
Index

- erf(x), 141
- Euler-Mascheroni constant, 150
- air drag, 114
- air resistance, 15
- amplitude, 41
- analytic, 145
- angular frequency, 41
- anonymous function, 82
- associated Legendre functions, 161
- atmospheric density, 105
- autonomous, 213, 264
- Baumgartner, Felix, 104
- beat frequency, 54
- Bernoulli equation, 22, 262
- Bernoulli, Daniel, 22, 168
- Bernoulli, Jacob, 22
- Bernoulli, Jacob II, 22
- Bernoulli, Johann, 22
- Bernoulli, Johann II, 22
- Bernoulli, Johann III, 22
- Bernoulli, Nicolaus I, 22
- Bernoulli, Nicolaus II, 22
- Bessel equation, 151
- Bessel functions, 168
 - first kind, 169
 - generating function, 171
 - identities, 170
 - order one half, 155
 - orthogonality, 171
 - recursion formula, 171
 - second kind, 170
- Bessel, Friedrich Wilhelm, 169
- bifurcation, 266
- bifurcation point, 266
- Big Chill, 129
- Big Crunch, 129
- big-Oh, 348
- binomial coefficients, 344
- binomial expansion, 343
- capacitor, 42
- carrying capacity, 260
- Cauchy-Euler equations, 65, 143
 - nonhomogeneous, 68
- center, 219
- Chain Rule, 319
- characteristic equation, 34, 65, 237
- chemical kinetics, 231
- chili problem, 30
- Clairaut equation, 23
- Clairaut's Theorem, 8
- Clairaut, Alexis Claude, 23
- classical orthogonal polynomials, 161, 162
- coefficient matrix, 235
- conservation
 - angular momentum, 118
 - energy, 120
- constant coefficient equations, 34
 - complex roots, 36
 - repeated roots, 35
- convolution
 - Laplace transform, 199
- convolution theorem
 - Laplace transform, 198
- cooling, 14
- cosmological constant, 124
- coupled systems, 213
- Cramer's rule, 203, 216
- creeping flow, 131
- critical density, 125
- current, 42
- curvature tensor, 124
- cycloid, 127
- damped harmonic motion, 220
- de Moivre's Formula, 343
- de Moivre, Abraham, 343
- density parameter, 125
- DEplot, 89
- derivatives, 311
 - table, 319

- DEtools, 89
- difference equation, 185
- differential equations, 188
 - autonomous, 5
 - first order, 4, 6
 - linear, 4, 31
 - nonhomogeneous, 49
 - Runge-Kutta methods, 95
 - second order, 31
 - separable, 5
 - series, 169
 - Taylor methods, 90
- differential operator, 31
- Differentiation Under Integral, 326
- Dirac delta function
 - Laplace transform, 196
 - sifting property, 195
- Dirac, Paul Adrien Maurice, 194
- direction field, 84, 218
- direction fields, 81
- distribution, 194
- double factorial, 165
- double tank problem, 230
- drag coefficient, 130
- drag force, 15, 105, 108, 114
- dsolve, 80, 88
- Duffing equation, 291
- Duffing, Georg, 291

- eigenvalue, 237
- eigenvalue problem, 237
- eigenvector, 237
- Einstein field equation, 124
- Einstein tensor, 124
- Einstein, Albert, ix, 123, 211
- Einstein-de Sitter universe, 126
- ellipse, 119
- elliptic functions, 301
- elliptic integral, 297, 298
 - complete, 299
 - incomplete, 299, 300
- epidemic model, 233
- equilibrium, 215
 - center, 219
 - degenerate node, 221
 - focus, 220
 - node, 219
 - saddle, 219
 - source, 219
- equilibrium solution, 261, 264
- error function, 141, 176
- Escher, M. C., 75
- Euler's Formula, 342
- Euler's Method, 75, 120
- Euler, Leonhard, 22, 168, 298
- Euler-Cromer method, 102
- Exact differential equations, 8
- expanding universe, 123
- exponential function, $E_1(x)$, 150
- exponential of a matrix, 235
- ezplot, 80

