

Index

Note: Page numbers followed by *f* indicate figures, *t* indicate tables and *b* indicate boxes.

A

Abe, 16
ABS braking, 385–394
Adhesion, 79–80
Aerodynamic drag, 514
Aligning stiffness, 93–94, 153, 228
Aligning stiffness, definition, 5–6
Aligning torque, definition, 3
Aligning torque, steady state, 4, 88, 228–230
Axes system, 4–5, 62–63
Axle characteristics, 7, 12, 36–37, 40
Axle cornering stiffness, 9–12
Axle side force, 11

B

Badalamenti and Doyle, 478
Bakker, 165, 168, 171
Bandel, 464–465, 478–479
Bayer, 506–507
Bayle, 165, 171–173
Belt distortion, 75, 128
Belt dynamics, 271, 404–405, 445
Belt segments, 583
Bernard, 82, 89–90
Berritta, 506–507
Berzeri, 426
Besselink, xiv–xv, 177, 214, 231f, 241, 250, 256–257, 287–288, 298, 306–311, 313–315, 349–350, 620
Biral, 507
Brake lever arm, 460–462
Braking, 49–51, 140–147, 385–394, 515, 546–547, 550
Breuer, 506–507
Brockman and Braisted, 458–459
Bruni, 455
Brush model, 82, 84, 88, 90–127, 406–426
Böhm, 88–90

C

Calspan flat track test stand, 204, 569
Camber angle, 4, 70, 74–75, 77, 79, 109–110, 121, 155, 160, 171, 175–176, 192, 201, 332, 344–346, 427, 445, 513, 515–516, 519, 544–545, 552, 559–560, 567

Camber reduction factor, 126–127
Camber stiffness, 77, 156
Capsize mode, 531
Carcass compliance, 82–85, 126, 349–351, 382, 621
Carcass distortion, 75
Caster length (trail), 9, 300, 312, 511
Center of gravity, 22–23, 306–309, 533, 540, 550
Characteristic equation, 29–30, 290, 321–322
Characteristics, cf. tire characteristics
Characteristic speed, 25–26
Cheli, 455
Clark, 458
Cleat, 487–493
Coefficient of friction, 5–6, 82, 131–132, 176
Combined slip, 100–111, 126–127, 158–162, 174, 424–426
Combined slip with F_x as input, 163–165
Composite slip, 175
Conicity, 79, 129–131, 191–196
Constitutive relations, 453–462
Contact center, 62–63, 200
Contact length, 95–96, 153–154, 281, 624
Contact patch mass, 350, 387, 400–401
Contact patch slip model, 406–444, 587, 588f
Contact width, 116
Cornering force, cf. side force
Cornering on uneven road, 58, 214
Cornering stiffness, 5–6, 93–94, 223–224
 loss (side force), 359
 string model, 215–240, 258–268
 vs normal load, 2, 5, 143–144, 168
Cornering stiffness, definition, 5–6
Cossalter, 507
Critical speed, 25, 28, 55, 144–145, 531, 548
Cross section, 64–65, 75, 199–200, 510
Curvature factor, 166–167
Cutoff frequency, 233–237

D

Damping:

- motorcycle steer, 524
- shimmy, 291–292
- tire, 454
- vehicle handling, 28

Davis, 478–479

Deflections (tire), 63, 84

Delft dynamic brake and cleat rig,
463–464, 574f

Delft flat plank, 491, 498f, 572

Delft pendulum test stand, 464–465, 465f,
474, 574–575

Delft-Tire, 588

Delft tire test trailer, 462–463, 466

Delft University of Technology, 362, 404,
462–463, 572Delft yaw oscillation test rig, 464–466,
575–576

Differential equations:

- with carcass compliance, 415–417
- contact patch, 396, 407, 409, 415
- single contact point, 312, 355
- string approximations, 253–255

Dijks, 178–179

Dugoff, 82

E

Effective inputs, 404–405, 475–476

Effective road plane height/slope, 476,
478–487, 493–497Effective rolling radius, 63, 69, 77, 156, 201,
344, 348, 367–370, 459, 461–462,
487–493, 498–499, 618

Effective rolling radius, def., 3–4, 63

Eigenvalues:

- motorcycle, 529, 531
- vehicle handling, 28

Eindhoven University of Technology, 572,
586–587

Eldik Thieme, van, xiv, 568, 572

Empirical model, 82

Energy flow, 302–303, 309–310, 311–320

Enveloping, 404–405, 577–578, 587–588,
624

Equations of motion:

