Index

χ^2 test, 520, 523
χ^2 distribution, 521

acoustic impedance, 384
action potential, 437
adaptive time step, 413
adiabatic approximation, 29
air drag, 21
air drag at high altitudes, 30
air drag, approximate theory, 22
aliasing, 488
amino acids, 390
annealing, 402
approach to equilibrium, 204, 279
Arnoldi-Saad method, 537
arrow of time, 204
autocorrelation function, 490
avalanche, 447

banjo, 373
barrier potential, 318
baseball, batted, 32
baseball, effect of wind, 34
baseball, long home runs, 35
baseball, spin-dependent force, 38
baseball, trajectory of a curveball, 36
baseball, trajectory of a knuckleball, 42
Bernoulli effect, 37
bicycles, 18
bifurcation, 67
billiard problem, 82
Biot-Savart law, 148
bisection, 471
blind ant, 230
Boltzmann factor, 237
brain models, 418
breadth-first search method, 225

cannon shell trajectory, 25
canonical ensemble, 237
cellular automata, 445
cellular automata, game of *life*, 445
centered difference methods, 464
central limit theorem, 521
chaos and noise, 89
chaos, Feigenbaum δ, 69
chaos, pendulum, 60
chaos, period doubling, 73
chaos, sensitivity to initial conditions, 61
chaos, strange attractors, 65
chaotic motion of Hyperion, 123
cluster growth, 206
cluster labeling method, 220
cluster, fractal dimensionality, 210
coarse graining, 195
correlation function, 255
Crank-Nicholson method, 338
cream-in-coffee problem, 182, 197
critical exponents, α, 253
critical exponents, β, 243
critical exponents, γ, 255
critical phenomena and fluctuations, 257
critical temperature, 241
critical temperature, 2-D Ising model, 250

data collapsing, 267
data fitting, 493
debugging and checking, 11
depth-first search, 191
derivative, finite difference form, 2
detailed balance, 246
diffusion, 131, 181, 185, 291
diffusion and entropy, 203
diffusion and fluctuations, 186
diffusion and probability, 195
diffusion constant, 184
diffusion equation, 196
diffusion limited aggregation, 206
diffusion on a fractal, 229
dimensionality of a cluster, 209
Dirac delta function, 480
discrete Fourier transform, 481
dispersion, 171
dynamical matrix, 374

earthquakes, 407
Eden model, 206
eigenfunctions, 527
eigenvalue problems, 304, 324, 373, 527

eigenvalue problems and random walks, 231
eigenvalue problems, approximate methods, 537
electric field, 135
electric potential, 129
energy landscape, 426
entropy, 203
equilibrium, 204
equipartition, 279
ergodic hypothesis, 204
error, global, 457, 458
error, local, 457, 458
Euler method, 3, 20, 456
Euler-Cromer method, 52, 97, 462
exchange interaction, 237

fast Fourier transform, 483
Feigenbaum δ, 69
Fermi-Pasta-Ulam problem, 294
ferromagnet, 236
FFT, 483
finite difference, first derivative, 2
finite difference, fourth derivative, 170
finite difference, second derivative, 157
first-order phase transitions, 259
fluctuation-dissipation theorem, 254, 255
forest fire problem, 227
Fourier analysis, 89, 165, 360
Fourier transform, 479
fractal clusters, 210
fractal coastlines, 216
fractal dimension, 210
fractal dimensionality of a curve, 212
free energy, 241
free energy landscape, 401
friction, 370, 409

gas, dilute, 280
Gauss-Jordan elimination, 530
Gauss-Seidel method, 142, 534
Gaussain quadrature, 504
Gaussian elimination, 528
general relativity, effect on mercury, 108
generating fractal curves, 212
genetic algorithms, 473
golden mean, 471
golf, 44
golf ball, effect of dimples, 45
graphing results, 10
guitar, 357
guitar string, 163
guitar, standing waves, 359
Gutenberg-Richter law, 406

half-life, 2
Halley's comet, 100
Hamming distance, 427
Hebbian learning, 427
Heisenberg model, 238
Heisenberg uncertainty principle, 340
Helmholtz motion, 368
Hodgkin-Huxley model, 439
homogeneous functions and scaling, 265
Hoshen-Kopelman algorithm, 221
hypercubic lattice, 184
Hyperion, chaotic tumbling, 123
hysteresis, 260

initial value problem, 2
integration, 500
inverse square law, 101, 103
ion channels, 438
Ising model, 236

Jacobi method, 131

Kepler's laws, 98
Kirkwood gaps, 119
Koch curve, 212

Laplace's equation, 129
leapfrog method, 335, 383
least squares, 494, 497
least-squares fitting, 112
Lennard-Jones potential, 273, 318, 327
Levinthal's paradox, 392
linear congruential random number generator, 512
linear regression, 494
linear systems, 527
logistic map, 70
Lorenz butterfly, 81
Lorenz model, 75
LU decomposition, 531
Lyapunov exponent, 62

magnetic field of a soleniod, 152
magnetic fields, 148
magnetic fields and spin systems, 239

