<table>
<thead>
<tr>
<th>Term</th>
<th>Page Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute amplitude ratio</td>
<td>435-439</td>
</tr>
<tr>
<td>Acceleration</td>
<td>379</td>
</tr>
<tr>
<td>- centripetal</td>
<td>410</td>
</tr>
<tr>
<td>- lateral</td>
<td>410</td>
</tr>
<tr>
<td>- low-speed</td>
<td>13</td>
</tr>
<tr>
<td>- power-limited</td>
<td>21</td>
</tr>
<tr>
<td>- versus static deflection</td>
<td>416-417</td>
</tr>
<tr>
<td>- traction-limited</td>
<td>35</td>
</tr>
<tr>
<td>Acceleration performance</td>
<td></td>
</tr>
<tr>
<td>- automatic transmissions in</td>
<td>28-32</td>
</tr>
<tr>
<td>- engines in</td>
<td>21-23</td>
</tr>
<tr>
<td>- power-limited acceleration in</td>
<td>21</td>
</tr>
<tr>
<td>- power train in</td>
<td>23-28</td>
</tr>
<tr>
<td>- traction-limited acceleration</td>
<td>35</td>
</tr>
<tr>
<td>- traction limits</td>
<td>39</td>
</tr>
<tr>
<td>- transverse weight shift due to drive torque</td>
<td>35-38</td>
</tr>
<tr>
<td>Accident experience</td>
<td>327-331</td>
</tr>
<tr>
<td>Ackerman Angle</td>
<td>196</td>
</tr>
<tr>
<td>Ackerman Geometry</td>
<td>196-197, 277, 278</td>
</tr>
<tr>
<td>Ackerman steer angle</td>
<td>227, 228, 403, 411</td>
</tr>
<tr>
<td>Ackerman steer angle gradient</td>
<td>403, 412</td>
</tr>
<tr>
<td>Ackerman Steering</td>
<td>196</td>
</tr>
<tr>
<td>Active control</td>
<td>159-163</td>
</tr>
<tr>
<td>Active suspensions</td>
<td></td>
</tr>
<tr>
<td>- functions</td>
<td>270</td>
</tr>
<tr>
<td>- dive control</td>
<td>271</td>
</tr>
<tr>
<td>- height control</td>
<td>270-271</td>
</tr>
<tr>
<td>- ride control</td>
<td>270</td>
</tr>
<tr>
<td>- road holding</td>
<td>271</td>
</tr>
<tr>
<td>- roll control</td>
<td>271</td>
</tr>
<tr>
<td>- squat control</td>
<td>271</td>
</tr>
<tr>
<td>- performance</td>
<td>271-273</td>
</tr>
<tr>
<td>suspension categories</td>
<td></td>
</tr>
<tr>
<td>- full-active suspensions</td>
<td>270</td>
</tr>
<tr>
<td>- passive suspensions</td>
<td>269</td>
</tr>
<tr>
<td>- self-leveling suspensions</td>
<td>269</td>
</tr>
<tr>
<td>- semi-active suspensions</td>
<td>269-270</td>
</tr>
<tr>
<td>ADAMS models</td>
<td>292</td>
</tr>
<tr>
<td>Aerodynamic aids</td>
<td>93-96</td>
</tr>
<tr>
<td>Aerodynamic angle of attack</td>
<td>408</td>
</tr>
</tbody>
</table>
Aerodynamic drag, 49, 119-120
Aerodynamic force, 87-88
Aerodynamic force and moment coefficients, 408-409
Aerodynamic motion variables, 407-408
Aerodynamic nomenclature, 407-409
Aerodynamics, 79
  aerodynamic aids, 93-96
  aerodynamic forces, 87-88
  crosswind sensitivity, 106-110
  drag, 97-101
  drag components, 88-93
  lift force, 103
  mechanics of air flow around a vehicle, 79-84
  pitching moment, 103-104
  pressure distribution on a vehicle, 84
  rolling moment, 105-106
  side force, 101-102
  yawing moment, 104-105
Aerodynamic sideslip angle, 408
Air dams, 94
Air density, 97-98
Air flow, mechanics of, around vehicle, 79-84
Aligning moment, 359
  path curvature, 361-362
  relevance to vehicle performance, 362-363
  slip angle, 360-361
Aligning stiffness, 393
Aligning stiffness coefficient, 394
Aligning torque, 223, 226, 291, 393
Ambient wind angle, 407
Ambient wind velocity, 407
American Society for Testing and Materials Method
  E-274, 60, 346
  E-501, 346
Amplitude, 378-379
  static, 379
Amplitude peak-to-peak, 378-379
Amplitude ratio (relative magnification factor), 379
Angular orientation, 397
Anti-dive suspension geometry, 254-256
Anti-lock brake systems, 67-68, 347
Anti-squat and anti-pitch suspension geometry, 248
  equivalent trailing arm analysis, 248-250
Aspect ratio, 352-353
Asymptotic stability, 402
Automatic transmissions, 28-32
Automotive engineering, status of, 2-3
Axle fore-and-aft shake, 384
Axle side shake, 384
Axle vibration modes, 384
Axle windup, 384
Axle yaw, 384

