

# Software Product Description

PRODUCT NAME: Maple, Version 4.3V

SPD 34.63.01

## DESCRIPTION

Maple™ software is a product of Waterloo Maple Software and distributed under Digital Equipment Corporation's Standard Terms and Conditions.

Maple is a powerful interactive system for algebraic manipulation (or symbolic computation). It is used by educators, scientists, engineers, researchers and students to teach, understand and solve both numeric and symbolic mathematical problems.

Specific applications include VLSI design, robotics, laser design, relativistic physics, satellite guidance systems and electrical engineering. Maple is also used in the areas of accounting, economics and financial analysis.

### Overview

Facilities described below work with both symbolic and numeric quantities where appropriate (e.g., Fibonacci numbers are obviously numeric only). The functions described in the *General Mathematics* section of this SPD are loaded as needed, while the other packages must be activated by an appropriate `with()` statement (e.g., `with(linalg)` before using the linear algebra package).

The various control structures described under *Programming Facilities* are also available at the interactive level.

### Object Manipulation

Concatenation, address of, copy, assembly and disassembly of objects, editing, operand extraction and counting, operand substitution, length determination, linear printing, address dereferencing, subexpression optimization, procedure construction, string searching, pattern matching, timing, output redirection, aliasing.

### Operators

Recall (`"`, `""`, `"""`), `+`, `-`, `*`, `/`, exponentiation (`^` or `**`), factorial (`!`), mod, composition (`@`), repeated composition (`@@`), neutral (user defined), relational (`<`, `<=`, `=`, `>=`, `>`, `<>`), Boolean (`and`, `or`, `not`), range (`..`), selection (`[ ]`), concatenation (`.`), sequencing (`,` and `$`), assignment (`:=`).

### Predefined Constants

Catalan, E, I, Pi, `falsa`, gamma, infinity, true.

### General Mathematics

- Trigonometric and hyperbolic functions and inverses
- Asymptotic expansion
- Bernstein polynomials
- Bessel functions
- Beta function
- Binomials
- B-splines
- Chebyshev series
- Chinese Remainder Algorithm
- Cosine integral
- Collection of coefficients
- Commutators
- Composition
- Convergents
- Extraction of denominator or numerator
- Degree computation
- Differentiation
- Differential equations
- Dilogarithm integral
- Discriminant
- Polynomial division
- Euler-Maclaurin summation
- Algebraic numbers
- Complex evaluation
- Boolean
- Hardware floating point evaluation
- Exponentiation
- Expansion

- Factoring
- Extraction of integer or fractional part
- Fresnel integral
- Galois fields
- Gamma function
- GCD
- Gosper's algorithm
- Hypergeometrics
- Indeterminates
- Indefinite and definite integration
- Polynomial interpolation
- Set intersection and union
- Integer solution
- Primality
- Laplace and inverse Laplace transforms
- LCM
- Lexicographic ordering
- Limits
- Logarithm
- Macro definition
- Matching, maximum and minimum of lists or functions
- Infinity norm
- Set membership and difference
- Modular computation
- Normalization
- $O()$
- Subexpression optimization
- Psi
- Quotient and remainder of polynomials
- Radical simplification
- Random numbers and polynomials
- Reciprocal polynomials
- Recurrences
- Residue
- Resultant
- Rounding
- Series expansion
- Signum
- Simplification

- Singularities
- Square root
- Summation (definite and indefinite)
- Singular value decomposition
- Taylor series expansion
- Total ordering
- Trigonometric substitution
- Zeta function

#### *Combinatorics*

Bell numbers, combinations, Fibonacci numbers, k-partitions, multinomials, permutations, power sets, random permutations, Stirling numbers.

#### *Conversions*

Arbitrary number bases, binary, octal, hexadecimal, continued fraction form, angular units, trigonometric to exponential, Horner form polynomials, summations to hypergeometrics, inverse trigonometric to logarithmic, metric, partial fraction form, polar coordinates, float to rational approximation, square-free form.

#### *Differential Forms*

Exterior differentiation, form finding, mixed partials, extension mod 2, simplification of differential forms, wedge product.

#### *Geometry and Projective Geometry*

Altitude, Apollonius circles, area, concurrency, collinearity, orthogonality, parallelism, perpendicularity, similarity, tangent, bisector, center, centroid, circumcircle, conics, convex hulls, diameter, distance, Euler circles and line, excircles, Gergonne points, incircles, intersection, median, midpoints, Nagel points, orthocenter, polar points, pole lines, projections, radical axes, reflection, rotation, similitude, Simson lines, symmetric points, tangent points.

#### *Grobner Bases*

Univariate polynomials, basis computation, solution of systems, computation of leading monomial, reduced forms, solvability, S-polynomials.

#### *Group Theory*

Centralizer, right coset representatives, generators and relations, membership test, order, intersection, inverse permutations, normality, permutation multiplication, normalizers, permutation representation.