"book" — 2005/6/14 — 20:40 — page 543 — #557

magnetization, 238
Magnus force, 37
matrix method in quantum mechanics, 323
Maxwell velocity distribution, 282
mean field approximation, 240
mean free paht, 271
melting, 285
metastable states, 260, 400
Metropolis algorithm, 245
molecular dynamics, 270
Monte Carlo integration, 506
Monte Carlo method, 235, 244, 395, 423, 474
multiple linear regression, 498

neural networks, 418
neural networks, Hopfield model, 434
neuron, 418
neurons and Ising spins, 421
Newton-Cotes methods, 502
Newton-Raphson method, 469
nonlinear springs, 295
normal distribution, 521
normal modes, 296
Nyquist frequency, 483

octave stretching, 173
optimization, 469, 472
ordinary differential equations, 456

parity, 308
pendulum, chaotic, 58
pendulum, damped and nonlinear, 54
pendulum, driven, 55
pendulum, simple, 48
perceptron, 434
percolation, 218
percolation and phase transitions, 222
percolation clusters, 218
percolation clusters and fractals, 224
percolation threshold, 219
period doubling, 68, 73
periodic boundary conditions, 249, 275
phase diagrams, 261
phase space, 62
phase transition, 235
piano, 362
piano tone spectrum, 168
planetary data, 97
planetary orbits, 101
planetary orbits, stability and the inverse square law, 103
Poincaré section, 63
Poisson's equation, 144
power laws, 243
power method, 325
power spectrum, 89, 165, 490
precession of the perihelion of mercury, 108
program listings, 4
programming guidelines, 14
programming languages, 3
projectile motion, 18
protein folding, 390
proteins, primary structure, 390
proteins, tertiary structure, 390
pseudocode, 3

Q factor, 387
quantum mechanics, anharmonic oscillator, 322
quantum mechanics, matching method, 315
quantum mechanics, shooting method, 307
quantum mechanics, two-dimensional harmonic oscillator, 329
quantum mechanics, variational principle, 326
quantum mechanics, variational–Monte Carlo method, 328
quantum mechanics, wave packet spreading, 340

radioactive decay, 1
random number generators, 512
random numbers, 183
random numbers, nonuniform distributions, 516
random numbers, quality tests, 514
random numbers, rejection method, 517
random numbers, transformation method, 516
random systems, 181
random walk, 182
random walk in one dimension, 183
recursion, 212
regression, linear, 494
regression, multiple linear, 498
relaxation method, 131, 533

relaxation method, diffusion, 131
resonance, 387
Richardson's formula, 503
Romberg integration, 503
root finding, 469
round-off error, 12
routes to chaos, intermittency, 80
routes to chaos, period doubling, 68
Runge-Kutta methods, 458

sandpile, 447
scaling, 264
Schrödinger equation, Monte-Carlo methods, 328
Schrödinger equation, time-dependent, 333, 345, 350
Schrödinger equation, time-independent, 303
Schrödinger equation, two-dimensional harmonic oscillator, 329
Schrödinger equation, variational method, 326
secant method, 471
second order differential equations, 460
second order phase transitions, 223
second-order phase transitions, 243
second-order transition, 260
self-avoiding walk, 189
self-organized criticality, 407, 448
shooting method, 307, 309
simple harmonic oscillator, 48
Simpson's rule, 502
simulated annealing, 473
simultaneous over-relaxation, 142
solar system, 94
spanning cluster, 218
specific heat, 253
spectral methods, 174, 350
stadium billiard, 82
staggered grid, 383
step sizes, 13
stick-slip motion, 370
stochastic systems, 181
Stokes' law, 21
strange attractor, 65
susceptibility, 254

Taylor expansion, 2
three-body problem, 113
time-dependent Schrödinger equation, 333
time-dependent Schrödinger equation, spectral method, 350
time-dependent Schrödinger equation, two dimensions, 345
time-independent Schrödinger equation, 303
trapezoidal rule, 502
traveling salesman problem, 475
triangular lattice, 287
tunneling, 318
turbulence, 75
two-dimensional harmonic oscillator, 329

unitarity, 337

variational principle, 326
Verlet method, 272, 463
vibrating membrane, 373
violin, 368
virial theorem, 285
viscosity, 24

wave equation, 156, 359, 363
wave equation and stability, 161
wave equation for a stiff string, 170
wave equation for sound, 383
wave equation in two dimensions, 376
wave equation, solution, 158
wave packet, 339
waves, 156
waves on a string, 159
waves, reflection, 162
waves, spectral methods, 174

XY model, 238