- Fagnano, Giulio Carlo, 298
- Feynman's trick, 327
- Feynman, Richard, 181, 317, 327
- Fibonacci sequence, 344
- fixed point, 261, 264
- force
 - drag, 108, 114
 - lift, 108
 - Magnus, 108
- Fourier, Joseph, 1, 168
- free fall, 1
- frequency, 41
- Friedmann's Equation, 124
- Friedmann, Alexander Alexandrovich, 124
- Frobenius method, 147
- function
 - average, 329
 - sigmoid, 264
- functions
 - exponential, 312
 - hyperbolic, 317
 - inverse trigonometric functions, 317
 - logarithmic, 312
 - polynomial, 312
 - rational, 312
 - trigonometric, 313
- fundamental matrix, 245
- fundamental matrix solution, 246
- Fundamental Theorem of Calculus, 2, 321, 327

- Gödel, Kurt, 31
- Gamma function, 171, 187
- generalized function, 194
- geometric series, 334
- GNU Octave, 85
- gravitational potential, 163
- Green's functions, 32
 - initial value, 60
- Green, George, 61
- Gregory, James, 336
- Gudermann, Christoph, 323
- Gudermannian, 323

- half-life, 13
- Hankel, Hermann, 135
- harmonic series
 - partial sum, 161
- Hawking, Stephen, 129
- Heaviside function, 191
- heteroclinic orbits, 279
- hold command, 82
- homogeneous, 213
- Hooke's Law, 40
- Hubble's constant, 125
- Hubble, Edwin, 124
- Huen's method, 97
- hyperbolic cosine, 317
- hyperbolic function
 - identities, 318
 - substitution, 331
- hyperbolic sine, 317
- hyperbolic tangent, 318
- identities
 - double angle, 314
 - half angle, 314
 - product, 316
 - Pythagorean, 313
 - sum and difference, 314
 - tangent, 313
- implicit solution, 5
- Implicit-Euler Method, 121
- impulse function
 - unit impulse, 196
- indicial equation, 148
- inductor, 42
- initial value problem, 4, 188
- integral transforms, 181
- integrals, 311
 - integration limits, 322
 - simple substitution, 321
 - table, 320
 - trigonometric, 328
- integrating factor, 6
- integration by parts, 323
- integration by recursion, 185
- interval of convergence, 340
- inverse Laplace transform, 189
- Jacobian matrix, 270
- Kepler's Laws of Planetary Motion, 119
- Kepler, Johannes, 168
- kernel, 61
- kinematic viscosity, 105, 130
- Kirchoff's rules, 42
 - Loop rule, 204, 228
 - Point rule, 204, 228
- Kittinger, Joe, 104
- Lagrange equation, 23
- Lagrange, Joseph Louis, 23
- Lagrange, Joseph-Louis, 168
- Lambert, Johann Heinrich, 323
- laminar flow, 130
- Laplace transform, 181
 - convolution, 198
 - differential equations, 188
 - periodic functions, 193
 - properties, 187
 - transform pairs, 183
- Laplace, Pierre-Simon, 181
- Law of cooling, 14
- LC circuit, 46
- Legendre equation, 142
- Legendre polynomials, 161
 - generating function, 163
 - normalization, 167
 - recurrence relation, 162
 - recursion formula, 162
 - Rodrigues Formula, 162
- Legendre, Adrien-Marie, 161, 171
- Lemaître, Georges, 124
- lift force, 108
- line of equilibria, 222
- linear operator, 31
- linearity, 31
- linearization, 264, 271
- linearly dependent, 32
- logarithmic differentiation, 157
- logistic equation, 260
 - solution, 263
- Lotka, Alfred James, 281
- Lotka-Volterra model, 281
 - first integral, 284
- LRC circuits, 42, 227
- lsode, 85
- Maclaurin series, 135, 235, 338
- Maclaurin, Colin, 336
- Magnus force, 108
- Malthus, Thomas Robert, 12, 260
- Maple, 88
- mass-spring system, 40
 - coupled, 212
- MATLAB, 79
- matrix formulation, 234
- mechanical energy, 297
- megaparsec, 124
- Method of Reduction of Order, 37, 141,