Bead, 389
Bead base, 389
Bead toe, 389
Beaming, 383
Benz, Karl, 2
Bernoulli's equation, 80, 82
Bias-belted tires, 336
Bias-ply tires, 336
Bias tire construction, 336-337
Bobillier’s Construction, 280
Boom, 383
Bounce/pitch frequencies, 172-177
Boundary layer, 82-83
Bouton, George, 240
Brake coefficient, 69-70
Brake factor, 51-54, 52
Brake force imbalance, 296-297
Brake hop, 384
Brake proportioning, 60-67
Brakes, 50
disc, 50
drum, 50
Braking efficiency, 69-70
Braking force, 392
Braking force coefficient, 392
Braking performance
anti-lock brake systems, 67-68, 347
basic equations, 45-46
constant deceleration, 46-47
deceleration with wind resistance, 47-48
energy/power, 48
brakes, 50
brake factor, 51-54
braking efficiency, 69-70
braking forces, 48
  aerodynamic drag, 49
  driveline drag, 49
  grade, 50
  rolling resistance, 48-49
federal requirements for, 59-60
pedal force gain, 74
rear wheel lockup, 71-74
tire-road friction, 54-57
  inflation pressure, 57
  velocity, 56
  vertical load, 57
Braking squeal, 395
Braking stability, 295-297
Braking stiffness, 393
Braking stiffness coefficient, 394
Braking torque, 393
Braking traction coefficient, 394
Bumper spoilers, 93-94
Bump stop, 387
Bureau of Motor Carrier Safety (BMCS), 330-331
Burnish, 60n
Burton-Douglas chart, 461

Camber angle, 218-219, 386
Camber change, 217-219
Camber force, 392
Camber stiffness, 393
Camber stiffness coefficient, 394
Camber thrust, 217, 226, 355-356
  inflation pressure, 358-359
  load, 358
  other factors, 359
  relevance to vehicle performance, 359
  tire type, 356-358
  tread design, 359
Caster angle, 283-284, 385
Caster offset, 385
Center of parallel wheel motion, 387
Center of tire contact, 385, 409
Central force, 392
Centrifugal caster, 385
Centripetal acceleration, 399, 410
Characteristic speed, 204, 404
Complex damping, 381
Compliance camber, 405
Compliance camber coefficient, 406
Compliance oversteer, 405
Compliance steer, 405
Compliance steer coefficient, 405
Compliance understeer, 405
Composite force variation, 134
Compression, 386-387
Conicity and ply steer, 367-369
relevance to vehicle performance, 369
Conicity force, 396
Constant deceleration, 46-47
Constant peak driving force, 444-446
Constant radius method, 227-229
Constant speed method, 229-230
Control modes, 401
Cornering
effect of tractive forces on, 223-226
suspension effects on, 209-210
  aligning torque, 223
camber change, 217-219
effect of tractive forces on cornering, 223
  lateral force compliance steer, 221-222
roll moment distribution, 210-217
roll steer, 220-221
Cornering coefficient, 199, 352
Cornering equations, 199-202
Cornering properties, of tires, 347-348
Cornering squeal, 395
Cornering stiffness, 198-199, 350-351, 393
Cornering stiffness coefficient, 394
Coulomb damping, 380-381
comparison of viscous damping and, 449-452
  forced vibration with, 442-444
  free vibration with, 425-427
Coupling coefficient, 173
Course angle, 399
Critical damping, 380
Critical speed, 204-205, 404
Cross slope, 310-311
Crosswinds, side force in, 101-102
Crosswind sensitivity, 106-110
Cugnot, Nicholas Joseph, 1
Cycle, 378

