Computer Programs by Chapter and Section

1.0	`flmoon`	calculate phases of the moon by date
1.1	`julday`	Julian Day number from calendar date
1.1	`badluk`	Friday the 13th when the moon is full
1.1	`caldat`	calendar date from Julian day number
2.1	`gaussj`	Gauss-Jordan matrix inversion and linear equation solution
2.3	`ludcmp`	linear equation solution, LU decomposition
2.3	`lubksb`	linear equation solution, backsubstitution
2.4	`tridag`	solution of tridiagonal systems
2.4	`banmul`	multiply vector by band diagonal matrix
2.4	`bandec`	band diagonal systems, decomposition
2.4	`banbks`	band diagonal systems, backsubstitution
2.5	`mprove`	linear equation solution, iterative improvement
2.6	`svbksb`	singular value backsubstitution
2.6	`svdcmp`	singular value decomposition of a matrix
2.6	`pythag`	calculate $(a^2 + b^2)^{1/2}$ without overflow
2.7	`cyclic`	solution of cyclic tridiagonal systems
2.7	`sprsin`	convert matrix to sparse format
2.7	`sprsax`	product of sparse matrix and vector
2.7	`sprstx`	product of transpose sparse matrix and vector
2.7	`sprstp`	transpose of sparse matrix
2.7	`sprspm`	pattern multiply two sparse matrices
2.7	`sprstm`	threshold multiply two sparse matrices
2.7	`linbcg`	biconjugate gradient solution of sparse systems
2.7	`snrm`	used by `linbcg` for vector norm
2.7	`atimes`	used by `linbcg` for sparse multiplication
2.7	`asolve`	used by `linbcg` for preconditioner
2.8	`vander`	solve Vandermonde systems
2.8	`toeplz`	solve Toeplitz systems
2.9	`choldc`	Cholesky decomposition
2.9	`cholsl`	Cholesky backsubstitution
2.10	`qrdcmp`	QR decomposition
2.10	`qrsolv`	QR backsubstitution
2.10	`rsolv`	right triangular backsubstitution
2.10	`qrupdt`	update a QR decomposition
2.10	`rotate`	Jacobi rotation used by `qrupdt`
3.1	`polint`	polynomial interpolation
3.2	`ratint`	rational function interpolation
3.3	`spline`	construct a cubic spline
3.3	`splint`	cubic spline interpolation
3.4	`locate`	search an ordered table by bisection

3.4	`hunt`	search a table when calls are correlated
3.5	`polcoe`	polynomial coefficients from table of values
3.5	`polcof`	polynomial coefficients from table of values
3.6	`polin2`	two-dimensional polynomial interpolation
3.6	`bcucof`	construct two-dimensional bicubic
3.6	`bcuint`	two-dimensional bicubic interpolation
3.6	`splie2`	construct two-dimensional spline
3.6	`splin2`	two-dimensional spline interpolation
4.2	`trapzd`	trapezoidal rule
4.2	`qtrap`	integrate using trapezoidal rule
4.2	`qsimp`	integrate using Simpson's rule
4.3	`qromb`	integrate using Romberg adaptive method
4.4	`midpnt`	extended midpoint rule
4.4	`qromo`	integrate using open Romberg adaptive method
4.4	`midinf`	integrate a function on a semi-infinite interval
4.4	`midsql`	integrate a function with lower square-root singularity
4.4	`midsqu`	integrate a function with upper square-root singularity
4.4	`midexp`	integrate a function that decreases exponentially
4.5	`qgaus`	integrate a function by Gaussian quadratures
4.5	`gauleg`	Gauss-Legendre weights and abscissas
4.5	`gaulag`	Gauss-Laguerre weights and abscissas
4.5	`gauher`	Gauss-Hermite weights and abscissas
4.5	`gaujac`	Gauss-Jacobi weights and abscissas
4.5	`gaucof`	quadrature weights from orthogonal polynomials
4.5	`orthog`	construct nonclassical orthogonal polynomials
4.6	`quad3d`	integrate a function over a three-dimensional space
5.1	`eulsum`	sum a series by Euler–van Wijngaarden algorithm
5.3	`ddpoly`	evaluate a polynomial and its derivatives
5.3	`poldiv`	divide one polynomial by another
5.3	`ratval`	evaluate a rational function
5.7	`dfridr`	numerical derivative by Ridders' method
5.8	`chebft`	fit a Chebyshev polynomial to a function
5.8	`chebev`	Chebyshev polynomial evaluation
5.9	`chder`	derivative of a function already Chebyshev fitted
5.9	`chint`	integrate a function already Chebyshev fitted
5.10	`chebpc`	polynomial coefficients from a Chebyshev fit
5.10	`pcshft`	polynomial coefficients of a shifted polynomial
5.11	`pccheb`	inverse of `chebpc`; use to economize power series
5.12	`pade`	Padé approximant from power series coefficients
5.13	`ratlsq`	rational fit by least-squares method
6.1	`gammln`	logarithm of gamma function
6.1	`factrl`	factorial function
6.1	`bico`	binomial coefficients function
6.1	`factln`	logarithm of factorial function

