Do More With Maple™ 2016!

Maple™ 2016 lets you solve more problems, more easily, than ever before!

Whether you are an educator looking for new ways to help your students learn, a researcher exploring the boundaries of mathematics and science, or an engineer solving challenging design problems, Maple 2016 will make your job easier. Here are just some of the many new things you can do with Maple 2016:

Organize your projects and applications using the new Maple Workbook, so all related Maple documents, code files, and data are together in a single file, and dependencies are automatically maintained when you share your work with others.

Use Clickable Math™ to perform new operations at the click of a button, from writing fractions as repeating decimals, to computing cross products and dot products, or even converting Maple code to Julia.

Take advantage of flexible and intuitive data frames to organize and analyze labeled data.

Search through over 900 solutions to Einstein's field equations for spacetime metrics with particular properties, and use these metrics in your general relativity computations.

Leverage new high performance computing tools that analyze your code to detect barriers to safe parallelization and help you resolve them.

Solve even more mathematical problems, such as finding analytic solutions to new classes of partial differential equations with boundary conditions, constructing the transitive closure of graphs, finding the series and asymptotic expansions of hypergeometric functions, and much more.

Create even more complex interactive applications using the one-step app creation facility, Explore, then share them online through the MapleCloud™.

Perform calculations with thermophysical properties of pure fluids, humid air and mixtures, generate customized psychrometric charts, and more.

Use new statistical analysis and visualization tools to gain insight into your data, including principal component analysis, heat maps, and more.

Help your students explore concepts such as the Sieve of Eratosthenes, tessellations, and the area of a circle, using new interactive Math Apps.

Workbook

The new Maple Workbook makes it easy to organize and share your projects and Maple applications, simply and reliably.

- All related Maple documents, data, source code, variables, and other attachments are kept together in a single project file, so individual components cannot get lost or out of sync with the rest of the application.
- References to files in the Workbook do not rely on external file locations, so you can be confident the application will run properly when it is moved or shared, even between operating systems.
- Project files can be easily organized in folders and subfolders in your Workbook, all managed from within the new Workbook palette.
- You can save variables inside the Workbook and access them from other Workbook documents without redefining them, even after a restart.

One-Step App Creation with Explore

The Explore facility offers an easy-to-use tool for creating interactive applications. Maple 2016 offers significant updates and additions to the Explore command.

- Create applications more quickly and easily with a simplified calling sequence and parameter handling.
- Customize the appearance, position, and behavior of sliders, dials, and more.
- Record animations created using the Explore facility, and then use them outside the exploration.
- Customize more of the colors used in your application, including components, fonts, and fill colors.
- Set the size and alignment of the application inside your document.
- Control the appearance of the borders of your application and its individual components.
- Allow the user to set fixed values in the explored expression using text input areas.

Interactive Components

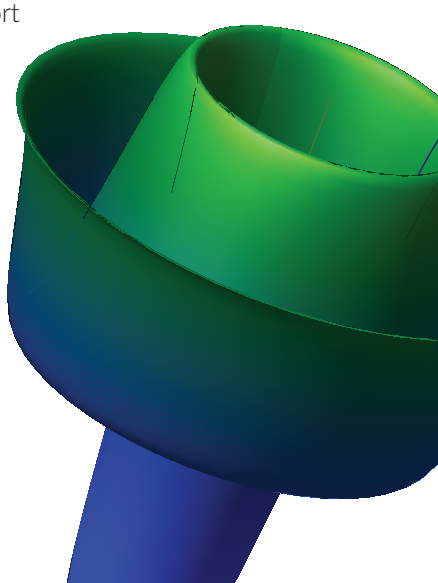
Maple 2016 gives you even more control over the appearance of your custom-built applications and broadens the scope of the applications you can create.

- Create and modify document tables programmatically, constructing and modifying both their appearance and their content dynamically.
- Query a plot component to determine where the mouse pointer is hovering over the plot, so your application can take actions based on the pointer's location.
- Control the font color for buttons, check boxes, combo boxes, labels, list boxes, radio buttons, sliders, and text areas.
- Customize the background color of components.

Visualization

Maple 2016 includes completely new visualizations as well as new customization options for both 2-D and 3-D plots.

- Color schemes can now be applied to the vast majority of visualizations in Maple.
- New color schemes support gradients in the x, y and z directions, allow you to color 3-D surfaces using functions of the x, y, and z values of your plot, and partition the data and assign colors based on associated values or ranges of values.

