## MathematicaHandbook Index

## A BCDEFGHIJKLMNOPQRSTUV WXYZ

A
AC Circuits, Circuits
Accuracy and Precision, description of
Adjoint, operator, construction of
Analytic, function, definition of, as option to Limit, testing functions for
Animation, examples of
Apply command, @@ for determining \#zeros-\#poles of a complex function
Argument principle, functions, DE and properties
Arrow, drawing 2D; drawing 3D
Associated Legendre, $\quad$ for specifying properties of parameters
Assuming, example
Assumptions, for specifying properties of parameters
Asymptotic solutions to DEs near irregular singular points

```
Asymptotic Analysis
```

B

Beats, resulting from adding 2 waves with slightly different frequencies
Bernoulli trial probability of k successes in N trials
Bessel equation, series solutions to DE, orthogonality and Sturm-Liouville properties numerical solutions to DE, facts about functions

Binomial, use in counting and probability
Biot-Savart law, calculation using
Block protects local variables in multi-line functions, simple examples
Bohr radius, result of dimensional analysis; in hydrogenic wave functions

Boolean, variable, elementary examples
Bose Einstein, integrals in statistical mechanics, expressing in terms of PolyLog
Boundary value problem, for ODEs; for PDEs
Bracket, tool for matching [], \{ \}, (), etc
Branch cut, for Sqrt example and plots
Break for exiting loops, simple example
Brusselator, non linear PDE
C

Cases command, simple example; example using levels
Cauchy integral formula, for complex functions
Cauchy-Riemann, condition for differentiability of complex functions
Chisquared, distribution
Cell, converting Style from Input to Text, Title, etc.
center of mass, calculation for irregular object
central force problem, Lagrangian for; numerical solution and animations of
Chain rule for partial derivatives

Change of variable, for ODE for PDE
Chisquared, distribution
Circuits, Circuits circuits with switches
ClassifyODE function, in DETools package
Clear removes symbol definitions
Comments, using (* *) ; using Text cells
ComplexExpand examples for finding the real and imaginary parts of expressions
ComplexMap function for visualizing $\mathrm{w}=\mathrm{f}[\mathrm{z}]$ in the w and z planes
Complex variables simple examples of; calculus in the complex plane
condition number of a matrix
Conditional probability, definition and examples
Confluent hypergeometric, function and DE , properties
conservation law, relation to FirstIntegrals
constrained optimization analytic and numerical techniques for
Contour integral, analytic, numerical
ContourPlot, 2D examples of; 3D examples of


Drawing tools examples using Drawing Tools palette; freehand drawing; geometrical drawing
Dual space, of a vector space
E

| Einstein, | summation convention for tensors |
| :---: | :---: |
| elasticity, | tensor of |
| Element, | specifying data type in Assumptions |
| Epilog | adding text and features to plots example |
| equation, | == converting into an expression performing an operation on both sides of an equation |
| EqToMat, package | function that converts lists of equations ( with $==$ ) into $A x=$ rhs form, in Utilities ; part of LinAlgebraTools |
| EqToSparse, | rules for defining sparse matrices |
| Error bar, | adding to graph |
| Error messages, | turning On and Off |
| Essential singularity, plots of L Laurent series of |  |
| Euler equation, derivation of |  |
|  | use in mechanics |
| Euler's formula, | for $\mathbb{e}^{\wedge} \dot{1} \mathrm{z}$ |
| EulerGamma, | used in series expansions |
| EvaluationMonitor | monitoring numerical solutions example |
| Excel, | reading and writing files |
| Export command, | examples of Exporting numerical data; examples of Exporting graphics |

## F

Faraday, law of induction
Fermi Dirac, integrals in statistical mechanics, expressing in terms of PolyLog
Files and Directories, examples using SetDirectory[ ], FileNames[ ], Get Path tool, etc.
FindRoot, usage and examples
Finite difference, numerical method, for ODE boundary value problem, for Laplace equation
finitedifEVP, a general purpose function for eigenvalue boundary value problems
Finite element method for numerical solution of boundary value problems
Fit, elementary use of for least squares fitting
nonlinear
Fluid mechanics, $\quad$ discussion and examples
Fourier series, $\quad$ simple examples using Sin and Cos; general algorithm using complex exponentials
Fourier transform, $\quad$ 1D table of, multi-dimensional
Free energy $\quad$ definition of thermodynamic functions
Freehand drawing $\quad$ examples
Fresnel equation, reflection at an interface
Frobenius, series solution for ODE details of algorithm
Front end, $\quad$ commands
Function command, used for substituting expressions into DEs
Function, user defined $\quad$ examples and rules

## G

Galerkin method, $\quad$ applied in finite elements
Gamma function, properties of
Gassian distribution, derivation as limit of binomial distribution
Gaussian elimination, details of algorithm
Gauss's law,
geometrical drawing, techniques and examples
Graphics objects, examples of Line, Disk, Circle, Rectangle, etc.

