CAMBRIDGE

Cambridge University Press
978-1-107-17960-8 — Advanced Analytical Dynamics
Vincent De Sapio
Index
More Information

Index

analytical dynamics software, 263–268
  dedicated multibody dynamics software, 267–268
  general purpose mathematical software, 263–267
angular acceleration, 60
angular momentum, 86–93
angular velocity, 46, 79
angular velocity addition, 52–54
angular velocity tensor, 46
Appell, Paul, 4
arc length, 23–24, 32–33
axis-angle representation, 38–39

biomechanical systems, 235–262
Bizzarie di Varie Figure, 1
Braccelli, Giovanni Battista, 1
branching chain devices, 5

calculus of rotations, 44–54, 79
  angular velocity, 46, 52–54, 79
  Euler angles, 47–48
  quaternion, 46–47
  rotation matrix, 45–46
center of mass, 85
centrifugal and Coriolis vector, 111
configuration space, 9, 70, 76–77
  generalized coordinates, 3, 9, 70, 76–77, 105, 114, 142, 143, 145, 146
coning angle, 64, 69
conservation of angular momentum, 84
conservation of translational momentum, 84
conservation principles, 83–100
  Newton's Laws, 83–84
  Newton-Euler Principle, 83–99
constrained biomechanical systems, 245–262
  muscle-based actuation, 246–253
constrained Hamiltonian systems, 143–145, 150
constrained least action, 140–142
constrained-motion manifold, 116
constrained muscle-based actuation, 246–253
constrained task space dynamics, 227–232, 233–234
  direct mapping of constraints, 227–229
  task/constraint partitioning, 229–232, 233–234
constraint matrix, 115
constraints, 76–77, 81–82, 101, 113–128, 140, 148–149, 150, 151, 160–178, 185–187, 188, 197–200, 211–213, 224, 226, 227–232, 233–234
  holonomic constraints, 113–128, 148–149, 150, 211–213, 227–232, 233–234
  nonholonomic constraints, 160–178, 185–187, 197–200, 213
  rheonomic constraints, 101, 224, 226
  scleronomic constraints, 101, 128, 140, 151, 188
covariant derivative, 26
curvature tensor, 25, 35
curves, 23–24, 32–33
  arc length, 23–24, 32–33
  extrinsic curvature, 24, 32–33
  tangent vector, 23, 32–33

d'Alembert's Principle, 2, 101–128, 147–149
  constraints, 113–128
  single particle, 101–102
  single rigid body, 102–104
  system of particles, 104–106
  system of rigid bodies, 106–113
  virtual work, 107
d'Alembert, Jean Le Rond, 2
dedicated multibody dynamics software, 267–268
  commercial software, 267–268
  open source software, 268
deformation gradient, 272
degrees of freedom, 76–77, 81–82
Delta mechanism, 5
Denavit-Hartenberg parameters, 69–70, 79–80
derivatives in rotating reference frames, 59–61
diffeomorphism, 23, 269
differential geometry, 22–28, 32–35, 116, 269
  curves, 23–24, 32–33
  k-manifolds, 23, 116, 269
  surfaces, 24–28, 33–35
double pendulum, 5
dynamically consistent inverse, 216

© in this web service Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-1-107-17960-8 — Advanced Analytical Dynamics
Vincent De Sapio
Index
More Information

eigenbasis, 18–19
eigenspace, 18
eigenvalue problem, 18–19, 32
elimination of Lagrange multipliers, 145–147
Euler angles, 39–41, 78
Euler's disk, 7
Euler, Leonhard, 1
Euler-Lagrange equations, 3, 128–140, 149–150
  kinetic energy ellipsoid, 131–132
  single particle, 130
  single rigid body, 130–132
  system of particles, 132–134
  system of rigid bodies, 134–140, 149–150
extrinsic curvature, 24, 32–33

first-order nonholonomic constraints, 160–178
  rolling ball, 168–172
  rolling disk, 163–168
  two-wheeled assembly, 172–178
first-order variational principles, 151, 187
  Jourdain's Principle, 151–178
  Kane's method, 179–184
  virtual power, 151, 152, 154, 156, 157, 158, 159
four-bar linkage, 5, 6, 148, 211–213

Gauss map, 24, 33–35
Gauss's Principle, 188, 200
  constraints, 197–200
  single particle, 188–189
  single rigid body, 189–191
  system of particles, 191–193
  system of rigid bodies, 193–197
Gauss's Principle of Least Constraint, 4
Gauss, Carl Friedrich, 4
Gaussian curvature, 25, 35
general purpose mathematical software, 263–267
  packages for multibody dynamics, 263–267
generalized accelerations, 4, 111, 192, 197, 201, 202
generalized constrained equation of motion, 127–128
generalized constraint forces, 115, 116, 121, 145, 201
generalized coordinates, 3, 9, 70, 76–77, 105, 114, 142, 143, 145, 146
generalized forces, 94, 105, 133, 134, 147
generalized momenta, 142
generalized velocities, 4, 114, 142, 143, 144, 155, 159, 179, 182, 192, 207
geodesic curvature, 26–27, 33
geodesics, 26–28, 35, 213
  covariant derivative, 26
  geodesic curvature, 26–27, 33
Gibbs, Josiah Willard, 4
Gibbs-Appell method, 4, 206–210, 213
  system of rigid bodies, 206–210
Gram-Schmidt orthogonalization, 16, 31
gravity vector, 111
gyroscope, 5, 135–140

