Index

Aberth, O., 34, 122, 133, 146, 147, 155
absolute value, 9
accurate dot product, 28
addition of intervals, 10, 11
  associativity, 31
  commutativity, 31
additive identity element, 31
Alefeld, G., 17, 76
Archimedes’ method, 1, 4
associative laws, 31
atomic energy lower bounds, 158
automatic differentiation, 109, 129, 137
  backward mode, 141
  forward mode, 141
backward mode, automatic differentiation, 141
Banach spaces, 128
BARON, 82, 167
barycentric coordinates, 145
Berz, M., 147, 155
binary arithmetic, IEEE, 23
box, 15
branch-and-bound algorithm, 82
branching, 62
C-XSC, 28
cancellation law, 33
Cartesian product, 173
Center for Reliable Engineering Computing, 169
centered form, 67
chaos, 158
chemical engineering, 163
chemical kinetics equilibrium, 163
closed interval, 2, 7
clustering problem, 83
code list, 65
codomain, 174
commutative laws, 31
complement, 172
complex eigenvalues, 170
complex roots, 170
composition, 174
computational differentiation, 109
computational graph, 65
computer assisted proofs, 157
computer graphics, 169
computing with sets, 10, 15, 113
constraint propagation, 115, 168
continuous function, 51
convergent sequence, 51
COSY, 147
Cset arithmetic, 114
Darboux integrals, 146
degenerate interval, 7
difference of intervals, 10, 11
differential equation, 149
direct method, 88
directed roundings, 16
discontinuous flag, 123
disjoints sets, 172
division of intervals, 10, 13
domain
  of function, 174
dot product, accurate, 28
double-bubble conjecture, 158
Einarsson, B., 158
electrical engineering, 170
empty set, 171
enclosure, 2
  tightness of, 2
Index