Greens function, for ODEs

## H

Hamiltonian, definition inclassical mechanics
Hard sphere, collision, kinematics of
Harmonic function discussion of for Re and Im part of f[z]
Harmonic oscillator, damped classical ; quantum
Heat conduction, derivation of equation ; separable solutions ; numerical solutions
Hermite, series solutions to DE; orthogonality relations
Histogram, simple demo used for probability distributions
Hydrogen atom, detailed discussion; finite difference calculation of bound states
Hypergeometric, series solutions of DE, properties of functions


## J

Jacobian, in chain rule, ; in VectorAnalysis package function JacobianMatrix

## K

Kirchoff, law for circuits
Kramers-Kronig, relations between Re and Im parts of a complex function
Kummer, DE, properties of

Lagrange equations, applications in mechanics
Lagrange multipliers, examples of use in constrained algebraic optimization ; examples in calculus of variations
Laguerre, special function properties
Laplace equation
Laplacian, separable solutions in standard coordinate systems; numerical solutions using finite differences

Laurent series, power series expansion in complex plane; examples of calculation

Least squares, | simple example using Fit |
| :--- |
|  |
| detailed discussion in terms of maximum liklihood |

Legendre, $\quad$| series solutions to DE, orthogonality and Sturm-Liouville properties |
| :--- |
|  |
| numerical solutions to DE, facts about functions |

Levi-Civita symbol, relation to Signature
LinAlgebraTools, MathematicaHandbook package in Utilities
Linear equations general discussion ; converting to matrix form using EqToMat
over-determined systems; under determined systems
LinearSolve, compared to Solve
Log-Log, plots

## M

Manipulate basic information and examples
Matrix multiplication simple example
Maximum liklihood method for curve fitting
Maxwell's equations, boundary conditions for
Maxwell relation, in thermodynamics
Mesh generation, examples in finite element calculations
Metric tensor, covariant and contravariant components

| Minors | use in calculating Determinants |
| :--- | :--- |
| Module | protects local variables in multi-line functions, simple examples |

molecular dynamics, of 2D hard spheres
Moment of inertia, example calculations
Monte Carlo integration
.mp3 file, Importing and manipulating
Multinomial, use in counting and probability
Multiple integrals, symbolic using Integrate
numerical using MonteCarlo

Navier-Stokes,
equation
N body, simulation of hard sphere dynamics
NDSolve, initial value problems for ODEs, boundary value problems for ODEs initial value problems for PDEs

```
Needs, for loading Packages
Newton method, description of algorithm
NIntegrate, basic usage; examples using: Method->MonteCarlo; Method-> Oscillatory ; use of
EvaluationMonitor
NMinimize, example of use
Non-orthonormal, basis vectors
NonlinearFit, examples
NonlinearRegress, examples
non separable,boundary value problems
NSolve, examples of use
NullSpace, geometric significance
```



Operators, construction of using pure functions makeop for constructing linear partial differential operators
optimization constrained
order of derivative, function for finding
orthogonality relations forspecial functions
$P$

Packages, loading; comprehensive list
Palette, displaying BasicInput
ParabolicCylinderD, properties
Pattern matching, techniques of
Perturbation theory, general discussion; for algebraic equations ; for eigenvalues; for ODEs
PDF, probability density function
phase, of a complex number, finding with Arg
phase space, of 2 nd order $D E$
PhotoShop, importing images from
PieChart, examples of
PlotMatrix to find non zero elements of large matrices; example
Plots 2D, basic information; fancier plots using PlotLabel, Text, Dashing, etc.
Plots 3D, examples

```
PlotVectorField, basic usage ; used fordrawing phase space flows
PlotVectorField3D, example in Waveguides
Poisson distribution, derivation of; Poisson distributed random numbers
Poisson equation, in electrostatics
Poisson half plane formula for 2D boundary value problem
Polar coordinates, diagram for; used for expressing complex numbers
poles of a complex function, contour plots
role in integration
PolyLog function, properties in Special Function Facts
Postfix operator, // examples of
PowerPoint, pasting graphics from
powerss power series solution function in DETools package
Precision description of
PrincipalValue, of an integral, examples of
Probability, axioms and rules; random variables
Programming elementary examples
PseudoInverse, derivation of ; solving overdetermined systems: example of use in curve fitting
Pure function, \#\& examples of
```