- braked wheel system, 382
- car-trailer, 53–57
- contact patch mass, 428, 449
- motorcycle, 520–529
- rigid belt, 446
- shimmy, 294

steering vibrations, 381

vehicle handling, 16–17, 19–21, 31–32

F

Fancher, 82

Fiala, 82, 88–90, 150–152

Finite Element Model, 478

Forissier, 171

Four wheel steer, 35f

Frank, 88

Frequency response:

- align. torque (SWIFT), 236
- and approximations, 243f
- braked wheel, 109–110
- lateral force (SWIFT), 237
- longitudinal force (single point), 372–373
- longitudinal force (SWIFT), 394, 408f,
410f
- steering vibrations, 379–385
- string model, 224–225
- string with approx. dynamics, 272
- SWIFT (zero belt mass), 410–411
- vehicle handling, 32

Freudenstein, 88–90, 139–140

Fritz, 214

Fromm, 88, 288

FTire, 405, 582–586

G

Geometric filtering, 475

Gillespie, 16

Gipser, xv, 84, 405, 478, 582, 586

Goncharenko, 256

Gong, 478

Gough, 476

Green function, 84

Growth (centrifugal), 440, 618

Guan, Dihua, 84

Guntur, 390–391

Guo, 84, 89–90

Gyroscopic couple, 218, 269–271, 288, 294,
297–300, 306–309, 348–349, 533**H**

Handling curve, 36, 556–557

Handling diagram, 36f, 38, 557f, 559–560

Handling experiments, 598

Hasegawa, 506–507

Higuchi, 139–140, 215, 332, 338–343

Ho and Hall, 214

HSRI (UMTRI), 82

Human rider model, 506

Hurwitz stability criterium, 55, 290
Hysteresis, 366–367

I

Iffelsberger, 506–507
Inclination angle, cf. camber angle
Influence function, 84
Instability:
 divergent, 28, 56, 290, 292, 296–297
 oscillatory, 2, 55–57, 292, 312

J

Jagt, van der, 198, 206, 349–350, 386, 394,
 438–441
Jansen, xiv, 507
Jianmin, 366–367, 624
Julien, 88

K

Karlsruhe University of Technology,
 569–572
Katayama, 507
Keldysh, 241, 256–257
Kluiters, 214, 241, 249–250
Kobiki, 468
Koenen, 506–507, 563–564
Kooijman, 507
Kortüm, 16

L

Laerman, 214
Lafon, 171
Lagrange's equations, 17
Lateral acceleration response, 34
Lateral c.g. offset (motorcycle), 550
Lateral force, cf. side force
Lateral slip, 67
Lateral slip stiffness, cf. cornering
 stiffness
Lateral stiffness
 standing tire, 228, 231
 suspension, 288
Lee, 191–192
Limebeer, 506–507
Limit-cycle, 287–288, 320–322
Lippmann, 476
Loaded radius, 198, 201, 448, 457, 461–462,
 618
Load transfer, 7, 9, 514–515
Load variations, 277–281, 410
Longitudinal force, 3–4, 157, 179, 181,
 366–378

Longitudinal force, definition, 3–4
Longitudinal slip, 97–100, 406–410
Longitudinal slip, definition, 3–4, 63–65, 70,
 97–100
Longitudinal slip stiffness, 6, 99–100, 156,
 387, 409, 617–618
Longitudinal slip stiffness, definition, 5–6
Lugner, xiv, 16

M

Magic Formula, 7, 82, 150–154, 165–206,
 330, 335, 387, 404–406, 415, 424,
 426–435, 441, 449–450, 452,
 517–519, 565, 587–588
Magic Formula, cosine version, 170f, 171
Magic Formula motorcyc., 176, 565
Magic Formula Tire Model, 165–206, 565
Magic Formula with turn slip, 183–188
Maneuvering, 52f, 507
Mastinu, 84
MATLAB, 611
Maurice, 214–215, 271, 404, 407, 413, 426,
 432, 435, 455, 466, 469–472, 474,
 574–576
Meier-Dörnberg, 214
Meijaard, 507
MF-Tire, 588
Michelin, 165, 168f, 171
Milliken, xvi, 16, 51, 53, 150–152
Milliken Research Associates, 51
Mitschke, 16, 458
Modes of vibration, 309–310, 454, 563–564
Moment method, 51–53
Moreland, 214, 241, 256–258
Motorcycle dynamics, 505–566
Motorcycle tire force/ and moment, 202–206
Mousseau, 478
MTS Flat Trac III, 203f, 206
MTS Flat Trac Roadway Simulator, 53, 53f

