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Vehicle Noise, Vibration, and Sound Quality

By Gang Sheng
(Gang Sheng Chen)
# Table of Contents

Preface .......................................................... ix

Chapter 1  Introduction to Vehicle Vibrations and Sound ........................................... 1

1.1 Vehicle vibrations and sound .............................................. 2
  1.1.1 Vehicle systems, subsystems, and components .......... 2
  1.1.2 Sources, paths, and receivers of vibrations and sound ........................................ 3

1.2 Characteristics of vehicle vibrations and sound ....................... 3

1.3 Significance of vehicle vibrations and sound .......................... 7

Chapter 2  Fundamentals of Vehicle Vibrations and Sound ......................................... 11

2.1 Introduction .................................................................. 12

2.2 Fundamentals of vibration ................................................ 12
  2.2.1 Vibration of linear discrete and continuous systems .................. 12
  2.2.2 Random vibrations ................................................. 34

2.3 Fundamentals of sound .................................................... 49
  2.3.1 Airborne sound and measures ................................. .50
  2.3.2 Sound perception and weighting curves .................... .51
  2.3.3 Sound wave equation ............................................. .55
  2.3.4 Sound radiation of structures ................................. .58
  2.3.5 Acoustic wave transmission, adsorption, and reflection ........ .59

2.4 Analysis and testing approaches ......................................... 62
  2.4.1 Finite element and boundary element methods .......... .62
  2.4.2 Modal analysis and modal synthesis methods ............ .73
  2.4.3 Transfer path analysis ............................................. .83
  2.4.4 Statistical energy analysis ....................................... .98
  2.4.5 Testing techniques ................................................ .111
2.5 Control of vehicle vibrations and sound

2.5.1 Basic features of vehicle vibrations and noise
2.5.2 Mode mapping and frequency separation of subsystems/components
2.5.3 Vibration reduction using isolator and absorber
2.5.4 Damping treatment
2.5.5 Noise control through insulation
2.5.6 Noise control through absorption material or structure
2.5.7 Active and semi-active control of noise and vibrations
2.5.8 Fundamentals of sound quality

Chapter 3 Powertrain Vibrations and Sound

3.1 Introduction
3.2 Engine vibrations
3.2.1 Engine vibration sources
3.2.2 Torsional vibrations
3.2.3 Bending vibrations of engine crankshaft
3.3 Engine noise
3.3.1 Introduction
3.3.2 Engine noise sources
3.3.3 Combustion noise
3.3.4 Engine mechanical noise
3.4 Transmission vibrations and noise
3.4.1 Transmission whine
3.4.2 Transmission rattle
3.4.3 Clutch system vibrations and noise
3.5 Sound in air intake and exhaust systems
3.5.1 Noise in air intake system
3.5.2 Sound in air exhaust systems
3.6 Drivetrain vibrations and noise
3.6.1 Driveline system and vibration and noise
3.6.2 Run-out, second-order excitation, unbalance, and critical speed of shaft
3.6.3 Vibrations and noise in driveline systems
3.7 Powertrain system vibration isolation
3.7.1 Vibration isolation
### Chapter 3

**3.7.2 Isolation evaluation using six-degree-of-freedom model**

- Page 304

**3.7.3 Engine mounts**

- Page 312

**3.7.4 Optimization of powertrain vibration isolation**

- Page 316

### Chapter 4

**Vibrations and Sounds of Body and Chassis Systems**

- Page 327

#### 4.1 Introduction

- Page 328

#### 4.2 Vehicle interior noise: structure-borne noise

- Page 329

| 4.2.1 Vehicle body structural vibration mode and sensitivity, acoustic modes of vehicle compartment | Page 329
| 4.2.2 Structural vibration, noise, and damping treatment | Page 337
| 4.2.3 Excitation transmissions of body structure connection points | Page 343
| 4.2.4 Sources of structure-borne interior noise | Page 347

#### 4.3 Vehicle interior noise: airborne noise

- Page 355

| 4.3.1 Sources of airborne noise | Page 355
| 4.3.2 Powertrain airborne noise | Page 356
| 4.3.3 Road and tire noise mechanisms | Page 357
| 4.3.4 Sound treatment of vehicle | Page 362

#### 4.4 Wind noise

- Page 375

| 4.4.1 Introduction | Page 375
| 4.4.2 Wind noise mechanism and testing | Page 376
| 4.4.3 The analysis of wind noise | Page 381
| 4.4.4 Wind noise abatement | Page 385

#### 4.5 Squeak and rattle

- Page 387

| 4.5.1 Friction- and impact-induced vibrations and noise | Page 388
| 4.5.2 Squeak and rattle control | Page 390

#### 4.6 Brake system vibration and noise

- Page 393

| 4.6.1 Introduction | Page 393
| 4.6.2 Low-frequency vibration and noise | Page 399
| 4.6.3 Low-frequency squeal | Page 402
| 4.6.4 High-frequency squeal | Page 403

#### 4.7 Vehicle low-frequency vibrations

- Page 405

| 4.7.1 Introduction | Page 405
Chapter 5  Evaluation of Vehicle Vibrations and Sound  