6.1	`beta`	beta function
6.2	`gammp`	incomplete gamma function
6.2	`gammq`	complement of incomplete gamma function
6.2	`gser`	series used by `gammp` and `gammq`
6.2	`gcf`	continued fraction used by `gammp` and `gammq`
6.2	`erff`	error function
6.2	`erffc`	complementary error function
6.2	`erfcc`	complementary error function, concise routine
6.3	`expint`	exponential integral E_n
6.3	`ei`	exponential integral Ei
6.4	`betai`	incomplete beta function
6.4	`betacf`	continued fraction used by `betai`
6.5	`bessj0`	Bessel function J_0
6.5	`bessy0`	Bessel function Y_0
6.5	`bessj1`	Bessel function J_1
6.5	`bessy1`	Bessel function Y_1
6.5	`bessy`	Bessel function Y of general integer order
6.5	`bessj`	Bessel function J of general integer order
6.6	`bessi0`	modified Bessel function I_0
6.6	`bessk0`	modified Bessel function K_0
6.6	`bessi1`	modified Bessel function I_1
6.6	`bessk1`	modified Bessel function K_1
6.6	`bessk`	modified Bessel function K of integer order
6.6	`bessi`	modified Bessel function I of integer order
6.7	`bessjy`	Bessel functions of fractional order
6.7	`beschb`	Chebyshev expansion used by `bessjy`
6.7	`bessik`	modified Bessel functions of fractional order
6.7	`airy`	Airy functions
6.7	`sphbes`	spherical Bessel functions j_n and y_n
6.8	`plgndr`	Legendre polynomials, associated (spherical harmonics)
6.9	`frenel`	Fresnel integrals $S(x)$ and $C(x)$
6.9	`cisi`	cosine and sine integrals Ci and Si
6.10	`dawson`	Dawson's integral
6.11	`rf`	Carlson's elliptic integral of the first kind
6.11	`rd`	Carlson's elliptic integral of the second kind
6.11	`rj`	Carlson's elliptic integral of the third kind
6.11	`rc`	Carlson's degenerate elliptic integral
6.11	`ellf`	Legendre elliptic integral of the first kind
6.11	`elle`	Legendre elliptic integral of the second kind
6.11	`ellpi`	Legendre elliptic integral of the third kind
6.11	`sncndn`	Jacobian elliptic functions
6.12	`hypgeo`	complex hypergeometric function
6.12	`hypser`	complex hypergeometric function, series evaluation
6.12	`hypdrv`	complex hypergeometric function, derivative of
7.1	`ran0`	random deviate by Park and Miller minimal standard
7.1	`ran1`	random deviate, minimal standard plus shuffle

7.1	`ran2`	random deviate by L'Ecuyer long period plus shuffle
7.1	`ran3`	random deviate by Knuth subtractive method
7.2	`expdev`	exponential random deviates
7.2	`gasdev`	normally distributed random deviates
7.3	`gamdev`	gamma-law distribution random deviates
7.3	`poidev`	Poisson distributed random deviates
7.3	`bnldev`	binomial distributed random deviates
7.4	`irbit1`	random bit sequence
7.4	`irbit2`	random bit sequence
7.5	`psdes`	"pseudo-DES" hashing of 64 bits
7.5	`ran4`	random deviates from DES-like hashing
7.7	`sobseq`	Sobol's quasi-random sequence
7.8	`vegas`	adaptive multidimensional Monte Carlo integration
7.8	`rebin`	sample rebinning used by `vegas`
7.8	`miser`	recursive multidimensional Monte Carlo integration
7.8	`ranpt`	get random point, used by `miser`
8.1	`piksrt`	sort an array by straight insertion
8.1	`piksr2`	sort two arrays by straight insertion
8.1	`shell`	sort an array by Shell's method
8.2	`sort`	sort an array by quicksort method
8.2	`sort2`	sort two arrays by quicksort method
8.3	`hpsort`	sort an array by heapsort method
8.4	`indexx`	construct an index for an array
8.4	`sort3`	sort, use an index to sort 3 or more arrays
8.4	`rank`	construct a rank table for an array
8.5	`select`	find the Nth largest in an array
8.5	`selip`	find the Nth largest, without altering an array
8.5	`hpsel`	find M largest values, without altering an array
8.6	`eclass`	determine equivalence classes from list
8.6	`eclazz`	determine equivalence classes from procedure
9.0	`scrsho`	graph a function to search for roots
9.1	`zbrac`	outward search for brackets on roots
9.1	`zbrak`	inward search for brackets on roots
9.1	`rtbis`	find root of a function by bisection
9.2	`rtflsp`	find root of a function by false-position
9.2	`rtsec`	find root of a function by secant method
9.2	`zriddr`	find root of a function by Ridders' method
9.3	`zbrent`	find root of a function by Brent's method
9.4	`rtnewt`	find root of a function by Newton-Raphson
9.4	`rtsafe`	find root of a function by Newton-Raphson and bisection
9.5	`laguer`	find a root of a polynomial by Laguerre's method
9.5	`zroots`	roots of a polynomial by Laguerre's method with deflation
9.5	`zrhqr`	roots of a polynomial by eigenvalue methods
9.5	`qroot`	complex or double root of a polynomial, Bairstow