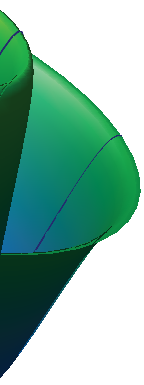


- New visualizations for statistics include heat maps, biplots, scree plots, and grids of plots that can be used to look for patterns in higher dimensional data sets.
- New tools are available for generating psychrometric charts for humid air and pressure-enthalpy-temperature charts for a range of fluids.

User Interface

Maple 2016 provides numerous improvements that make it even easier to perform common tasks.

- Easy toggling between executable and non-executable math
- Improved visual distinctions between multiplication and function application involving side-by-side parentheses
- New shortcut that lets you write a denominator first, and Maple will flip the fraction for you automatically
- Improved command completion that decreases typing and offers alternatives to deprecated commands
- New help page layout that lets you find the information you need faster
- Easy insertion of rows or columns into a matrix using the context-sensitive menu
- Finer control over document zooming
- Table-level control of the behavior of hidden table borders
- Full screen mode for Mac®
- Option for non-collapsible document sections without section delimiters
- Redesigned interface icons that offer improved scaling on high resolution monitors



Data Series and Data Frames

Flexible and intuitive data containers help you organize and analyze labeled heterogeneous data, making them highly suitable for analyzing real-world data, or any application where you need to deal with related information that spans different data types.

- Provides new, integrated fundamental data structures in Maple for any kind of statistical or observational data
- Supports the organization of heterogeneous data that spans multiple data types, such as strings, integers, and floats
- Handles both ordered and unordered data, including time series or sequential data
- Includes column and row labels that make it easier to index and select subsets of data as well as provide useful meta-information for data visualizations
- Offers numerous ways to view, analyze, manipulate, and visualize data series and data frames, through commands and at the click of a button through the context-sensitive menus
- Provides tools for dealing with duplicate entries, missing values, adding columns, and more

Partial Differential Equations

Maple 2016 incorporates new methods for finding analytic solutions to partial differential equations with boundary conditions. As a result, Maple can find solutions to more PDE problems, including linear PDEs on bounded domains with homogeneous boundary conditions, and first order PDEs with single boundary conditions that do not depend on the independent variables. In addition, new general-purpose commands and options for researching and solving PDEs have been added.

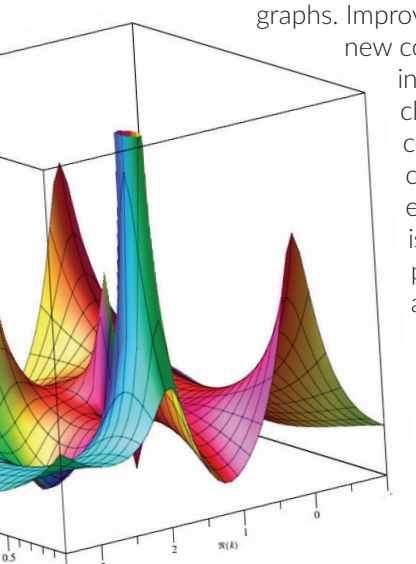
Mathematical Functions

The Mathematical Functions package and the related Function Advisor tool have been updated to provide more knowledge about the properties of special functions, more computational options, and easier access to information.

- The Mathematical Functions package and the Function Advisor now embed even more mathematical information, with new identities, differentiation rules and abilities, and sum representations.
- The Function Advisor can now return a sampling of 2-D and 3-D plots at different parameter values, to give you a sense of how the function behaves.
- The Function Advisor now returns both the first derivative and the nth derivative, as symbolic expressions, when asked for the differentiation rule of a given mathematical function.
- It is now possible to define, manipulate, and perform calculations on symbolic sequences, such as $a_m...a_n$, and display the results using textbook standard typesetting.
- The results of the general display option of the Function Advisor have been expanded, reorganized, and reformatted to make it easier to find the information you need.

Graph Theory

Maple includes a large selection of tools for creating, drawing, manipulating, and working with graphs. Improvements in Maple 2016 include new commands for constructing interval graphs and transitive closure graphs; computing clique covers, global and local clustering coefficients, and independent edge sets; and testing if a graph is an arborescence. It also provides improvements to the appearance of vertices.



Iterators

The Iterator package provides fast methods for iterating over discrete structures.

- Iterates over all the instances of a given structure, or produces the full list
- Generates combinations, partitions, permutations, products, binary trees, nested parentheses, Gray code, and more
- Takes advantage of compiled code and efficient memory management for fast execution
- Provides many examples, including computing the number of ranks of a poker hand, finding all integer divisors of a large integer, Dudney's century puzzle, and counting contingency tables

Logic

The Logic package is a collection of commands for inspecting, manipulating and transforming formulas in propositional logic. Maple 2016 introduces new efficient heuristics for determining Boolean satisfiability and testing the equivalence of Boolean expressions. In addition, truth tables take advantage of the new data frame structure, displaying column and row headers that make the results easier to interpret.