5.1  Introduction  

5.2  Noise and sound quality evaluation  
   5.2.1  Pass-by noise: Regulatory requirement  
   5.2.2  Interior noise: customer requirement  
   5.2.3  Sound quality: customer perception  

5.3  Vibration evaluation  
   5.3.1  Body characteristics under vibration environment  
   5.3.2  Discomfort and subjective evaluation  
   5.3.3  Objective evaluation of ride discomfort  
   5.3.4  Linear human body modeling  
   5.3.5  Objective evaluation of seats  
   5.3.6  Vehicle vibration evaluation  

Index  

About the Author
Preface

The last decade has been characterized by the remarkable development of many technical and scientific domains, and the development of vibration and sound technology of road vehicles has been on this same trajectory. The new generation of road vehicles is very different from the previous generation. Modern vehicles have new rules for features of vibration and sound beyond the conventional requirements simply for vibration and noise control. This book is intended to enable its readers to make engineering advances in this area.

This is a textbook intended for upper-level undergraduate and graduate students in automotive engineering as an independent study text and for practicing engineers, designers, researchers, and educators to use as a reference book.

In the past decades, educators, researchers, and practitioners have devoted considerable effort toward researching vibration and sound in vehicles. Many papers have been published, but very little information on this topic can be found in existing books. Some previously published books or book chapters contain relevant material that emphasizes particular systems. However, some important applications and a number of recent developments have not been included. There has been the lack of a book to integrate the principles and analysis approaches as well as test techniques to provide a means for mastering all of the concepts of vehicle vibration and sound, to give a big picture and framework on the topic to readers. This book is a contribution toward these efforts and aims to fill the void.

This book is based on my experiences as a researcher and teacher of sound and vibration problems in road vehicles, and on my experiences with developing and offering short courses in this area. I was once fortunate to serve as an advisory scientist and consultant in California and a research scientist in Michigan, USA from 2001–2008. I hope that I have contributed a few, practically realizable solutions. In the course of my work I have learned much from the practitioners of the art with respect to making the vehicle behave both acceptably and pleasurably from a sound and vibration standpoint.

The objective of the book is to give readers a working knowledge of vehicle vibration and sound, enabling them to analyze vehicle vibration and sound parameters ranging from vibration reduction, noise control, and sound quality design. In the book, equal emphasis is given to theory and practical application. The principles, analytical formulations, design approaches, and testing techniques are presented and illustrated. The balance covers the different levels from vehicle, to system, to key components.
To that end, the book is comprised of five chapters. The basic principles of vibration and sound are presented in the first two chapters. Chapter 1 provides an introduction. Chapter 2 develops the fundamentals of vehicle vibrations and sound, starting with basic vibration and sound concepts, followed by the analysis and testing approaches used to treat vehicle vibration and sound. Then, the basic features of vehicle vibrations and sound are introduced. The conventional and contemporary approaches for vehicle vibration reduction and noise control as well as sound quality design are described.

Chapter 3 discusses powertrain vibrations and sound, including the vibrations and sound of the engine, transmission, driveline, intake system, and exhaust system.

Chapter 4 deals with vibrations and sound of the body and chassis systems with a focus on vehicle interior noise, including structure-borne and airborne noise. This chapter also covers wind noise, squeak and rattle, brake system vibration and noise, and vehicle low-frequency vibrations that include ride dynamics and structural vibrations.

Chapter 5 presents the techniques to evaluate vehicle vibrations and sound, including vibration, noise, and sound quality evaluation, from vehicle interiors to exteriors.

The main objectives of this book are to cover most major vehicle vibration and sound topics in a unified presentation that solves relevant problems. These objectives are addressed by providing depth and breadth to governing fundamental principles plus a background in modern measurement and computational tools for vehicle vibration and sound.

The purpose of this book is to provide a systematic understanding of vehicle vibration and sound. It provides comprehensive topics, with up-to-date and self-contained results.

I sincerely hope that this book will help students, teachers, and researchers to develop an appreciation for the topic of vehicle vibration and sound. Any errors, oversights, omissions, or other comments to help improve the book can be communicated to the author and will be greatly appreciated.
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I am unusually fortunate in having worked with numerous expert-caliber individuals during my six years of automotive industrial employment in Detroit, Michigan prior to returning to academia in 2008.

I am indebted to a number of individuals for encouraging and educating me about the automotive industry.

I would like to especially thank Dr. Jian Pang, former NVH specialist at Ford Motor Company and Dr. Hua He, former NVH specialist at General Motors Inc., with whom I developed much understanding of vehicle vibrations and sound. I want to thank many kind individuals who have expanded my perspective of the subject over the years. I here acknowledge those individuals: Wade Bray, Dr. Bob Dowell, John Bonhanic, Dr. Keqin Xu, Dr. Yen Ren, Dr. Hurry Vissey, Dr. Lin Zhu, Dr. Shuiyuan Luo, Dr. Frank Min, Eric Luis, Dr. Xiandi Zeng, Dr. David Feng, Dr. Richard Chen, Dr. Frank Zhong, late Professor Rao Dukkipati, Professor Mohamad Qatu, Dr. Tze-Chi Jao, Dr. Qi Wan, Dr. Frank Chen, Dr. Mike Yeng, and Dr. Mike Qang.

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—Gang Sheng Chen (Gang Sheng)