

Index

An *italic* page number indicates that the term appears as part of an exercise in a problem section.

- advection term, 27, 60
 - centered discretization, 60
 - downwind discretization, 60
 - upwind discretization, 60
- advection-diffusion equation, 16, 27, 37, 59, 60, 68
- advection-reaction-diffusion equation, 27, 59
- Alembert, J. le Rond d', 28
- Ampere's law, *see* Maxwell–Ampere law
- assembly
 - finite element, 137, 140, 142
 - finite volume, 84
- backward Euler, 36
- boundary condition, 16, 17, 19, 20, 30, 49, 69
 - Dirichlet, *see* Dirichlet boundary condition
 - homogeneous, 22, 24, 30, 42
 - Neumann, *see* Neumann boundary condition
 - Robin, *see* Robin boundary condition
 - with finite differences, 56
 - with finite volumes, 69, 71
- bounded variation, 90
- centered scheme, 61
- Chebyshev
 - points, 102
 - polynomial, 103, 109
 - spectral method, 102
- conservation laws, 42
- control volume, 69, 70
- convection-diffusion equation, 27
 - see also* advection-diffusion equation
- crude oil production, 10
- curl, 5, 33
- curl-free, 36
- current density, 32
- differential operator, 5, 58
 - order, 58
- differentiation matrix
 - Chebyshev spectral, 104
 - finite difference, 95
 - Fourier spectral, 95, 96
- diffusion, 26, 27
 - equation, 19, 25, 37
 - see also* heat equation
- Dirichlet boundary condition, 24, 46, 49
 - with Chebyshev spectral, 106
 - with finite differences, 49, 56
 - with finite elements, 121
 - with finite volumes, 71, 72
- discrete cosine transform, 104, 110
- discrete maximum principle, 53, 68
- divergence, 5, 33
 - theorem, 19, 42
- downwind scheme, 59
- electric permittivity, 32, 37
- element stiffness matrix, 137
- elliptic problems, 34
- essential boundary condition, 121
- Euler, Leonhard, 35
 - constant, 39
 - incompressible equations, 34
- explicit method, 36
- Faraday's law, *see* Maxwell–Faraday law
- finite difference
 - centered, 47, 57, 59
 - convergence, 51
 - downwind scheme, 59
 - five-point star, 48, 49, 55
 - ghost point, 57
 - in time, 35
 - method, 1, 45, 55
 - nine-point star, 55
 - one-sided, 56–59
 - program, 64
 - relation with finite volumes, 74
 - upwind scheme, 59
- finite element
 - convergence, 125
 - method, 1, 114
 - program, 137
 - shape functions, 136
- finite volume
 - cell centered, 72, 74, 85
 - convergence, 80
 - method, 1, 69
 - program, 83
 - relation with finite differences, 74
 - vertex centered, 72, 85
- forward Euler, 36
- Fourier
 - coefficient, 89, 94
 - discrete transform, 94
 - Fast Fourier Transform (FFT), 96
 - law of heat flux, 17
 - series, 22, 88, 93
 - spectral method, 95
- Fourier, Joseph, 18
- FV4 scheme, 78