Number Theory

The completely rewritten Number Theory package provides comprehensive coverage of topics from number theory, including working with primes, lattices, integral bases, modular operations, cyclotomic polynomials, and much more. The new package is easier to learn and use, and many of its operations are now available from the context-sensitive menus.

Advanced Mathematics

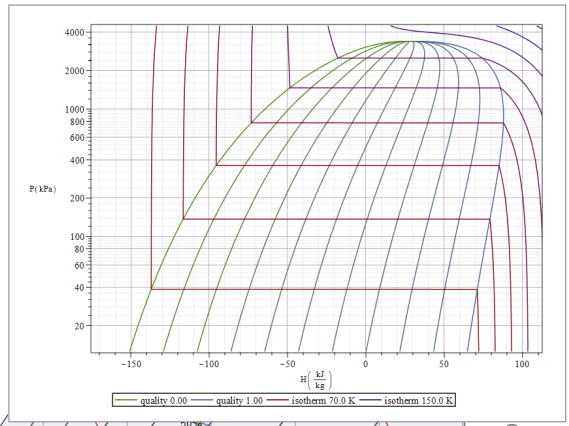
Maple 2016 offers numerous advancements in a variety of branches of mathematics, allowing you to solve even more mathematical problems.

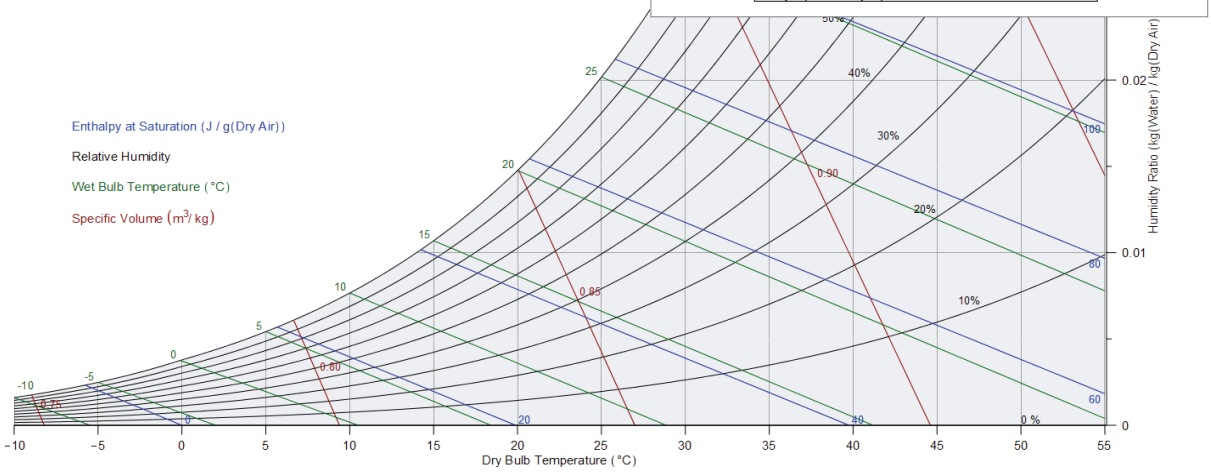
- Many improvements were made to series and limit computations, including new series and asymptotic expansions of hypergeometric functions and harmonic numbers, and enhanced handling of logarithmic branch cuts and oscillating functions.
- Definite integration of rational functions has been improved, providing simpler forms of results and solutions to problems that could not be solved in earlier versions.
- Improvements to symbolic summation include support for piecewise expressions with more than two branches, better support for doubly infinite sums, improved divergence testing for infinite sums, and more.
- Products over RootOfs are handled in more cases.
- A faster, multithreaded algorithm is used for computing Gröbner bases.
- The conjugate command now has extended support for RootOf expressions.
- The eval command now supports an additive change of variable for indefinite integrals, sums, products, and differentiations.

Thermophysical Data

With Maple 2016, you can perform calculations with thermophysical properties of pure fluids, humid air and mixtures, generate customized psychrometric charts, and more.