Quality factor $\quad Q$ for damped harmonic oscillator
Quantum mecahnics, time independent: harmonic oscillator; square well via shooting method; H atom via finite differences

```
1D time dependentseparable solutions; numerical solutions
```


## R

Random variables, general discussion; list of built-in discrete ; list of built-in continuous
Rayleigh-Ritz variational methods
ReadSpreadSheet, convenient package for reading data files
Reading data, from files and URLS
Real part, of a complex expression, why ComplexExpand is crucial
Reciprocal vector definition
Recurrence, relations for special functions
Reflection of waves, Fresnel formulas
Regression, linear using Regress
ReduceUnits, function in DimTools which expresses compound units in terms of mass, length, time
Riemann surface for Sqrt, for Log
Reaction-Diffusion non linear PDE
Relaxation method, for solving finite difference equations
Repeated trials probability of k successes in $N$ trials
Residue, use in computing integrals; calculating by hand
Roots of equations, examples using Solve, NSolve and FindRoot
Rotating graphics $\quad 3 D$ example
RowReduce, use in: solving linear equations, computing nullspace

## S

Schrödinger equation, time independent: harmonic oscillator; square well via shooting method; Hatomvia finite differences

```
                                    1D time dependent separable solutions; numerical solutions
```

Semi-Log, plots
series solutions, for ODEs; for PDEs ; perturbation series
Shadowing error, avoiding
shooting method, used for nonlinear boundary value problem; eigenvalue problem
Signature use for calculationg determinants
simulation, of hard spheres
SingularValueDecomposition example using
Slide Show basic information
Snell's law, elementary example
Sort, basic usage, for finding index of maximum element
Sound , Importing and generating musical notes and speech
SparseArray example
Special characters, typing using escape codes
Spherical bessel functions, properties
Spherical coordinates, diagram and properties
Spherical harmonics, properties
Spontaneous singularity, in solutions to a nonlinear DE
Spreadsheet, writing data to; reading data from

Statics, solving a truss problem using Solve
Stationary phase, method for evaluating integrals
Statistics, basic functions, Mean, Median, StandardDeviation, etc.
StepMonitor monitoring numerical solutions example
Steepest descent, method for evaluating integrals
Stirling formula for asymptotic behavior of $n$ !
Stokes, integral theorem
strain, symmetric part of Jacobian
String patterns basic examples
Sturm-Liouville, form of DE
Sudoku, puzzle solver Widget
Symbolize example Symbolizing a matrix ; example Symbolizing a subscript
T

Tensors, algebra of Cartesian tensors ; general transformation formula; Levi-Civita tensor
Thermodynamics, calculating derivatives
Thomas-Fermi,ODE , numerical solution
Thread, examples of use
Transpose, inner product properties
Trapezoidal rule numerical integration demo
Trigonometric integrals, examples

## U

Undiagonalizabe matrix, example of
Uniform circular motion, simple example
Units, converting

## V

Variables, possible names for, subscripted, indexed $x[i][t]$
Variational theorem, for eigenvalues of symmetric matrices
Variation of parameters, technique for solving inhomogeneous DEs, applied to

Vector analysis, general discussion; use of Grad, Curl, Laplacian, etc in standard package; operators in various coordinate systems

Vector potential, derivation of
Vector space, axioms for
Visualizing, complex functions using various graphical techniques

## W

Watsons Lemma used in asymptotic evaluations of integrals
Wave equation, derivation ; separable solutions; free space solution series solutions ; numerical solutions
.wav file, Importing and manipulating
Wave guides, solution of Maxwell's equations for
Weak solution, of a PDE
Wheatstone bridge, Circuits
Widget, $\quad$ Sudoku example
Winding number example
WKB, approximation solution to ODE
Wronskian determinant, criterion for functional linear independence; use in analytic solutions of DEs

## X

Y

## Z

Zeta function, properties and relation to prime numbers in Special Function Facts

