Index

A	Convergence, 158, 238
Accuracy	difference from accuracy, 257
difference from convergence rate, 257	exponential, 293
Analog physics, 382	Gauss quadrature, 293
Arrays	inverse power iteration, 358
NumPy, 54, 55	iterative linear solvers, 151, 158, 162, 166
complex numbers, 65	Monte Carlo, 387
iterating, 64	Newton-Cotes quadrature, 272, 276
slicing, 63	polynomial, 294
Assert statement, 99–103	rate estimation, 253
AssertionError, 99, 102, 104	speed versus robustness, 223, 312
, , ,	Crank-Nicolson, 306, 308–311, 314, 321, 322, 324,
В	329
Back substitution, 112, 114, 116	unconditional stability, 312
Backward Euler, 305–307, 316, 320, 330, 332, 334	Criticality
unconditional stability, 312	bare cylinder, 359
Beefeaters' hat, 28, 30–32, 50	bare slab, 359
Bessel, 190, 247, 265, 284, 298, 359	bare sphere, 218, 357
Big-O notation, 125, 153, 252	diffusion k-eigenvalue, 352, 356
comparison of algorithms using, 154, 160	estimation with Monte Carlo, 426
estimating algorithm scaling, 126	k-eigenvalue meaning, 352
Bisection method, 216	parallelepiped, 243
number of iterations, 216, 218	reflected reactor, 360
	two-group bare reactor, 374
Boundary value problem, 333	two-group reflected reactor, 375
Branching, 14 Bugs, 6	Cubic spline, 182
bugs, o	SciPy function, 187
	Curve fitting, 193
C	hidden variables, 194
Cmath module, 11	
Comma-separated-values (CSV), 76, 397	D
Comments, 5	Decimal module, 278, 284
docstrings, 42, 43	Deer stalker, 32
Comparison operators, 15	Dictionaries, 76
Complex step derivative approximation, 262	Dirac delta function, 118
accuracy, 263	Discrete ordinates (S_N) , 429, 433
Computational cost	T.
history of, 259	E
Conjugate gradient, 163, 164	Edmonton Oilers, 302
graphical representation, 166	Eigenvalue, 320, 351, 352, 365, 371, 425
search directions, 165	generalized, 352
time to solution, 167	inverse power method, 353, 368

440 INDEX

F	Н
False position method (Regula Falsi), 219	Hello World, 4
linear interpolation, 220	
number of iterations, 221	I
slow convergence, 222	Indentation, 7
Fedora, 28, 30–32, 50	Initial value problem, 302
File input, 49	error, 305, 309
reading with for loops, 49	explicit methods, 303
Finite difference derivative, 234, 252	implicit methods, 306
backward difference, 255	non-oscillatory methods, 311, 312
central difference, 255	stability, 311, 312
comparison of approximations, 256, 257	Initial value problems
diffusion operator, 258	higher derivatives, 317
forward difference, 254	stability
higher derivatives, 258	for systems, 320
second derivatives, 257	systems of equations, 315
Finnegan's Wake, 193	Integers, 8
Fission spectrum, 398	
Floating point numbers, 8	J
finite precision errors, 33	Jacobi method, 146
Forward Euler, 302, 303, 305–307, 311, 315–321	fast implementation, 154, 156
conditional stability, 311	graphical representation, 152
Functions, 37, 40	time to solution, 152
default arguments, 41	tri-diagonal version, 168, 169
docstrings, 42, 43	Jacobian matrix, 242, 243
lambda, 88, 89	Joyce, James, 193
name as a parameter, 84	•
parameters, 41	K
return values, 41	Kafka, Franz, 93
side effects, 86	Keyboard input, 14
	Kierkegaard, Søren, 5
G	,
Gauss quadrature, 288	L
accuracy on polynomials, 288	Lagrange polynomials, 176
convergence on smooth functions, 293	efficiency, 181
derivation of rules, 289	Lambda Functions, 88, 89
Gauss-Legendre Quadrature, 288	Linear solvers
multi-dimensional integrals, 296	direct versus iterative, 145, 146
table of weights and abscissas, 288	iterations versus speed, 169
Gauss-Seidel method, 156, 157	numerical versus algorithmic improvements,
fast implementation, 160	163
graphical representation, 159	Linspace, 56
time to solution, 159	Lists, 29
Gaussian elimination, 112, 115	length, 31
pivoting, 119, 120	Loops
round-off errors, 118	for, 24, 26, 28, 49, 64, 78
time to solution, 124	while, 16, 17