N

Natural frequencies:
 shimmy, 309f, 310f
 steering vibration, 309–310, 315f
 tire in-plane, 371–372, 468t
 tire out-of-plane, 271, 468, 468t
 vehicle handling, 30
Neutral steer, 25
Neutral steer point, 24
Nishimi, 507
Non-dimensionalisation, 552
Non-holonomic constraint, 523

Non-lagging part, 496–497, 517
 Non-linear system, 517–520, 555–563
 Non-steady state, 211–286
 Nonuniformity, 366–378
 Normal deflect., 200, 456f, 494
 Normal force, 456–458, 494
 Nyquist plot:
 and approximations, 247f
 - with gyroscopic couple, 270
 string model, 215–240
 string with approx. dynamics, 274
 SWIFT (with zero belt mass), 431
 tire measurements, 239f, 245f

O

Obstacle, 475–476, 476f, 490–491, 587
 Oertel, xv, 405, 478, 578–582
 Olley, 288
 Optimization, 589
 Out of roundness, 370, 372–373
 Oversteer, 25, 40
 Overturning couple, 182, 196–201, 198f,
 198t, 206, 452

P

Pacejka, 565, 586–587
 Parameter assessment, 463, 466, 469, 483,
 589
 Parameters *Mag.F./SWIFT*, 613–625
 Parking maneuver, 436–444
 Path curvature, 24, 171, 183, 189f, 422, 541,
 548–549
 Pevsner, 16
 Phase plane, 46f
 Physical model, 82, 85, 420, 426, 582
 Plöchl, xvi
 Ply-steer, 75, 129–131, 191–196
 Pneumatic trail, 6, 27–28, 35, 43–44, 95,
 103–105, 103f, 136–137, 136f,
 165, 169–170, 227, 261,
 263, 517
 Pneumatic trail, definition, 5–6
 Point of intersection, 62–63
 Pothole response (SWIFT), 503–504
 Pressure distribution, 82–84, 89, 92
 Pure slip, 5

R

Radial stiffness, 478–480
 Radt, 16, 150–152
 Regression technique, 168
 Reimpell, 178–179, 198, 456–457

Relaxation length:

- with carcass compl., 398f
 contact patch model, 416f
 motorcycle tire, 531, 533
 vs normal load, 517
 single pt. model, 251–252, 329
 string model, 226f, 230f, 236
 string with tread elements, 258, 260–261,
 283
 vehicle handling, 22
 Residual stiffness, 404–405, 405f, 435, 466
 Residual torque, 156, 164–165, 195
 Response successive steps, 452f, 472f, 473f
 Response to cleats (SWIFT), 487–493, 499
 Response to load var., 277–281, 349, 365f
 Rider robot, 507, 536
 Rigid ring, 444, 454, 474
 Rigid wheel, 296–297, 484f
 Rise time, 31
 RMOD-K, 405, 578–582
 Road camber, 487
 Road experiments, 462–463, 483, 582–583
 Road unevenness, 389–390, 475–504
 Rogers, 213, 249
 Roll angle motorcycle, 540, 543–544
 Roll axis, 8, 611
 Rolling resist. moment, 63–64, 89, 182,
 459–462
 Rolling resistance, 371–372, 458–462, 616
 Roll steer/camber, 13–14, 21–22
 Rotation transformation, 511–512
 Ruijs, 507, 536

S

Sakai, 90, 126–127
 Savkoor, 88
 Scaling factors, 178–179
 Schlippe, von, 213, 221, 241, 287–288
 Schmeitz, xv, 478, 485–487, 589–591
 Segel, 6–7, 16, 82, 213, 215, 221, 345–346
 Self aligning torque, cf. aligning torque
 Self-excited oscillations, 287–288
 Separatrix, 47–48, 323–324
 Shang, Jin, 84
 Shape factor, 166
 Sharp, xiv, 84, 506–507
 Sharpness factor, 168f
 Shimmy, 288, 317–320
 Side force, 4, 88, 92, 172, 184–185, 277–286,
 473f
 Side force, definition, 2
 Side force steer, 9–10