Hamilton's canonical equations, 142–143, 150
Hamilton's Principle, 128–142
  constrained least action, 140–142
  Euler-Lagrange equations, 128–130
  Lagrangian, 128
Hamilton, William Rowan, 3
Hamiltonian, 143
Hamiltonian dynamics, 142–145, 150
  constrained dynamics, 143–145, 150
  Hamiltonian, 143
  unconstrained dynamics, 142–143, 150
Hertz's Principle of Least Curvature, 4, 202–206
Hertz, Heinrich Rudolf, 4
historical background, 1–4
Hoberman Sphere, 6
holonomic constraints, 76–77, 81–82, 113–128, 148–149, 150, 211–213, 227–232, 233–234
  constrained-motion manifold, 116
  constraint matrix, 115
  four-bar linkage, 148, 211–213
  Lagrange multipliers, 116
  parallel shoulder mechanism, 253–262
  planar parallel mechanism, 122–126, 230–232
  slider-crank, 148–149, 150, 233–234
  Stewart platform, 118–122
holonomically constrained devices, 5–6
  Delta mechanism, 5
  four-bar linkage, 5, 6, 148, 211–213
  Hoberman Sphere, 6
  parallel shoulder mechanism, 253–262
  planar parallel mechanism, 122–126, 230–232
  slider-crank, 6, 148–149, 150, 233–234
  Stewart platform, 118–122
homogeneous transform matrix, 54–55

inertia tensor, 88
inertial properties, 85–93, 99–100
  center of mass, 85–93, 99–100
  inertia tensor, 85–93, 99–100
inertial reference frame, 83
inner product, 10–12

Jacobian matrix, 70–72, 80–81
  relationship with screws, 72
Jourdain's Principle, 4, 151–178, 185–187
  constraints, 160–178
  single particle, 151–152
  single rigid body, 152–154
  system of particles, 154–156
  system of rigid bodies, 156–160
  virtual power, 151, 152, 154, 156, 157, 158, 159
Jourdain, Philip E. B., 4

© in this web service Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-1-107-17960-8 — Advanced Analytical Dynamics
Vincent De Sapio
Index
More Information

k-manifolds, 23, 116, 269
  constrained-motion manifold, 116
  diffeomorphism, 23, 269
Kane's method, 4, 179–184, 185
Kane, Thomas, 4
kinematic chains, 5, 69–76, 79–81, 94–99, 100, 111–113, 135–140, 147–148, 149–150, 217–219, 220–222, 233
  Denavit-Hartenberg parameters, 69–70, 79–80
  double pendulum, 5
  gyroscope, 5, 135–140
  Jacobian matrix, 70–72, 80–81
  rate vector propagation, 72–76, 81
  serial chain robot, 81, 94–99, 100, 111–113, 147–148, 149–150, 217–219, 220–222, 233
  tree-structured mechanism, 5
kinematics, 36–82
  degrees of freedom, 76–77, 81–82
  kinematic chains, 69–76, 79–81
  spatial kinematics, 54–69, 79
  spherical kinematics, 36–54, 77–79
kinetic energy, 130, 131, 133, 134, 204
kinetic energy ellipsoid, 131–132

Lagrange multipliers, 116, 145
Lagrange, Joseph-Louis, 3
Lagrangian, 128, 142, 204
least norm, 17–18, 31–32
least squares, 16–17, 31
Leibniz, Gottfried, 2
linear systems, 10–22, 31–32
  tensors in $\mathbb{R}^3$, 21
  vector and tensor operations, 21–22
  vector spaces in $\mathbb{R}^n$, 10–19, 31–32
  vectors in $\mathbb{R}^3$, 19–21

mass matrix, 111
mean curvature, 25, 35
motors, 57–58
  spatial velocity, 57, 72, 79
muscle activation dynamics, 236
muscle contraction dynamics, 236–238
  pennation angle, 236
muscle Jacobian, 236
muscle moment arm matrix, 236
musculoskeletal dynamics, 235–236
  muscle Jacobian, 236
  muscle moment arm matrix, 236

neuro-musculoskeletal dynamics, 235–243
  musculoskeletal dynamics, 235–236
  neuromuscular dynamics, 236–238
  stiff tendon model, 238–243
neuromuscular dynamics, 236–238
  activation dynamics, 236
  contraction dynamics, 236–238
Newton's Laws, 83–84
Newton, Isaac, 1
Newton-Euler Principle, 83–99, 100
  conservation of angular momentum, 84
  conservation of translational momentum, 84
  Newton's Laws, 83–84
  single particle, 84–85
  single rigid body, 85–93
  system of particles, 93
  system of rigid bodies, 93–99
nonholonomic constraints, 160–178, 185–187, 197–200, 213
  first-order nonholonomic constraints, 160–178
  rolling disk, 185, 213
  second-order nonholonomic constraints, 197–200
  two-wheeled assembly, 185–187
nonholonomically constrained devices, 6–7
  Euler's disk, 7
  rolling ball, 7, 168–172
  rolling disk, 163–168, 185, 213
  two-wheeled assembly, 7, 172–178, 185–187
normal curvature, 27, 33
null space projection matrix, 216