INDEX 441

LU factorization, 132, 354	1-D diffusion operator, 336
pivoting, 137	albedo boundary condition, 339
relation to Gaussian elimination, 134	boundary conditions, 334
Lyotard, Jean-Fraçois, 5	Dirichlet boundary condition, 339
•	discrete boundary conditions, 338
M	discretized equation, 338
Major League II, 109	harmonic-mean diffusion coefficient, 338
Math module, 9	k-eigenvalue problem, 352
Matplotlib, 66	Marshak boundary condition, 339
LATEX annotations, 68	quasi-steady form, 335, 347
Matrix	source-driven problems, 343
banded, 141	steady-state form, 335
block, 367	time-dependent form, 334
compressed storage, 168	two-group model, 365
conjugate vectors, 164	Newton-Cotes quadrature, 268
diagonal, 141	convergence, 272, 276
diagonal dominance, 146	error, 272
positive definite, 163	midpoint rule, 268
range, 354	Simpson's rule, 274
symmetric, 140	trapezoid rule, 269
tri-diagonal, 141	Newton's method, 230
tri-diagonal form, 168	inexact version, 234, 236, 306, 308
triangular, 132	initial guess, 232
Moby Dick, 210	Raphson's association, 230
Modules, 47	slow convergence, 238
Monte Carlo method	systems of equations, 242
	use of tangent, 230, 231
collision estimator, 412	
convergence, 387, 429	O
error, 387	Operator overloading, 12
estimation of integrals, 27	NumPy, 58
figure of merit (FOM), 411	_
fission cycles, 426, 429	P
fission matrix, 430–435	Pantheism, 230
implicit capture, 408	Phase field, 318, 319, 322
isotropic neutrons, 388	Phrygian cap, 28, 30–32, 50
origin, 382	Point-reactor kinetics equations (PRKEs), 324
particle weights, 408	prompt jump, 326
scattering, 391, 401	reactivity insertion, 327
spherical geometry, 394	rod drop, 325
track-length estimator, 414	stability for RK4, 326
variance reduction, 407	steady-state solution, 325
Mutability	Polynomials
lists, 32	approximation properties, 175
NumPy arrays, 61, 63, 87, 114	efficient evaluation, 174
tuples, 32	high-degree oscillations, 181
NT	Lagrange construction, 176
N	uniqueness, 176
Neutron diffusion equation	Porkpie, 28, 30–32, 50

442 INDEX

Power law, 210 approximation by Gaussian distribution, 212 Print, 4 Probability cumulative distribution function (CDF), 382 expected probability, 383 exponential distribution, 383 probability density function (PDF), 383 Q Quadrature classical definition, 268 composite form, 270 definition, 268 multidimensional integrals, 294	Root finding methods closed, 216 comparison of closed and open, 232 cost, 218 exhaustive enumeration, 22, 24 open, 230 Roots bracketing, 216 complex, 238, 240 definition, 215 multiple, 215, 216, 238, 239 Runge phenomenon, 181 Runge-Kutta method (fourth-order), 313 conditional stability, 314 systems of equations, 323
R	S
Random number generation, 26, 56, 385, 386 exponential distribution, 384 inverse CDF sampling, 385 rejection sampling, 399 stratified sampling, 417 Range, 25 Recursion, 45 Reed's problem, 345 time-dependent, 347 Regression coefficient interpretation, 201 least-squares formulation, 196 logarithmic transformation, 208 mean-absolute error, 204 NumPy function, 201 polynomial fitting, 206	S Scope, 44 Secant method, 236 starting, 236 Side effects, 114 Singular eigenfunction expansion, 393 Sombrero, 28, 30–32, 50 Spatial cells, 335, 352 Steak au poivre, 98 Strings, 11 subsetting, 12 Successive Over-Relaxation, 160 choice of relaxation parameter, 162, 163 graphical representation, 162 modification to Gauss-Seidel, 160 time to solution, 162
R ² , 196 variable selection, 203 Residual, 19, 22, 119, 123, 146, 151, 163 Richardson extrapolation, 259 application to integrals, 277, 282 extra order of accuracy, 260 higher-precision arithmetic, 278 repeated use, 261 use by computeers, 259 Ridder's Method, 223, 224, 226 extra function evaluation, 223 Romberg integration, 277, 282 efficient implementation, 282	T Tam o'shanter, 28, 30–32, 50 Toque, 30, 31 Trilby, 28, 30–32, 50 Try block, 102, 103 Tuple, 31, 32 U Unicode characters, 5 W Weierstrass approximation theorem, 175