- Side slip, definition, 2
 - Side walls, 87–88, 95–96
 - Sign convention, 3, 63, 609
 - Similarity modelling method, 161–162
 - Single point approximations
 - enhanced m..., 349, 397, 400–401
 - fully non-linear, 353
 - linear, 252, 289–290, 329
 - semi-non-linear, 335–336, 395, 400
 - Single track vehicle, 611
 - Singular point, 38–39, 45
 - Sliding region, 80, 93–94, 102–103, 118–119
 - Sliding velocity, 74, 79
 - Slip angle, 20, 92, 513
 - Slip angle, definition, 2, 4, 67
 - Slip components, 67
 - Slip point, 63, 97–98, 346–347
 - Slip radius, 63
 - Slip ratio, cf. longitudinal slip
 - Smiley, 213, 241, 248–249
 - Speed of revolution, 66
 - Speed of rolling, angular, 65, 69–70
 - Speed of rolling, linear, 65, 70, 97–98
 - Spin (slip), 67, 184, 332, 436
 - Stability:
 - car-trailer, 53–57
 - motorcycle, 529–538
 - vehicle handling, 16–58
 - Stability boundary, 40, 56f, 302t, 303–305, 312
 - Standing waves, 458–459
 - Standstill (stop, start), 334, 394–401, 436
 - State space, 323–324
 - Steady-state cornering, 24–27, 35–49, 539–564
 - Steady-state response:
 - string model, 215–240
 - vehicle handling, 16, 32
 - Steer angle, 21, 537–538, 542
 - Steer compliance, 7, 9–10
 - Steering vibrations, 379–385
 - Steer stiffness, 291–292, 297
 - Steer torque, 195, 551–552, 560–561
 - Stepan, 291–292
 - Step response (tire):
 - measured, 238, 339–343
 - motorcycle, 529–538
 - single point model, 330
 - string model, 225–232
 - and approximations, 242f, 243f
 - SWIFT (zero belt mass), 410–411
 - vehicle handling, 587
 - Strackerjan, 214, 271
 - Straight tangent approx., 215, 241, 250–251
 - String model, 215–240, 258–268, 277–281
 - String with tread elements, 258–268, 277–281
 - Suspension compliance, 300, 383
 - SWIFT, 404, 497–504, 586–591, 613–625
 - Synchronous oscillation, 325–328
 - System of axes, cf. axes system
- T**
- Takahashi, 214, 277, 338, 361–362, 364, 506–507
 - Tandem rear axle, 43
 - Tandem ‘cam’ technique, 485–486
 - Teerhuis, 507
 - Test facilities, 463–466, 567–576
 - Tire characteristics (steady-state):
 - brush model, 90–127, 117f, 119f
 - brush model, camber, 120f
 - brush model, spin, 119–120
 - example, 3–7
 - Magic Formula, 165–206
 - Magic Formula motor cycle, 207f
 - Magic Formula with turn slip, 183–184
 - measured, 82, 616
 - nondimensionalised, 151f
 - similarity method, 150–165
 - spin, turn slip, 138
 - string with tread elements, 258–268
 - tread simulation model, 128–140
 - Tire dynamics, 271, 444–462
 - Tire inertia, 268–276, 404, 621
 - Tire models, 81–85
 - Tire pull, 195–196
 - TNO-Automotive, xiv–xv, 176–177, 196, 404, 568
 - Toe angle, 9
 - Torsional stiffness:
 - motorcycle, 535–536
 - standing tire, 228, 237
 - Trailer, 53–57
 - Trajectory, 145–146
 - Transfer function:
 - string model, 228
 - string with tread elements, 258
 - Transient slip values, 392, 396
 - Transient tire behaviour, 385
 - Tread compliance, 130
 - Tread simulation model, 128–140
 - Tread width effect, 344, 431

Truck, 43, 139, 327
 TU-Delft, xiv, 165, 232f, 339–343, 568
 Turning, 112–127
 Turn slip, 68, 70, 112–113, 138, 183–188,
 228, 231
 Turn slip stiffness, 228, 231

U

UMTRI, 6–7, 572
 Unbalance, 325–327
 Understeer, 24–25, 541, 548
 Understeer at braking, 49–50

V

Vehicle handling, 16–58
 Vehicle handling experiments, 611
 Vehicle model, 7–8, 8f, 16–17
 Vehicle slip angle response, 31–32
 Vehicle stability, cf. stability
 Volvo, 165
 Vries, de, 171, 175–176, 464–466, 518

W

Wavelength, 212, 363, 386, 403–474
 Weave mode, 529
 Weighting function, 171–173, 184
 Weir, 507
 Wet road, 6–7, 155
 Wheel lock, 140–147
 Whipple, 506
 Willumeit, 84
 Wind-up oscillations, 397–400
 Winkler, 43
 Wisselman, 506–507
 Wobble mode, 531

Y

Yaw velocity response, 22–23

Z

Zegelaar, 214–215, 404, 453, 455, 460–461,
 463, 466, 469, 476, 478–481, 483,
 491, 497, 503–504, 586–587