- Provides data, computation, and visualization tools for working with thermophysical properties of fluids, humid air, solutions, and binary mixtures
- Leverages the popular CoolProp open source library of thermophysical data
- Determines both state-dependent and state-independent properties
- Handles units and unit conversions automatically
- Seamlessly combines with Maple's numerical solvers, optimizers, and differential equation solving routines
- Produces psychrometric charts and pressure-enthalpy diagrams

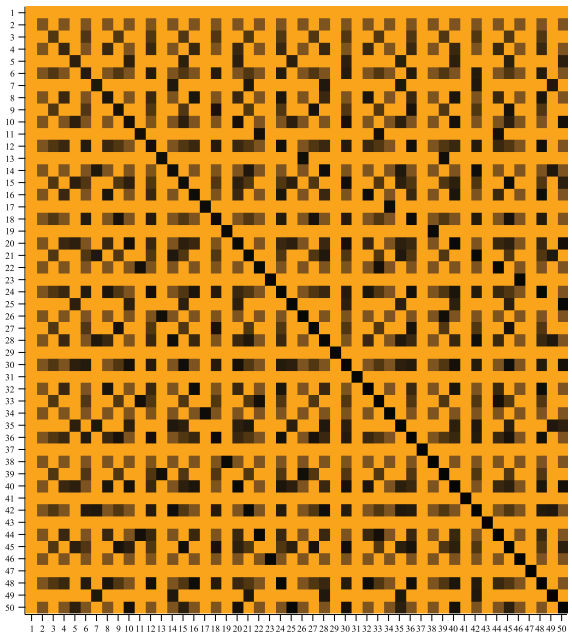




Physics

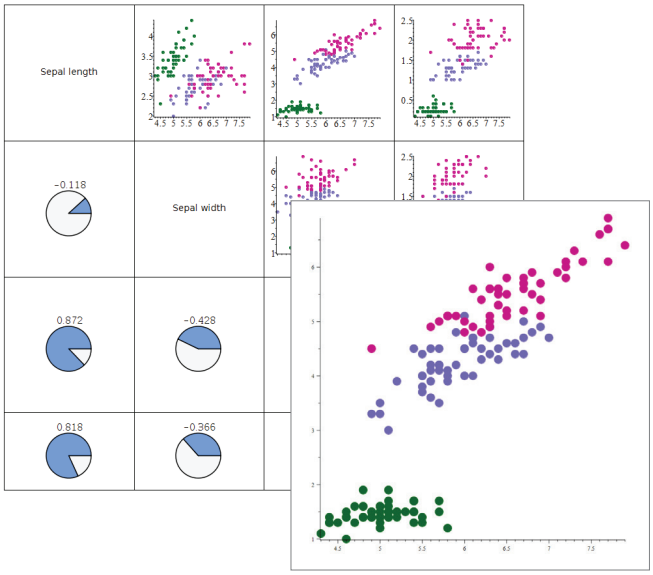
Maple provides a state-of-the-art environment for algebraic computations in physics, with emphasis on ensuring that the computational experience is as natural as possible. Maple 2016 includes significant enhancements in general relativity, as well as over 300 enhancements throughout the entire Physics package.

- A database of all 971 solutions from the classic text *Exact Solutions of Einstein's Field Equations*, which you can search to find spacetime metrics with particular properties, and then use these solution metrics, together with automatically derived related information, in your general relativity computations
- Improvements in tensor routines for special and general relativity, abstract vectors, and tools for programmatic interactions
- Support for computing with differential operators algebraically
- Implementation of tetrads for general relativity
- Factorization of expressions involving non-commutative operators
- New options for setting assumptions used in computations



Principal Component Analysis

Maple 2016 provides new computation and visualization tools for principal component analysis, which aims to identify patterns in data by reducing the dimensionality of multivariate data to a few key explanatory variables. Using Maple, you can determine which variables explain the majority of the variability in your data, and visualize the variance contributed by each of these principle components.



Statistics

Maple 2016 includes important new tools for data analysis and visualization.

- All linear regression commands can now provide a full summary for each of the regression coefficients, as well as the r-squared and adjusted r-squared values for the model.
- The hypothesis testing commands provide reports that are attractively and effectively presented using document tables.
- Multiple styles of summary statistics can be computed for the new data frame structure, and the results presented in document tables.

- New heat maps let you visualize the magnitude of your data as a discrete density plot.
- New tools for visualizing multidimensional datasets present a series of plots that correspond to the columns of your dataset.
- Additional new statistical visualizations include biplots, scree plots, and the ability to assign different colors to points based on other values associated with the data.

Parallelism

Maple is the only technical computing system that allows you to take advantage of multithreading in your own programs. Maple 2016 provides additional tools to help you develop thread-safe programs for performing large computations more quickly, including a new thread safety check to help identify global state in a procedure or module, and a lock option that enforces that at most one procedure with a lock option can run at any given time.

Program Analysis

Maple 2016 provides new tools for analyzing programs to determine if they are suitable for parallelization and to help formally verify that a program meets its specification.