12.4	`fourn`	fast Fourier transform in multidimensions
12.5	`rlft3`	FFT of real data in two or three dimensions
12.6	`fourfs`	FFT for huge data sets on external media
12.6	`fourew`	rewind and permute files, used by `fourfs`
13.1	`convlv`	convolution or deconvolution of data using FFT
13.2	`correl`	correlation or autocorrelation of data using FFT
13.4	`spctrm`	power spectrum estimation using FFT
13.6	`memcof`	evaluate maximum entropy (MEM) coefficients
13.6	`fixrts`	reflect roots of a polynomial into unit circle
13.6	`predic`	linear prediction using MEM coefficients
13.7	`evlmem`	power spectral estimation from MEM coefficients
13.8	`period`	power spectrum of unevenly sampled data
13.8	`fasper`	power spectrum of unevenly sampled larger data sets
13.8	`spread`	extirpolate value into array, used by `fasper`
13.9	`dftcor`	compute endpoint corrections for Fourier integrals
13.9	`dftint`	high-accuracy Fourier integrals
13.10	`wt1`	one-dimensional discrete wavelet transform
13.10	`daub4`	Daubechies 4-coefficient wavelet filter
13.10	`pwtset`	initialize coefficients for `pwt`
13.10	`pwt`	partial wavelet transform
13.10	`wtn`	multidimensional discrete wavelet transform
14.1	`moment`	calculate moments of a data set
14.2	`ttest`	Student's t-test for difference of means
14.2	`avevar`	calculate mean and variance of a data set
14.2	`tutest`	Student's t-test for means, case of unequal variances
14.2	`tptest`	Student's t-test for means, case of paired data
14.2	`ftest`	F-test for difference of variances
14.3	`chsone`	chi-square test for difference between data and model
14.3	`chstwo`	chi-square test for difference between two data sets
14.3	`ksone`	Kolmogorov-Smirnov test of data against model
14.3	`kstwo`	Kolmogorov-Smirnov test between two data sets
14.3	`probks`	Kolmogorov-Smirnov probability function
14.4	`cntab1`	contingency table analysis using chi-square
14.4	`cntab2`	contingency table analysis using entropy measure
14.5	`pearsn`	Pearson's correlation between two data sets
14.6	`spear`	Spearman's rank correlation between two data sets
14.6	`crank`	replaces array elements by their rank
14.6	`kendl1`	correlation between two data sets, Kendall's tau
14.6	`kendl2`	contingency table analysis using Kendall's tau
14.7	`ks2d1s`	K–S test in two dimensions, data vs. model
14.7	`quadct`	count points by quadrants, used by `ks2d1s`
14.7	`quadvl`	quadrant probabilities, used by `ks2d1s`
14.7	`ks2d2s`	K–S test in two dimensions, data vs. data
14.8	`savgol`	Savitzky-Golay smoothing coefficients