Daimler, Gottlieb, 2
d’Alembert, Jean le Rond, 12
d’Alembert force, 12
Damped vibrating systems, 380
Damping
  complex, 381
  coulomb, 380-381
  critical, 380
  viscous, 380
Damping devices, 382-383
Damping ratio, 380
Deceleration
  constant, 46-47
  with wind resistance, 47-48
Deck lid spoilers, 94
de Dion, Count, 240
de Dion system, 240
Deflection, 388
  static versus acceleration, 416-417
Degrees of freedom, of a vibrating system, 380
Diesel engines
  fuel consumption of, 22
  torque curve for, 22
Directional dynamics, 401-406
Directional response behavior, 196
Disc brakes, 50
  torque properties of, 52
Disturbance response, 402
Dive control, 271
Divergent instability, 402, 411
Drag, 97-101
  aerodynamic, 49
  driveline, 49
Drag coefficient, 98-101
Drag components, 88-93
Drag force, 393
Driveline drag, 49
Driveline excitation, and ride, 138-143
Driveline torque about the steer axis, 297
Driveshaft, imbalance of, 139-140
Driving force, 392
Driving force coefficient, 392
Driving torque, 393
Driving traction coefficient, 394
Drum brakes, 50
torque properties of, 52
Durability forces, 369-371
Duryea, Charles, 2
Duryea, Frank, 2
Dynamic axle loads, 11-13
loads on grades, 13-14
low-speed acceleration, 13
static loads on level ground, 13
Dynamic imbalance, 133
Dynamic index, 381
Dynamic rate, 382
Dynamometer, tire, 3

Earth fixed coordinate system, 9, 397
Eccentricity, of tire/wheel assembly, 135-136
Effective rolling radius, 391
Effective static deflection, 382
Electronic control unit, in anti-lock brake systems, 67
Energy absorption and impact, 457-459
Energy/power, 48
Engine, as source of propulsive power, 21-23
Engine/transmission, 143-146
Equivalent impedance, 434-435, 448-449
Equivalent trailing arm analysis, 248-250
Ergonomics, 74
Euler angles, 10
Euler equation, 80
Excitation, applied to spring support, 435-442
Excitation sources, 126
driveline excitation, 138-143
ingine/transmission, 143-146
road roughness, 126-132
  tire/wheel assembly, 132-38
Exciting frequency, 378
Experimental measurement
  understeer gradient, 227
    constant radius method, 227-229

Federal Motor Vehicle Safety Standards (FMVSS), 59, 105, 329
  braking standard, 64-65
FMVSS 121, 60, 65
First order lateral force variation, 396
First order radial force variation, 396
Fixed control, 401
Flat tire radius, 388
Force coefficients, 408
Force control, 401
Forced vibration, 377
  with coulomb damping, 442-444
  with viscous damping, 429-442
Forces, 10, 400-401
Force transmission, through suspension, 444-456
Ford, Henry, 2
Fore/aft load transfer, 300
Forebody drag, 90
Form drag, 83
Forward velocity, 397
Four-link rear suspension, 239, 259-260
  with parallel arms, 261-262
Four-wheel drive, 254
Four-wheel steer, 301
  high-speed cornering, 303-304
  low-speed turning, 301-303
Free control, 401
Free fall, impact from, 460
Free-rolling tire, 391
Free vibration, 377
  with coulomb damping, 425-427
  with viscous damping, 427-429
Frequency, 378
  exciting, 378
  natural, 378
  resonant, 378
Frequency ratio, 378
Friction, tire-road, 54-57
Friction circle, 364-365
    relevance to vehicle performance, 366-367
    variables, 366
Friction drag, 83
Front solid drive axle, 253
Front-wheel drive, influence of, on steering system, 297-301
Front wheel geometry, 282-284
Front wheel lockup, 71
Fuel economy effects, 119-120
Full-active suspensions, 270

Gasoline engines
    fuel consumption of, 22
    torque curve for, 21-22
Goldman presentation, 461
Grade, 50
    loads on, 13-14
Gravity acceleration, impact without, 460
Gross contact area, 390