*Linear Algebra*

Matrix addition and multiplication, linear combination of rows or columns, adjoint, angle between vectors, band matrices, find basis, Bezout matrices, characteristic matrices and polynomials, row or column extraction, condition number, cross product, curl, determinant, divergence, dot product, eigenvalues, eigenvectors, matrix exponentiation, Fibonacci matrices, Gaussian elimination, Gauss-Jordan form, coefficient matrices, gradient, Hermite normal form, Hessian matrices, Hilbert matrices, Hermitian transpose, inverse, Smith normal form, Jacobian, kernel, Laplacian, least squares, solution of linear and non-linear systems (including over- and under-determined systems), minimum polynomial, norm, orthogonality, permanent, random matrices, rank, scalar multiplication, singular values, Sylvester matrices, Toeplitz matrices, trace, transpose, Vandermonde matrices.

*Linear Optimization*

Basis vectors, convex hull, dual, conversion to equality form, feasibility, minimize, maximize, pivot, pivot equations, pivot variables, ratios, standardization to ' $\leq$ ' form.

*Number Theory*

Bernoulli numbers and polynomials, partial fraction convergents, cyclotomic of polynomial, divisors, Euler numbers and polynomials, factor set, Fermat numbers, Legendre, lambda function, Mersenne primes, Chinese remaindering, Mbius function, modular roots, primitive roots, totient function, roots of unity, sum of divisors.

*Orthogonal Polynomials*

Gegenbauer polynomials, Hermite polynomials, Laguerre polynomials, Legendre polynomials, Jacobi polynomials, Chebyshev polynomials (1st and 2nd kind).

*Power Series*

Addition, composition, evaluators, inverse, constant multiplication, negation, differentiation, exponentiation, integration, logarithm, solution of differential equations, quotient, reversion, subtraction.

*Statistics*

Average, Chi-square distribution, correlation coefficient, covariance, exponential distribution, F-test, linear regression, median, mode, multiple regression, Normal distribution, projection matrices, standard deviation, standard error, Student T distribution, uniform distribution, variance.

*Student Package*

Change variables, complete the square, combine terms, differential operator, differentiate, distance, inert integration, intercept, integration by parts, integral approximation (with plotting), inert limits, midpoint, slope, inert summation, Simpson's rule, trapezoidal rule.

*User Interface**For ULTRIX Systems*

X Window support for editing and recall of input and output, scroll back, three dimensional plotting with mouse-controlled rotation and separate on-line help windows.

*For VMS Systems*

On-line help system, execution of operating system commands without leaving Maple, editing and recall of previous line.

**Programming Facilities***General*

Functional programming (definition), procedural programming with Maple's Pascal-like language, automatic generation of procedures from expressions, aliases, macros.

*Debugging*

Execution tracing, print level control to select amount of internal detail displayed, separate Mint Syntax and usage checker (similar to lint for the C language).

*Programming Structures*

```
if..then..elif...else...fi,
for...from...by...to,
while...do...od,
for...in...while...do..od,
proc()...end.
```

*Basic Data Types*

Integer (arbitrary precision), rational, floating point (arbitrary precision), hardware floating point, string, Boolean.

*Derived Data Types*

Indexed name, sum, product, series, relation, range, expression sequence, set, list, table, array, procedure, unevaluated function invocation, unevaluated concatenation, unevaluated expression.

*Operator Definition*

Definition of properties and characteristics for group and linear operators, definition of properties by rule list, definition of operators by property list, creation of operator algebras.

**Data Formats***Output Formats and Destinations*

Two-dimensional mathematical notation, one-dimensional FORTRAN-style notation, optimized FORTRAN source code, LATEX, eqn.

*PostScript® Files*

Output to screen or files (redirectional also possible under most operating systems).

*Input Formats and Sources*

One-dimensional FORTRAN-style expression input, interactively or from files (redirectional also possible under most operating systems).

*File Formats*

ASCII text files or Maple internal format (.m) files for more rapid loading.

**Documentation (ULTRIX and VMS)**

*Maple Language Reference Manual*, by Char, Geddes, Gonnet, Leong, Monagan, and Watt.

*First Leaves: A Tutorial Introduction to Maple*, by Char, Geddes, Gonnet, Monagan, and Watt.