- 150
- Method of undetermined coefficients, 32, 49
 - modified, 52
- Midpoint method, 96
- mixture problems, 17, 229
- modified Euler method, 97
- n -body problem, 117
- nested radicals, 315
- Neumann function, 170
- Newton's Law of Cooling, 14
- Newton's Law of Gravitation, 4, 117
- Newton's second law, 1, 40
- Newton, Isaac, 14
- nonautonomous, 213
 - nonlinear systems, 290
- nonhomogeneous solutions, 249
- nonlinear pendulum
 - forced, 290
 - numerical, 100
 - period, 296
- numerical solutions, 75
- ode45, 80, 98
 - second order, 83
- odeint, 86
- one-form, 8
- orbit, 217
- ordinary differential equation, 4
- ordinary point, 145
- orthogonal polynomials, 162
- oscillations
 - coupled, 211
 - damped, 47
 - forced, 52
 - underdamped, 48
- overdamped, 221
- partial fraction decomposition, 16, 189
- particular solution, 5
- Pascal's triangle, 344
- Pascal, Blaise, 344
- pendulum, 40
 - forced nonlinear, 290
 - nonlinear, 269
 - period, 296
- pendulum, simple, 41
- period, 41
- periodic function, 317
- periodic functions
 - Laplace transform, 193
- phase plot, 84
- phase portrait, 216
- pitchfork bifurcation, 268
- Pochhammer symbol, 174
- Pochhammer, Leo August, 174
- Poincaré surface of section, 292
- Poincaré, Jules Henri, 259
- point at infinity, 177
- Poisson, Siméon, 168
- polar coordinates, 223
 - derivatives, 223
- population models, 260
 - logistic, 260
 - Lotka-Volterra, 281
 - Malthusian, 11, 260
- potential drops, 42
- potential energy, 297
- predator-prey model, 232
- principal matrix solution, 248
- pursuit curves, 19
- Python, 86
- quadrature, 297
- quiver, 82, 84
- radicals
 - nested, 315
- radioactive decay, 12
- radius of convergence, 340
- RC circuits, 43
- re-indexing series, 138
- Reduction of Order, 35, 37, 141, 146
- relative error, 296
- resistor, 42
- resonance, 54
- Reynolds number, 105, 115, 130
- Reynolds, Osborne, 130
- Riccati equation, 26, 262
- Riccati, Jacopo Francesco, 26, 262
- Riemann, Georg Friedrich Bernhard, 61
- RMS voltage, 329
- Romeo and Juliet, 233
- root mean square, 329
- Runge-Kutta, 95
 - fourth order, 97
 - second order, 96
- Runge-Kutta-Fehlberg method, 98
- Russell, Bertrand, 311
- saddle point, 219
- saddle-node bifurcation, 267
- salsa problem, 257
- scale factor, 124
- scheme
 - Laplace transform, 181
- Schwartz, Laurent, 194

-
- scipy, 86
 - semi-implicit Euler Method, 102
 - separatrix, 279
 - sequence
 - Fibonacci, 344
 - series
 - binomial series, 346
 - geometric series, 334
 - Maclaurin series, 135, 338
 - power series, 135, 336
 - re-indexing, 138
 - Taylor series, 135, 337
 - telescoping, 335, 352
 - sigmoid function, 264
 - simple harmonic motion, 40, 196, 212, 221
 - simple harmonic oscillator, 83
 - singular point, 145
 - singular solutions, 24
 - sky diving, 104
 - slope field, 217
 - small angle approximation, 42
 - soccer ball, 107
 - solitons, 317
 - solutions
 - equilibrium, 215
 - Special Relativity, 347
 - spiral, 220, 223
 - sports balls, 107
 - square wave, 193
 - Störmer, Fredrik Carl Mülertz, 122
 - Störmer-Verlet Method, 122
 - stability criteria, 265
 - step function, 191
 - Stokes drag force, 131
 - Sturm-Liouville, 171
 - substitution
 - hyperbolic, 331
 - trigonometric, 329
 - surfaces of section, 292
 - symplectic integrators, 121
 - systems
 - constant coefficient, 213
 - Tabular Method, 325
 - tank problem, 17
 - Taylor polynomials, 96, 337
 - Taylor series, 135, 337
 - Taylor, Brook, 336
 - terminal velocity, 15
 - The indicial equation., 149
 - time constant, 44
 - time dilation, 346
 - trajectory, 217
 - transcritical bifurcation, 267
 - transforms
 - Laplace, 181
 - transitional flow, 131
 - trigonometric
 - identities, 313
 - substitution, 329
 - turbulent flow, 131
 - underdamped, 221
 - unstable node, 219
 - van der Pol, Balthasar, 285
 - variation of parameters, 32, 57
 - vector spaces, 31
 - Velocity Verlet Method, 122
 - Verhulst, Pierre François, 260
 - Verlet Method, 122
 - Verlet, Loup, 122
 - viscosity, 130
 - Volterra integral equation, 208
 - Volterra, Vito, 208
 - von Ettingshausen, Andreas Freiherr, 345
 - Watson, G.N., 168
 - Wronskian, 33, 247