Harmonic motion, relations in simple, 420
Harshness, 383, 395
Hartmann’s Construction, 280
Hartog, Den, 442
Heading angle, 399
Height control, 270-271
High-speed cornering, 198, 303-304
    cornering equations, 199-202
    lateral acceleration gain, 205
    sideslip angle, 206-208
    static margin, 208-209
    tire cornering forces, 198-199
    understeer gradient, 202-204
    yaw velocity gain, 205-206
Highway Safety Act (1965), 59
Hooke’s law, 36, 292
Hop, 383-384
Hotchkiss drive, 238-239
Hotchkiss suspension, 262-263
Inclination angle, 391
Inclined parallel links, 267
Independent front-drive axle, 253
Independent rear drive, 252-253
Independent suspension roll centers, 263-268
  inclined parallel links, 267
  MacPherson strut, 267-268
  negative swing arm geometry, 265-266
  parallel horizontal links, 266
  positive swing arm geometry, 264-265
  swing axle, 268
Independent suspensions, 241
  MacPherson strut, 243-244
  multi-link rear suspension, 244
  SLA front rear suspension, 242-243
  trailing arm suspension, 241-242
Inflation pressure, 57, 345, 354
Inflection circle, 280
Instability, oscillatory, 403

Jacking, 247, 264
Janeway recommendation, 461
Jerk, 379

Kinematics, 397-401
Kingpin geometry, 385
Kingpin inclination, 385
Kingpin offset, 385

Lanchester, Frederick William, 3
Lateral acceleration, 399, 410
Lateral acceleration gain, 205
Lateral force, 289-290, 392
Lateral force coefficient, 392
Lateral force compliance steer, 221-222, 226
Lateral force offset, 396
Lateral force variations, 138, 396
Lateral load transfer, 226
Lateral run-out, 395
Lateral traction coefficient, 394
INDEX

Lateral velocity, 397
Leaf springs, 238-239
Levassor, Emile, 2
Lift force, 103
Linear vibrating systems, 380
Load, 353
Loaded radius, 390
Loads on grades, 13-14
Longitudinal acceleration, 399
Longitudinal force, 392, 400
Longitudinal force coefficient, 408
Longitudinal slip, 391
Longitudinal slip velocity, 391
Longitudinal velocity, 397
Low-speed acceleration, 13
Low-speed turning, 196-197, 301-303
Lumped mass, 7-8

MacPherson, Earle S., 243
MacPherson strut, 243-244, 267-268
Mass imbalance, 139-140
Mathematical relations, 460
Metal-to-metal position, 387
Mobility, 434
Modeling, 7
  earth fixed coordinate system in, 9
  Euler angles in, 10
  forces in, 10
  lumped mass in, 7-8
  motion variables in, 8
  Newton’s second law in, 10-11
  vehicle fixed coordinate system in, 8
Moment coefficients, 409
Motion variables, 8, 397, 399-400
Motor vehicles
  development of, 1-4
  speed capability of, 2
Multi-link rear suspension, 244

National Highway Traffic Safety Administration, 59, 74
Natural frequency, 378

481
FUNDAMENTALS OF VEHICLE DYNAMICS

Negative swing arm geometry, 265-266
Net contact area, 390
Neutral stability, 402
Neutral steer, 404
Neutral steer line, 404
Newton’s second law, 10-11, 22-23, 45, 80, 150, 199-202, 248
Nonlinear vibrating systems, 380
Normal acceleration, 399
Normal force, 392, 401
Normal force coefficient, 409
Normalized tire force and moment stiffnesses, 394
Normal velocity, 397

Olds, Ransom, 2
Olley, Maurice, 175-176, 241
criteria of, 176-177
Open-loop cornering, 196
Optimization, in automotive aerodynamics, 95-96
Oscillatory instability, 403, 411
Outside diameter, 388
Ovality, of tire/wheel assembly, 136
Overall steering ratio, 404, 412
Oversteer, 404
Overturning couple, 406
Overturning couple distribution, 406
Overturning moment, 393