endpoints, 7
epsilon inflation, 83, 120
equality of intervals, 7
equivalence class, 173
equivalence relation, 173
error-squaring property, 107
excess width, 55
exponential function, 39, 40
extended arithmetic, 16
extended interval arithmetic, 110
extension, 42, 174
feasibility test, 160
feasible point, 159
feasible solution, 165
Feigenbaum constant, 158
FILIB++, 28
finite convergence, 58, 60, 107
finite element method, 168
fixed-point theorem, 116
forest planning, 158
formula, 42
forward mode, automatic differentiation, 141
function(s), 174
codomain, 174
composition of, 55, 174
continuous, 51
domain, 174
exponential, 39, 40
extension, 174
identity, 175
image, 174
interval extension of, 42, 45
interval-valued, 37
invertible, 175
logarithmic, 40
monotonic, 39, 50
natural interval extension, 47
nonmonotonic, 40
one-to-one, 174
onto, 174
preimage, 174
range, 174
rational interval, 46
restriction, 174
square root, 40
unary, 64
Fundamental Theorem of Interval Analysis, 47, 53, 86
Gauss–Seidel method, interval, 96
Gaussian elimination, interval, 100
Gaussian quadrature, verified, 145
global optimization, 82
global optimizing point, 165
global optimum, 165
GlobSol, 41, 127, 163, 164, 167
gravitational constant, 170
Hankel matrices, 103
Hansen, E., 16, 68, 73, 82, 91, 96, 127, 168
Hansen–Sengupta method, 96
Hargreaves, G., 27
Hass, J., 157
heat convection, 158
Herzberger, J., 17, 76
historical references, 16
IA, 22
iCOs, 167, 168
identity element
additive, 31
multiplicative, 31
identity function, 175
IEEE binary arithmetic, 23
ill-conditioned system, 90
image, 175
of function, 174
inclusion isotonicity, 35, 46, 55, 150
indirect method, 88
initial value problem, 151
inner product, 15
Institute of Reliable Computing, 17
integral, 129, 131
integral equation, 149
intersection, 8, 172
interval addition, 10, 11
interval arithmetic, 10
inclusion isotonicity, 34
outwardly rounded, 22
properties of, 31
interval dependency, 38, 42
interval division, 10, 13
interval enclosure, 135
interval extension, 42, 45
Lipschitz, 53
interval Gauss–Seidel method, 96
interval Gaussian elimination, 100
interval hull, 8
interval integral, 129
interval majorant, 149
interval matrices, 16, 85
midpoint, 85
norm, 85
width, 85
interval multiplication, 10, 12
interval operator, 149
interval polynomial enclosure, 135
interval subtraction, 10, 11
interval vector(s), 14
intersection of, 14
membership in, 14
midpoint, 14
norm, 15
set containment, 14
width, 14
interval(s), 7
absolute value of, 9
addition of, 11
closed, 2, 7
degenerate, 7
division of, 13
endpoints, 7
equality of, 7
intersection of, 8
midpoint of, 3, 9
multiplication of, 12
negative, 10
negative of, 12
order relations for, 9
positive, 10
product of, 10, 12
quotient of, 10, 13
reciprocal of, 13
subdistributive law for, 32
subtraction of, 10, 11
sum of, 10, 11
symmetric, 33
union of, 8
width of, 3, 9
interval-valued function, 37
INTLAB, 4, 22, 41, 70, 74, 87, 101, 118
references, 27
representation
infimum-supremum, 22
midpoint-radius, 25
significant digits, 25, 26
uncertainty, 26, 59
inverse, 175
isometric embedding, 53
isometry, 53
Jacobian matrix, 116
Jaulin, L., 162
Jouanolou foliation, 158
K. A. M. bounds, 158
Kahan arithmetic, 16, 113
Kahan, W., 16
Kantorovich theorem, 127
Kearfott, R. B., 168
Kepler’s conjecture, 157
Krawczyk method, 17, 91, 92, 116
Krawczyk, R., 17
Kreinovich, V., 195
Kulisch, U., 17, 28
Lake Constance currents, 158
lattice theory, 156
least squares problems, 158
limit, 51
Lin, Y., 163
Lipschitz condition, 53
logarithmic function, 40
long accumulator, 28
Lorenz attractor, 157, 158
Makino, K., 155
Mathematics Research Center, 17
Mayer, G., 103
mean value extension, 69
mean value form, 69
mechanical engineering, 170
metric, 52
metric space, 52
midpoint, 3, 9, 14, 85
midpoint test, 160
magnitude, 87
molecular models, 163
monotonic function, 39, 50
monotonicity test form, 75, 76
Monte Carlo method, 100
Moore, R. E., 16, 107, 113, 120, 128, 156, 161, 162
MPFI, 28
Muhanna, R. L., 169
Mullen, R. L., 169
multiple integral, 145
multiplication of intervals, 10, 12
associativity, 31
commutativity, 31
multiplicative identity element, 31
multivariate interval Newton method, 123
natural interval extension, 47
negative interval, 10
negative of interval, 12
Neumaier, A., 17, 83, 168
Newton’s gravitational constant, 170
Newton’s method, 105
geometric interpretation, 107
Nickel, K., 16
norm, 15, 85
number pair extension, 5
Numerica, 168
Oishi, S., 28
operator equation, 149
operator overloading, 70
optimal outward rounding, 22
optimization, 159
optimizing point, global, 165
order relations, 9
ordered pair, 5
Orr–Sommerfeld equations, 158
outward rounding, 20
optimal, 22
parameter, 2
parameter estimation, 161, 170
partial differential equations, 156
partial ordering, 10, 173
partition, 173
PDE, 156
persymmetric matrices, 103
photoelectron spectroscopy, 161
polynomial enclosure, 141
polynomial integration, 133
positive interval, 10
preimage, 174, 175
product of intervals, 10, 12
PROFIL/BIAS, 28
propagation of uncertainties, 20
quadratic convergence, 118
quotient of intervals, 10, 13
range, 174
rational interval function, 46
Ratschek, H., 68, 168
reciprocal of interval, 13
recursion, 3
refinement, 55, 64
relation, 173
antisymmetric, 173
equivalence, 173
on a set, 173
reflexive, 173
symmetric, 173
transitive, 173
restriction, 174
robotics, 162
robust control, 162, 170
Rohn, J., 103
Rokne, J., 17, 168
roundoff error, 3
Rump, S. M., 17, 27, 120, 158
safe starting interval, 121
semidefinite programming, 166
sequence(s)
convergent, 51
limit, 51
nested, 58
set(s), 171
Index

complement, 172
difference, 173
disjoint, 172
elements, 171
empty, 171
equality, 172
intersection, 172
members, 171
notation, 171
subset of, 172
union, 172
simplex, 145
Skelboe–Moore algorithm, 77
slope, 72
slope form, 72, 73
small divisors in Hamiltonian dynamics,
  158
SPICE, 158
splitting, 56
square root function, 40
stability of matter, 158
Stadtherr, M. A., 163
structural engineering, 168
Sturm–Liouville problem, 158
subdistributive law, 32
subset, 172
  proper, 172
subset property, 45
subtraction of intervals, 10, 11
sum of intervals, 10, 11
symmetric interval, 33
symmetric matrices, 103
Szpiro, G. G., 157
Taylor arithmetic, 147, 163
Toeplitz matrices, 103
transitive relation, 9
Tucker, W., 157
turbine eigenfrequencies, 158
unary function, 64
uniform subdivision, 55
union, 8, 172
united extension, 38, 54
  subset property of, 45
Walster, G. W., 16, 82, 127, 168

width, 3, 9, 14, 85
  excess, 55
  wrapping effect, 155
Wright, S., 100