- New commands for analyzing the data dependencies in for-loops will determine when they can be parallelized, and transformations can be applied to resolve these dependency issues and enable the loop's parallelization.
- The invariants of a while-loop can be computed and, when combined with the pre-condition and guard condition of the loop, used to verify whether or not the post-condition will be satisfied.

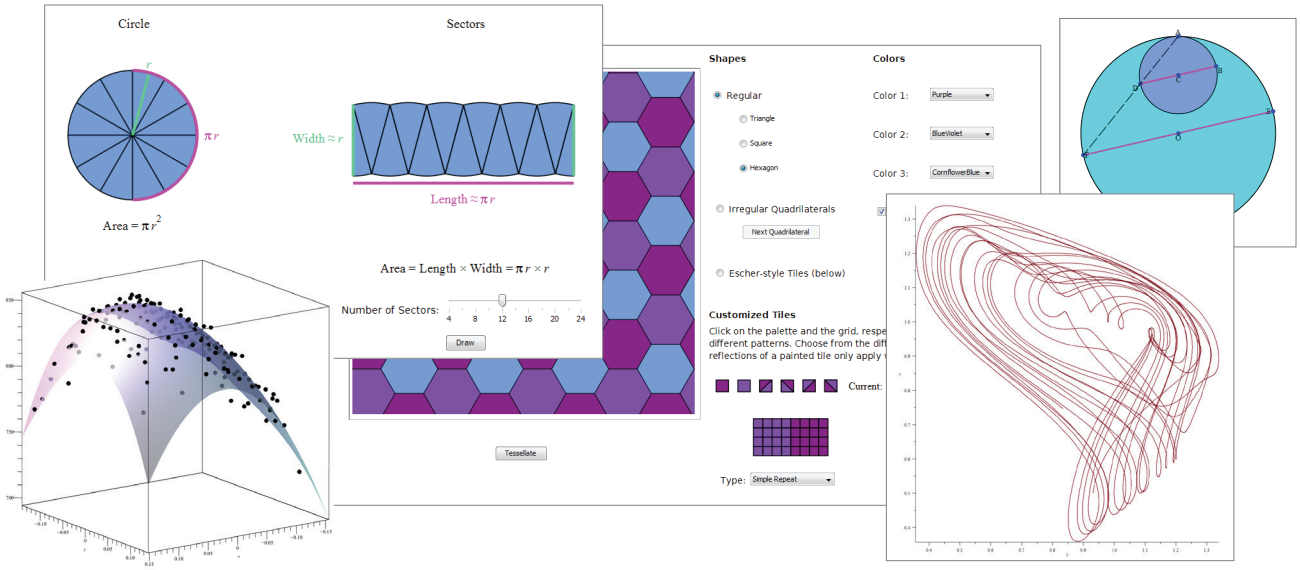
Code Generation

Maple's code generation tools provide the ability to translate Maple procedures and expressions into many other programming languages, including C, Fortran, MATAB®, Visual Basic®, Java™, and more. With Maple 2016, Maple can now also generate code for the Julia programming language.

Language and Programming

In addition to the improvements related to programmatic content creation, program analysis, data frames, and parallelization, there were many other improvements made to the Maple language.

- A new multiset data structure makes it easier to work with collections of unordered data with repeated members.
- The indets function has a new option that finds only the top level subexpressions.
- Operations involving univariate polynomials are substantially faster due to improvements made to the fundamental modular arithmetic operations.
- You can now see the partition size and message information when executing parallel Map and Seq commands in grid computing.
- You can now overload elementwise operations when using objects.
- The forget command can now selectively clear references from all procedure caches and remember tables at once.
- The Essay Tools package, which has an assortment of commands for analyzing essays and words, now makes it easier to get access to the built-in words list.



Multivariate Calculus for Students

Maple can solve many problems in multivariate calculus using both a Clickable Math approach and using commands. The Student package for Multivariate Calculus has been expanded to include enhanced support for the Lines and Planes section of the typical multivariate calculus course. Additions include the ability to calculate norms, normalize vectors, and find cross products, dot products, and triple scalar products.

Math Apps, Applications, and Examples

Maple 2016 provides dozens of additional pre-built Math Apps, applications, and examples you can use right away, or take them as a starting point for custom development.

- New interactive Math Apps help your students explore concepts such as the Sieve of Eratosthenes, tessellations, and the area of a circle.
- Applications and examples cover a wide variety of topics, including working with thermodynamic properties, building interactive applications, number theory, delay differential equations, principal component analysis, and more.
- "How do I..." tutorials provide step-by-step instructions for common tasks, including plotting multiple functions on the same axes, solving ordinary differential equations, and working with random generators.

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