15.2	fit	least-squares fit data to a straight line
15.3	fitexy	fit data to a straight line, errors in both x and y
15.3	chixy	used by fitexy to calculate a χ^2
15.4	lfit	general linear least-squares fit by normal equations
15.4	covsrt	rearrange covariance matrix, used by lfit
15.4	svdfit	linear least-squares fit by singular value decomposition
15.4	svdvar	variances from singular value decomposition
15.4	fpoly	fit a polynomial using lfit or svdfit
15.4	fleg	fit a Legendre polynomial using lfit or svdfit
15.5	mrqmin	nonlinear least-squares fit, Marquardt's method
15.5	mrqcof	used by mrqmin to evaluate coefficients
15.5	fgauss	fit a sum of Gaussians using mrqmin
15.7	medfit	fit data to a straight line robustly, least absolute deviation
15.7	rofunc	fit data robustly, used by medfit
16.1	rk4	integrate one step of ODEs, fourth-order Runge-Kutta
16.1	rkdumb	integrate ODEs by fourth-order Runge-Kutta
16.2	rkqs	integrate one step of ODEs with accuracy monitoring
16.2	rkck	Cash-Karp-Runge-Kutta step used by rkqs
16.2	odeint	integrate ODEs with accuracy monitoring
16.3	mmid	integrate ODEs by modified midpoint method
16.4	bsstep	integrate ODEs, Bulirsch-Stoer step
16.4	pzextr	polynomial extrapolation, used by bsstep
16.4	rzextr	rational function extrapolation, used by bsstep
16.5	stoerm	integrate conservative second-order ODEs
16.6	stiff	integrate stiff ODEs by fourth-order Rosenbrock
16.6	jacobn	sample Jacobian routine for stiff
16.6	derivs	sample derivatives routine for stiff
16.6	simpr	integrate stiff ODEs by semi-implicit midpoint rule
16.6	stifbs	integrate stiff ODEs, Bulirsch-Stoer step
17.1	shoot	solve two point boundary value problem by shooting
17.2	shootf	ditto, by shooting to a fitting point
17.3	solvde	two point boundary value problem, solve by relaxation
17.3	bksub	backsubstitution, used by solvde
17.3	pinvs	diagonalize a sub-block, used by solvde
17.3	red	reduce columns of a matrix, used by solvde
17.4	sfroid	spheroidal functions by method of solvde
17.4	difeq	spheroidal matrix coefficients, used by sfroid
17.4	sphoot	spheroidal functions by method of shoot
17.4	sphfpt	spheroidal functions by method of shootf
18.1	fred2	solve linear Fredholm equations of the second kind
18.1	fredin	interpolate solutions obtained with fred2
18.2	voltra	linear Volterra equations of the second kind
18.3	wwghts	quadrature weights for an arbitrarily singular kernel
18.3	kermom	sample routine for moments of a singular kernel

18.3	quadmx	sample routine for a quadrature matrix
18.3	fredex	example of solving a singular Fredholm equation
19.5	sor	elliptic PDE solved by successive overrelaxation method
19.6	mglin	linear elliptic PDE solved by multigrid method
19.6	rstrct	half-weighting restriction, used by mglin, mgfas
19.6	interp	bilinear prolongation, used by mglin, mgfas
19.6	addint	interpolate and add, used by mglin
19.6	slvsml	solve on coarsest grid, used by mglin
19.6	relax	Gauss-Seidel relaxation, used by mglin
19.6	resid	calculate residual, used by mglin
19.6	copy	utility used by mglin, mgfas
19.6	fill0	utility used by mglin
19.6	mgfas	nonlinear elliptic PDE solved by multigrid method
19.6	relax2	Gauss-Seidel relaxation, used by mgfas
19.6	slvsm2	solve on coarsest grid, used by mgfas
19.6	lop	applies nonlinear operator, used by mgfas
19.6	matadd	utility used by mgfas
19.6	matsub	utility used by mgfas
19.6	anorm2	utility used by mgfas
20.1	machar	diagnose computer's floating arithmetic
20.2	igray	Gray code and its inverse
20.3	icrc1	cyclic redundancy checksum, used by icrc
20.3	icrc	cyclic redundancy checksum
20.3	decchk	decimal check digit calculation or verification
20.4	hufmak	construct a Huffman code
20.4	hufapp	append bits to a Huffman code, used by hufmak
20.4	hufenc	use Huffman code to encode and compress a character
20.4	hufdec	use Huffman code to decode and decompress a character
20.5	arcmak	construct an arithmetic code
20.5	arcode	encode or decode a character using arithmetic coding
20.5	arcsum	add integer to byte string, used by arcode
20.6	mpops	multiple precision arithmetic, simpler operations
20.6	mpmul	multiple precision multiply, using FFT methods
20.6	mpinv	multiple precision reciprocal
20.6	mpdiv	multiple precision divide and remainder
20.6	mpsqrt	multiple precision square root
20.6	mp2dfr	multiple precision conversion to decimal base
20.6	mppi	multiple precision example, compute many digits of π