**HARDWARE REQUIREMENTS***Processors Supported - VAX VMS-based Systems:*

VAX: VAXft 3000 Model 310  
 VAX 4000 Model 300 Series,  
 VAX 6000 Model 200 Series,  
 VAX 6000 Model 300 Series,  
 VAX 6000 Model 400 Series,  
 VAX 6000 Model 500 Series  
  
 VAX 8200, VAX 8250, VAX 8300, VAX 8350,  
 VAX 8500, VAX 8530, VAX 8550, VAX 8600,  
 VAX 8650, VAX 8700, VAX 8800, VAX 8810,  
 VAX 8820, VAX 8830, VAX 8840  
  
 VAX 9000 Model 210, VAX 9000 Model 410  
  
 VAX-11/730, VAX-11/750, VAX-11/780,  
 VAX-11/785

MicroVAX: MicroVAX II, MicroVAX 2000, MicroVAX  
 3100, MicroVAX 3300, MicroVAX 3400,  
 MicroVAX 3500, MicroVAX 3600, MicroVAX  
 3800, MicroVAX 3900

VAXstation: VAXstation II, VAXstation 2000, VAXstation  
 3100 Series, VAXstation 3200, VAXstation  
 3500, VAXstation 3520, VAXstation 3540

VAXserver: VAXserver 3100, VAXserver 3300,  
 VAXserver 3400, VAXserver 3500,  
 VAXserver 3600, VAXserver 3602,  
 VAXserver 3800, VAXserver 3900,  
 VAXserver 4000 Model 200, VAXserver  
 4000 Model 300, VAXserver 6000-210,  
 VAXserver 6000-220, VAXserver 6000-310,  
 VAXserver 6000-320, VAXserver 6000-410,  
 VAXserver 6000-420, VAXserver 6000-510,  
 VAXserver 6000-520

*Processors Not Supported:*

VAX-11/725, VAX-11/782, MicroVAX I, VAXstation I,  
 VAXstation 8000

*For VAX/RISC ULTRIX-based Processors:*

VAX: VAX 6000 Model 200 Series,  
 VAX 6000 Model 300 Series,  
 VAX 6000 Model 400 Series,  
 VAX 6000 Model 500 Series

VAX 8200, VAX 8250, VAX 8300, VAX 8350,  
 VAX 8500, VAX 8530, VAX 8550, VAX 8600,  
 VAX 8650, VAX 8700, VAX 8800, VAX 8810,  
 VAX 8820, VAX 8830, VAX 8840

VAX-11/750, VAX-11/780, VAX-11/785

MicroVAX: MicroVAX II, MicroVAX 2000, MicroVAX  
 3100, MicroVAX 3300, MicroVAX 3400,  
 MicroVAX 3500, MicroVAX 3600, MicroVAX  
 3800, MicroVAX 3900

VAXstation: VAXstation II, VAXstation II/GPX,  
 VAXstation 2000, VAXstation 3100,  
 VAXstation 3200, VAXstation 3500,  
 VAXstation 3520, VAXstation 3540

VAXserver: VAXserver 100, VAXserver 2000,  
 VAXserver 3100, VAXserver 3300,  
 VAXserver 3400, VAXserver 3500,  
 VAXserver 3600, VAXserver 3602,  
 VAXserver 3800, VAXserver 3900

VAXserver 6000 Model 210, VAXserver 6000  
 Model 220, VAXserver 6000 Model 310,  
 VAXserver 6000 Model 320, VAXserver 6000  
 Model 410, VAXserver 6000 Model 420,  
 VAXserver 6000 Model 510, VAXserver 6000  
 Model 520

DECstation: DECstation 2100, DECstation 3100, DECstation 3100s, DECstation 5000 Model 120/125, DECstation 5000 Model 120/125CX, DECstation 5000 Model 120/125PX, DECstation 5000 Model 120/125PXG, DECstation 5000 Model 120/125PXG TURBO, DECstation 5000 Model 200, DECstation 5000 Model 200CX, DECstation 5000 Model 200PX, DECstation 5000 Model 200 PXG, DECstation 5000 Model 200 PXG TURBO

DECsystem: DECsystem 3100, DECsystem 5000 Model 100 & Model 200, DECsystem 5100, DECsystem 5400, DECsystem 5500, DECsystem 5810, DECsystem 5820, DECsystem 5830, DECsystem 5840

*Processors Not Supported*

MicroVAX I, VAXstation I, VAX-11/725, VAX-11/782

**OPTIONAL HARDWARE**

PostScript printer

**SOFTWARE REQUIREMENTS**

*For VAX VMS-Based Systems:*

VMS Operating System V5.0 - V5.4

*For VAX/RISC ULTRIX-Based Systems:*

ULTRIX Operating System V4.0 - V4.1

**DISTRIBUTION MEDIA**

TK50 Streaming Tape

**ORDERING INFORMATION**

Software License, Media and Documentation:  
QB-GN8A9-VA

**SOFTWARE LICENSING**

This software is furnished under the licensing provisions of Digital Equipment Corporation's Standard Terms and Conditions. For more information about Digital's licensing terms and policies, contact your local Digital office.

**SOFTWARE PRODUCT SERVICES**

Software Product Services are supplied by Waterloo Maple Software for one year, commencing with the shipment of the software.

Waterloo Maple Software provides complete support services. The license fee includes one year of maintenance, support and the following:

- Bug fixes
- Updates and new versions of the software released within the one year

- Three-day turnaround on technical questions by phone, FAX or electronic mail

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None

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