Panhard, Rene, 2
Parallel hop, 384
Parallel horizontal links, 266
Parallel springing, 382
Passenger comfort, vertical vibration limits for, 465-466
Passive suspensions, 269
Path curvature, 361-362
Peak exciting force constant, 429-432
Peak-to-peak amplitude, 378-379
Peak-to-peak lateral force variation, 396
Peak-to-peak lateral tire run-out, 395-396
Peak-to-peak lateral wheel run-out, 395
Peak-to-peak loaded radial tire run-out, 395
Peak-to-peak radial force variation, 396
Peake-to-peak radial wheel run-out, 395
Peak-to-peak unloaded radial tire run-out, 395
Pedal force gain, 74
Percent deflection, 388
Period, 378
Periodic vibration, 378
Peugeot, Armand, 2
Piston engines, 143
Pitch, 383
Pitching moment, 103-104, 401
Pitching moment coefficient, 409
Pitch velocity, 399
Ply steer force, 396
Pneumatic trail, 223
Position control, 401
Positive swing arm geometry, 264-265
Power hop, 384
Power-limited acceleration, 21
  automatic transmissions in, 28-32
  engine in, 21-23
  power train in, 23-28
Power Spectral Density (PSD) function, 127-132
Power squat, 248
Power train, 23-28
Pressure distribution, on vehicle, 84-87
Protuberances, 91

Rack-and-pinion system, 276, 277
Radial force variations, 134-137, 396
Radial run-out, 395-396
Radial tire construction, 336
Random vibration, 378
Rate of camber change, 386
Rate of caster change, 385
Rate of track change, 386
Rear solid drive axle, 250-252
Rear-steer configuration, 277
Rear suspension
  four-link, 259-260
    with parallel arms, 261-262
  multi-link, 244
  three-link, 260-261
trailing-arm, 245, 246
Rear wheel lockup, 71-74
Rebound, 387
Rebound clearance, 387
Rebound stop, 387
Relative amplitude ratio, 439-442
Resistance, rolling, 48-49
Resonance, 377
Resonant frequency, 378
Resonant speed, on uniformly spaced road disturbances, 421-423
Resultant air velocity vector, 407
Resultant spring rate, 382
Ride, 125-126, 383
excitation sources, 126
driveline excitation, 138-143
gine/transmission, 143-146
road roughness, 126-132
tire/wheel assembly, 132-38
perception of, 181
other vibration forms, 187-189
tolerance to seat vibrations, 181-187
vehicle response properties, 146-147
active control, 159-163
bounce/pitch frequencies, 172-177
rigid body bounce/pitch motions, 168-172
suspension damping, 156-159
suspension isolation, 147-153
suspension nonlinearities, 166-168
suspension stiffness, 154-155
wheel hop resonances, 164-165
Ride analysis, 7
Ride and vibration data manual, 147, 181, 413-467
Ride clearance, 387
Ride control, 270
Ride rate, 382
Rigid body bounce/pitch motions, 168-172
Rigid-body motion, 146
active control, 159-163
bounce/pitch frequencies, 172-177
rigid body bounce/pitch motions, 168-172
suspension damping, 156-159
suspension isolation, 147-153
suspension nonlinearities, 166-168
INDEX

- Suspension stiffness, 154-155
- Wheel hop resonances, 164-165

Rigid vehicle, quasi-static rollover of, 310-314

- Rim diameter, 388
- Rim width, 388
- Road holding, 271

Road loads
- Aerodynamics, 79
  - Aerodynamic aids, 93-96
  - Aerodynamic forces, 87-88
  - Crosswind sensitivity, 106-110
  - Drag, 97-101
  - Drag components, 88-93
  - Lift force, 103
  - Mechanics of air flow around a vehicle, 79-84
  - Pitching moment, 103-104
  - Pressure distribution on a vehicle, 84
  - Rolling moment, 105-106
  - Side force, 101-102
  - Yawing moment, 104-105

- Rolling resistance, 110-111
  - Factors affecting rolling, 111-115
  - Typical coefficients, 115-118

- Total, 118-119
  - Fuel economy effects, 119-120

Road roughness, and ride, 126-132

- Roll, 383
- Roll axis, 406
- Roll camber, 405
- Roll camber coefficient, 405
- Roll center, 406, 412
- Roll center analysis, 257-58
- Roll control, 271
- Rolling moment, 105-106, 401
- Rolling moment coefficient, 409
- Rolling resistance, 48-49, 110-111
  - Factors affecting rolling, 111-115
  - Typical coefficients, 115-118

