Engineering Project Management – I.D.# 99003

Live Online
Sep 10-26  Fundamentals of Geometric Dimensioning & Tolerancing (GD&T) – I.D.# WB0933

For the most up-to-date live learning schedule,
training.sae.org/calendar/
PROFESSIONAL DEVELOPMENT SCHEDULE

Indianapolis, IN, USA - Indianapolis Marriott Downtown
Held in conjunction with the SAE 2018 On-Board Diagnostics Symposium – North America

Sep 14 Emissions-Related OBD Systems: A Design Overview – I.D.# C0708

Livonia, MI, USA - SAE International Troy Office

Sep 12 Fundamentals of Shielding Design for EMC Compliance – I.D.# C0835
Sep 18-20 Fundamentals of GD&T 1994 3-day – I.D.# ET2001
Sep 25-26 Fundamentals of GD&T for Inspectors 2-day – I.D.# ET2053

Pontiac, MI, USA - LHPU Campus

Sep 24-28 New! Gasoline Engine Calibration Engineering Academy – I.D.# ACAD10

Troy, MI, USA - SAE International Troy Office

Oct 1-5 Vehicle Noise Control Engineering Academy - Vehicle Interior Noise Track – I.D.# ACAD01
Oct 1-5 Vehicle Noise Control Engineering Academy - Powertrain Noise Track – I.D.# ACAD02
Oct 3-4 Diesel Engine Technology – I.D.# 93014
Oct 4-5 Leading High Performance Teams – I.D.# C0410
Oct 5 Exhaust Flow Performance and Pressure Drop of Exhaust Components and Systems – I.D.# C0235
Oct 9-10 Evaporative and Refueling Emission Control – I.D.# C0928
Oct 11-12 Acquiring and Analyzing Data from Sensors and In-Vehicle Networks – I.D.# C0522
Oct 15-16 Design of Experiments - Basic Simplified Taguchi – I.D.# C0231
Oct 24-26 Advanced Vehicle Dynamics for Passenger Cars and Light Trucks – I.D.# C0415
Oct 29-30 The Basics of Internal Combustion Engines – I.D.# C0103
Oct 29-31 Strategic Leadership – I.D.# C0620

Live Online

Oct 1-12 Design of Experiments (DOE) for Engineers – I.D.# WB0932
Oct 2-4 Driver Distraction from Electronic Devices: Insights and Implications – I.D.#WB1140
Oct 15 Advanced GD&T Competencies: Datum Usage – I.D.#WB1319
Oct 16-25 Root Cause Problem Solving: Methods and Tools – I.D.#WB0931

Oct 17 Advanced GD&T Competencies: Profile of a Surface– I.D.# WB1320
Oct 19 Advanced GD&T Competencies: Composite Positioning– I.D.# WB1321
Oct 29-Nov 9 Finite Element Analysis (FEA) for Design Engineers – I.D.# WB1401

Greer, SC, USA - BMW Performance Center

Oct 15-17 Applied Vehicle Dynamics – I.D.# C0414

Palm Desert, CA, USA - JW Marriott Desert Springs Resort & Spa
In Conjunction with the Brake Colloquium & Exhibition - 36th Annual

Oct 11-12 Introduction to Brake Control Systems: ABS, TCS, and ESC– I.D.# C0315
Oct 18 Brake Friction Materials: Testing, Quality and Selection – I.D.# C1020
Oct 18 Introduction to Brake Noise, Vibration, and Harshness– I.D.# C1337
Oct 19 Brake Noise Problem Resolution – I.D.# C0831

Livonia, MI, USA - Effective Training Inc. (ETI)

Oct 9-10 Product Liability and The Engineer – I.D.# 82001
Oct 11-12 The Role of the Expert Witness in Product Liability Litigation – I.D.# 92054
Oct 23-24 Applications of GD&T 2-day – I.D.# ET2512

Pontiac, MI, USA - LHPU Campus


El Segundo, CA, USA - MicroTek - El Segundo

Oct 15 Reconstruction and Analysis of Rollover Crashes of Light Vehicles – I.D.# C1502
Oct 16 Reconstruction and Analysis of Motorcycle Crashes – I.D.# C1506
Oct 17-19 Injuries, Anatomy, Biomechanics & Federal Regulation – I.D.# 85049

California, USA - Location TBD

Oct 23-26 Accessing and Interpreting Heavy Vehicle Event Data Recorders – I.D.# C1022
PROFESSIONAL DEVELOPMENT SCHEDULE

November 2018

Troy, MI, USA - SAE International Troy Office

Nov 5  Introduction to NVH Aspects of Hybrid and Electric Vehicles – I.D.# C1128
Nov 5-6  New! Introduction to Radar for Automotive Applications – I.D.# C1627
Nov 6-7  Introduction to Hybrid and Electric Vehicle Battery Systems – I.D.# C0626
Nov 6-7  Introduction to Highly Automated Vehicles – I.D.# C1603
Nov 7  The Tire as a Vehicle Component – I.D.# C0101
Nov 8  Surface Texture: Specification and Control – I.D.# C1110
Nov 8  Tire and Wheel Safety Issues – I.D.# C0102
Nov 8  Safe Handling of High Voltage Battery Systems – I.D.# C1602
Nov 12-13  Controller Area Network (CAN) for Vehicle Applications – I.D.# C0120
Nov 12-14  Designing On-Board Diagnostics for Light and Medium Duty Emissions Control Systems – I.D.# C0707
Nov 12-16  Engineering Management Academy – I.D.# ACAD09
Nov 14-16  Principles of Cost and Finance for Engineers – I.D.# C0828
Nov 25-27  Effective Writing for Engineering and Technical Professionals – I.D.# C1605
Nov 26-27  Side Impact Occupant Safety and CAE – I.D.# C0717
Nov 28-29  Engineering Project Management – I.D.# 99003
Nov 28-30  Applying Automotive EDR Data to Traffic Crash Reconstruction – I.D.# C1210

Live Online

Nov 27-30  Introduction to Design Review Based on Failure Modes (DRBFM) – I.D.# WB1047
Nov 28-Dec 10  Vibration Analysis Using Finite Element Analysis (FEA) – I.D.# WB1402

Livonia, MI, USA - Effective Training Inc. (ETI)

Nov 6-7  New! Critical Concepts of Tolerance Stacks – I.D.# ET1701
Nov 8  Introduction to Statistical Tolerance Stacks 1-day – I.D.# ET2055

Phoenix, AZ, USA - Training to You (Phoenix)

Nov 5-7  New! Vehicle Crash Reconstruction: Principles and Technology – I.D.# C1728

December 2018

Troy, MI, USA - SAE International Troy Office

Dec 3-5  Fundamentals of Modern Vehicle Transmissions – I.D.# 99018
Dec 3-7  Hybrid and Electric Vehicle Engineering Academy – I.D.# ACAD06
Dec 6-7  New! Fundamentals of Vehicle Suspension Design – I.D.# C1618
Dec 10-12  Managing Engineering & Technical Professionals – I.D.# C0608
Dec 10-12  Weibull-Log Normal Analysis Workshop – I.D.# 86034
Dec 10-12  Combustion and Emissions for Engineers – I.D.# 97001
Dec 13  Principled Negotiation – I.D.# C1602

Live Online

Dec 11-20  Tolerance Stack-up Fundamentals – I.D.# C0842

Livonia, MI, USA - Effective Training Inc. (ETI)

Dec 4-6  Fundamentals of GD&T 2009 3-day – I.D.# ETII51

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