- Galerkin approximation, 117, 125, 130
- Gauss law, 33
- Gauss–Green theorem, 41
see also divergence theorem
- ghost point, 57
- gradient, 5
 weak, 123
- grid function, 53
- hat functions, 118
- heat equation, 16, 17, 19, 24, 36
 time-harmonic, 37
see also diffusion equation
- Helmholtz equation, 145
see also wave equation
- Hooke's law, 28
- initial condition, 6, 16, 17, 20, 30
- initial value problem, 6
- isoparametric element, 137
- Laplace equation, 25, 36
see also Poisson equation
- Laplacian, 5
 discrete, 48
- local truncation error, 55
- Lotka, Alfred J., 9
- Lotka–Volterra model, 9, 41
- magnetic permeability, 32
- Maple, 38
 curl, 5
 D (operator), 3, 4
 derivative, *see* diff (function)
 diff (function), 2, 4
 divergence, 5
 dsolve, 7
 expression, 4
 functions, 4
 gradient, 5
 Laplacian, 5
 linalg package, 5
 ODE solution, 39
 partial derivative, 3
 sequence operator \$, 2
- mass matrix, 118, 136
 global, 137
- MATLAB, 38
 data fitting, 12
 delsq, 65
 fft, 96, 102, 106
 Fourier coefficients, 96
 ifft, 102
- linear system, 39
- numgrid, 62
- ODE solution, 8, 39
- ode45, 8, 13
- plotting, 39
- sparse, 83, 143
- spy, 64
- Maxwell's equations, 31, 145
- Maxwell, James C., 32
- Maxwell–Ampere law, 32
- Maxwell–Faraday law, 32, 36
- mesh, 69, 70
 arbitrary, 69
 Cartesian, 74
 cell, 119
 dual, 76
 generator, 130, 146
 parameter, 58, 62
 point distribution, 110
 primal, 76
 rectangular, 48, 70
 refined, 142
 refinement, 83, 84, 114, 126, 134
 size, 48, 55, 59, 65, 93, 127
 smoothing, 134
 tangling, 135
 triangular, 114
 uniform, 48
 visualization, 132
- minimization formulation, 119
- natural boundary condition, 121
- Navier, Claude-Louis, 34
 Navier–Stokes equations, 17, 33, 37
- Neumann boundary condition, 24, 46
 with Chebyshev spectral, 111
 with finite differences, 56, 67
 with finite elements, 121
 with finite volumes, 72, 85
- Newton, Isaac, 7
 law of cooling, 17, 40
 law of motion, 6, 28, 29
Principia Mathematica, 7
- ODE, *see* ordinary differential equation
- Ohm's law, 32
- order
 differential operator, 58
 local truncation error, 67, 68
 multi-index, 15
- of differentiation, 15
- partial differential equation, 15
 Runge–Kutta method, 8
- ordinary differential equation (ODE), 1, 6
 reduction to first order, 6
- Oseen equations, 34
- partial derivative, 3
- partial differential equation (PDE), 1, 15
 classification, 15
 elliptic, 16, 25
 hyperbolic, 16, 30
 order, 15
 parabolic, 16, 19
 separation of variables, 20, 42
- PDE, *see* partial differential equation, 87
- pendulum, 6, 39
 analytical solution, 8
 implicit solution, 7
- periodic boundary condition, 88
 compatibility condition, 89
 with finite differences, 108
 with Fourier spectral method, 95
- Poisson equation, 16, 25, 36, 46, 51, 56
- population dynamics, *see* Lotka–Volterra model
- predator–prey interaction, *see* Lotka–Volterra model
- reaction equation, *see* advection–reaction–diffusion equation
- reaction term, 27
- reference triangle, 137
- Ritz approximation, 119, 130
- Robin boundary condition, 57
 centered, 57
 one-sided, 57
 with finite differences, 57
 with finite volumes, 73
- Runge–Kutta method, 8
- semidiscretization, 35
- shape functions, 136, 137
 local, 139
- shifted Laplace equation, 37
- sparse
 linear system, 50, 71
 matrix, 50

- spectral
 - Chebyshev-based method,
 - 102, 110
 - program, 106
 - convergence, 90, 93, 100
 - Fourier-based method, 88, 95
 - convergence, 98
 - program, 101
 - method, 1, 87
- steady state solutions, 36
- stiffness matrix, 117, 120, 121, 136
 - element, 137
 - global, 137
- Stokes, George G., 34
 - Navier–Stokes equations, 17, 33
 - Stokes equation, 37
- strong form, 115, 120, 129
- structured
 - linear system, 71
 - matrix, 50
- Taylor series, 38, 47, 62, 66, 76, 79, 81, 88
- test function, 120, 122, 127, 129
 - space, 120, 121, 125
- time-harmonic, 37
- total variation, 90
- TPFA, *see* two-point flux approximation
- trial function, 121
 - space, 120
- truncation error, 48
 - estimate, 52
- two-point flux approximation (TPFA), 71, 78
- upwind scheme, 59, 61
- variational form, *see* weak form
- Volterra, Vito, 9
 - Lotka–Volterra model, 9, 41
- Voronoi cells, 70
- wave equation, 16, 28
 - time-harmonic, 37
- see also* Helmholtz equation
- weak form, 115, 117, 120, 130