Rolling resistance and overturning moments, 291

- Rolling resistance force, 392, 410
- Rolling resistance force coefficient, 392
- Rolling resistance moment, 393
- Roll moment distribution, 210-217

485
Rollover, 309-310
  accident experience, 327-331
  quasi-static of rigid vehicle, 310-314
  quasi-static of suspended vehicle, 314-317
  transient rollover, 317-318
    simple roll models, 318-322
    tripping, 324-327
    yaw-roll models, 322-324
Roll oversteer, 405
Rollover threshold, 311-312
Roll steer, 220-221, 226, 281-282, 405
Roll steer coefficient, 405
Roll stiffness distribution, 406
Roll understeer, 405
Roll velocity, 399
Rotational systems, 11
Roughness, 395
Rumpler, Edmund, 247

Scrub, 283
Secondary couples, 140-143
Self-excited vibration, 377
Self-leveling suspensions, 269
Semi-active suspensions, 269-270
Semi-trailing arm, 245, 246
Separation point, 83
Shake, 383
Shimmy, 384
Shock absorber, 383
Side acceleration, 399
Side force, 101-102, 400
Side force coefficient, 408-409
Sideslip angle, 206-208, 399, 410
Sideslip angle gradient, 399
Side velocity, 397
Sidewall, 389
Sidewall rib, 389
Simple harmonic vibration, 377
Size and width, 354
Sizzle, 394
SLA front suspension, 242-243
Slap, 395
Slip angle, 348-351, 360-361, 391
Slip angle force, 392
Snubber, 383
Solid axle roll centers, 259-263
Solid axles, 238
    de Dion system, 240
    four-link, 239
    Hotchkiss drive, 238-239
Speed, 346
Spin axis, 390
Spin velocity, 391
Spring center, 382
Spring rate, 381-382
Spring support, excitation applied to, 435-442
Sprung mass, 381
    undamped natural frequency of, 417-420
Sprung mass vibrations, 383
Sprung weight, 381
Squat control, 271
Squeal, 395
Stability, 402-403
    asymptotic, 402
    divergent, 402
    neutral, 402
Standard loads and inflations, 388
Static amplitude, 379
Static deflection, 382
    versus acceleration, 416-417
    effective, 382
    total, 382
Static loaded radius, 390
Static loads on level ground, 13
Static margin, 208-209, 404
Static rate, 381
Static toe, 386, 409
Static toe angle, 386
Static imbalance, 133
Steady-state, 402
Steady-state cornering, 195-196
    high-speed cornering, 198
        cornering equations, 199-202
        lateral acceleration gain, 205
        sideslip angle, 206-208
static margin, 208-209
  tire cornering forces, 198-199
  understeer gradient, 202-204
  yaw velocity gain, 205-206
  low-speed turning, 196-197
Steady-state response gain, 402
Steady-state vibration, 378
Steer angle, 403
Steer axis, driveline torque about steer axis, 297-299
Steering gearbox, 276-277
Steering geometry error, 279-280
  roll steer, 281-282
  toe change, 280-281
Steering linkages, 275-279
Steering ratio, 293-294
Steering response, 401
Steering sensitivity, 402
Steering system, 226
effects
  braking stability, 295-297
  steering ratio, 293-294
  understeer, 294-295
forces and moments, 284-285
  aligning torque, 291
  lateral force, 289-290
  rolling resistance and overturning moments, 291
  tractive force, 290-291
  vertical force, 286-289
four-wheel steer, 301
  high-speed cornering, 303-304
  low-speed turning, 301-303
front wheel geometry, 282-284
  influence of front-wheel drive, 297-301
    driveline torque about the steer axis, 297
    fore/aft load transfer, 300
    influence of tractive force on aligning moment, 300
    influence of tractive force on tire cornering stiffness, 299-300
models, 291-293
Steering system vibrations, 384
Steering wheel angle, 403, 412
Steering wheel angle gradient, 404
Steering wheel torque, 404
Steering wheel torque gradient, 404
INDEX