orthogonal complement, 15–16
orthogonal projection, 16, 31

parallel shoulder mechanism, 253–262
pennation angle, 236
Piola-Kirchoff stress tensor, 272
planar parallel mechanism, 122–126, 230–232
positive definite matrix, 19, 88, 111, 131, 142, 216
potential energy, 130, 131, 133, 134
principal curvatures, 25, 35
Principle of Least Constraint, 200–206
  Hertz's Principle of Least Curvature, 202–206
  system of rigid bodies, 201–202
propagation of kinematic rate vectors, 72–76

quasi-accelerations, 115, 207, 208, 211
quasi-forces, 180, 208
quasi-Jacobians, 179, 207
quasi-velocities, 115, 179, 180, 182, 207, 210
quaternion derivative, 46–47
quaternions, 41–44

rheonomic constraints, 101
rolling ball, 7, 168–172
rolling disk, 163–168, 185, 213
rotation matrices, 36–38
rotation matrix derivative, 45–46

scleronomic constraints, 101, 128, 140, 151, 188
screws, 55–57, 79
second-order nonholonomic constraints, 197–200

© in this web service Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-1-107-17960-8 — Advanced Analytical Dynamics
Vincent De Sapio
Index
More Information

second-order variational principles, 188, 213
  Gauss's Principle, 188, 200
  Gibbs-Appell method, 206–211
  Principle of Least Constraint, 200–206
serial chain robot, 81, 94–99, 100, 111–113, 147–148, 149–150, 217–219, 220–222, 233
slider-crank, 6, 148–149, 150, 233–234
spatial kinematics, 54–69, 79
  derivatives in rotating reference frames, 59–61
  homogeneous transform, 54–55
  motors, 57–58, 79
  screws, 55–57, 79
  wrenches, 58–59
spatial velocity, 57, 72, 79
spherical kinematics, 36–54, 77–79
  axis-angle, 38–39
  calculus of rotations, 44–54, 79
  Euler angles, 39–41, 78
  quaternions, 41–44
  rotation matrices, 36–38
static optimization, 28–30
Stewart platform, 118–122
stiff tendon model, 238–243
surface traction, 272
surfaces, 24–28, 33–35, 213
  curvature tensor, 25, 35
  Gauss map, 24, 33–35
  Gaussian curvature, 25, 35
  geodesic curvature, 26–27, 33
  geodesics, 26–28, 35, 213
  mean curvature, 25, 35
  normal curvature, 27, 33
  principal curvatures, 25, 35

tangent vector, 23, 32–33
task space belted ellipsoid, 220
task space centrifugal and Coriolis vector, 216
task space dynamics, 214–234
  belted ellipsoid, 220
  centrifugal and Coriolis vector, 216
  constrained task space dynamics, 227–232
  dynamically consistent inverse, 216
  energy minimization, 223–224
  gravity vector, 216
  inertial properties, 219–222
  kinetic energy ellipsoid, 220
  kinetic energy minimization, 223–224
  least action, 226–227
  mass matrix, 216
  null space projection matrix, 216
  potential energy minimization, 223
  serial chain robot, 217–219
  task/constraint symmetry, 224–227
task space gravity vector, 216
task space kinetic energy, 219
task space kinetic energy ellipsoid, 220
task space mapping of constraints, 227–229
task space mass matrix, 216
task/constraint partitioning, 229–232, 233–234
task/constraint symmetry, 224–227
tensors in $\mathbb{R}^3$, 21
tree-structured mechanism, 5
two-wheeled assembly, 7, 172–178, 185–187

variational principles, 101–213
  first-order variational principles, 151, 187
  second-order variational principles, 188–213
  zeroth-order variational principles, 101–150
vector and tensor operations, 21–22
vector basis, 12–15
vector spaces in $\mathbb{R}^n$, 10–19, 31–32
  eigenbasis, 18–19
  eigenspace, 18
  eigenvalue problem, 18–19, 32
  Gram-Schmidt, 16, 31
  inner product, 10–12
  least norm, 17–18, 31–32
  least squares, 16–17, 31
  orthogonal complement, 15–16
  orthogonal projection, 16, 31
  vector basis, 12–15
vectors in $\mathbb{R}^3$, 19–21
virtual power, 151, 152, 154, 156, 157, 158, 159
virtual work, 107
vis viva, 2

wrenches, 58–59

zeroth-order variational principles, 101–150
  d'Alembert's Principle, 101–128
  Hamilton's Principle, 128–142
  virtual work, 107

© in this web service Cambridge University Press www.cambridge.org