Straight free-rolling tire, 391
Streamlines, 80
Subjective responses of the human body to vibratory motion, 466-467
Superelevation, 310-311
Surface friction of tires, 345-346
Suspended vehicle, quasi-static rollover of, 314-317
Suspension, force transmission through, 444-456
Suspension damping, 156-159
Suspension effects
  on cornering, 209-210
    aligning torque, 223
    camber change, 217-219
    effect of tractive forces on cornering, 223
    lateral force compliance steer, 221-222
    roll moment distribution, 210-217
    roll steer, 220-221
Suspension geometry, 385
Suspension isolation, 147-153
Suspension nonlinearities, 166-168
Suspension rate, 382
Suspension roll, 405
Suspension roll angle, 405
Suspension roll gradient, 405
Suspension roll stiffness, 406
Suspensions, 237-238
  active, 269
    categories of, 269-270
    functions, 270-271
    performance, 271-273
anti-dive suspension geometry, 254-256
anti-squat and anti-pitch suspension geometry, 248
  equivalent trailing arm analysis, 248-250
four-wheel drive, 254
front solid drive axle, 253
  independent front-drive axle, 253
  independent rear drive, 252-253
rear solid drive axle, 250-252
independent suspensions, 241
  MacPherson strut, 243-244
  multi-link rear suspension, 244
  semi-trailing arm, 245, 246
SLA front suspension, 242-243
swing axle, 247
trailing-arm rear suspension, 245, 246
trailing arm suspension, 241-242
roll center analysis, 257-58
independent suspension roll centers, 263-268
solid axle roll centers, 259-263
solid axles, 238
de Dion system, 240
four-link rear suspension, 239
Hotchkiss drive, 238-239
Suspension steer and roll properties, 403-406
Suspension stiffness, 154-155
Suspension systems, components and characteristics of, 381-383
Swing-arm radius, 386
Swing axle, 247, 268
Swing center, 386

Telescopic shock absorbers, 157
Telescopic shocks, 157
Three-link rear suspension, 260-261
Thump, 395
Tie-rod linkage, 276
Tire and wheel non-uniformity characteristics, 395-396
Tire angles, 391
Tire associated noise and vibrations, 394-395
Tire axis system, 391
Tire cornering forces, 198-199
Tire cornering stiffness, 226
  influence of tractive force on, 299-300
Tire force and moment stiffness, 393
Tire forces, 391-392
Tire forces and moments, 391-393
Tire inflation pressure/load, effect of, on rolling resistance, 112-113
Tire lateral load transfer, 406
Tire lateral load transfer distribution, 406
Tire load transfer, 406
Tire longitudinal load transfer, 406
Tire material and design, effect of, on rolling resistance, 114
Tire moments, 393
Tire overall width, 388
Tire rate, 382, 389
Tire-road friction, 54-57
INDEX

inflation pressure, 57
velocity, 56
vertical load, 57
Tires, 335-336, 388
  aligning moment, 359
    path curvature, 361-362
    relevance to vehicle performance, 362-363
    slip angle, 360-361
  camber thrust, 355-356
    inflation pressure, 358-359
    load, 358
    other factors, 359
    relevance to vehicle performance, 359
    tire type, 356-358
    tread design, 359
  combined braking and cornering, 363
    friction circle, 364-365
    relevance to vehicle performance, 366-367
    variables, 366
  conicity and ply steer, 367-369
    relevance to vehicle performance, 369
  construction of, 336-337
  cornering properties, 347-348
    inflation pressure, 354
    load, 353
    other factors, 355
    relevance to vehicle performance, 355
    size and width, 354
    slip angle, 348-351
    tire type, 352-353
    tread design, 354-355
  durability forces, 369-371
  functions of, 335
  mechanics of force generation, 340-42
  size and load rating, 337
  terminology and axis system, 338-40
  tractive properties, 342-44
    inflation pressure, 345
    relevance to vehicle performance, 346-347
    speed, 346
    surface friction, 345-346
    vertical load, 344-345
  types of, 352-353

491
vibrations, 371-374
Tire section height, 388
Tire section width, 388
Tire slip, effect of, on rolling resistance, 115
Tire temperature, effect of, on rolling resistance, 111-112
Tire traction coefficients, 394
Tire/wheel assembly, and ride, 132-38
Toe change, 280-281
Tolerance to seat vibrations, 181-187
Torque, 291
aligning, 223
Torque arm, 387-388
Torque-arm center
in braking, 387
in drive, 387
Torque-arm radius, 388
Torque converters, 28
Torsional shake, 383
Total road loads, 118-119
fuel economy effects, 119-120
Total static deflection, 382
Track change, 386
Traction-limited acceleration, 35
traction limits, 39
transverse weight shift due to drive torque, 35-38
Tractive force, 290-291, 393
effect of, on cornering, 223-226
influence of, on aligning moment, 300
influence of, on tire cornering stiffness, 299-300
Tractive force variations, 137-138
Tractive properties, of tires, 342-44
Tractrix equations, 197
Trailing-arm rear suspension, 245, 246
Trailing arm suspension, 241-242
Tramp, 384
Transient rollover, 317-318
simple roll models, 318-322
 tripping, 324-327
yaw-roll models, 322-324
Transient state, 402
Transient vibration, 378
Translational vibration systems, 10
Transmissibility, 379
Tread, 389
Tread arc width, 389
Tread chord width, 389
Tread contact length, 389
Tread contact width, 389
Tread contour, 389
Tread depth, 389
Tread design, 354-355
  other factors, 355
  relevance to vehicle performance, 355
Tread noise, 394-395
Tread pattern, 390
Tread radius, 389
Trevithick, Richard, 1
Trim, 402
Tripping, 324-327

Undamped vibrating systems, 380
Underbody, 91
Understeer, 294-295, 404
Understeer effects, 226
Understeer gradient, 202-204
  experimental measurement, 227
  constant radius method, 227-229
Understeer/oversteer gradient, 404
Uniformly spaced road disturbances, resonant speed on, 421-423
Unsprung mass, 381
Unsprung mass vibrations, 383-384
Unsprung weight, 381
Utility vehicles, 302n

Vehicle
  mechanics of air flow around, 79-84
  pressure distribution on, 84-87
Vehicle acceleration, 399. See also Acceleration
Vehicle area, 408
Vehicle axis system, 397
Vehicle dynamics, 4, 5-7
  analytical level of, 6
  empirical level of, 6
  terminology in, 377-412
Vehicle fixed coordinate system, 8
Vehicle pitch angle, 400
Vehicle response, 401-402
Vehicle response properties, 146-147
Vehicle roll angle, 400
Vehicle roll gradient, 400
Vehicle roll stiffness, 406
Vehicle suspension systems, vibrations of, 383-384
Vehicle velocity, 397
Vehicle weight, ratio of engine power to, 22
Vehicle wheelbase, 408
Velocity, 379
   effect of, on rolling resistance, 113-114
   and tire-road friction, 56
Vertical, 383
Vertical force, 10, 286-289
Vertical load, 351, 392
   and tire-road friction, 57
   of tires, 344-345
Vertical vibration limits, for passenger comfort, 465-466
Vertical vibrations, response to, 462-465
Vibrating mass and weight, 381
Vibrating system, 380-381
   damped, 380-381
   linear, 380
   nonlinear, 380
   with two degrees of freedom, 452-456
   undamped, 380
Vibrating system parameters, symbols for, 424
Vibration, 377-378
   free, 377
   periodic, 378
   random, 378
   self-excited, 377
   simple harmonic, 377
   steady-state, 378
   of tires, 371-374
   transient, 378
Vibration limits, for passenger comfort, 461-462
Vibration systems, 423-424
Vibratory motion
   subjective responses of the human body to, 466-467
   symbols for, 424-425
494
Viscous damping, 380, 444-449
  comparison of coulomb damping and, 449-452
  driving force on mass proportional to square of speed with, 446-448
  forced vibration with, 429-442
  free vibration with, 427-429
von-Karman Vortex Street, 83

Watt, James, 1
Weight transfer effect, 248
Wheelbase filtering, 168
Wheel camber, 385-386
Wheel caster, 385
Wheel center, 385
Wheelfight, 384
Wheel flutter, 384
Wheel hop resonances, 164-165
Wheel lockup
  front, 71
  rear, 71-74
Wheel plane, 385
Wheels, 388
Wheel skid, 391
Wheel toe, 386
Wheel torque, 393, 410
Wheel track, 386
Wheel vibration modes, 383
Wheel wobble, 384
Window and pillar treatments, 95
Wind resistance, deceleration with, 47-48
Windshield, 90-91

Yawing moment, 104-105, 401
Yawing moment coefficient, 409
Yaw rate response, 107
Yaw-roll models, 322-324
Yaw velocity, 399, 411
Yaw velocity gain, 205-206