



WHAT'S NEW

Maple 2018

Okay, we get it.

You love Maple™, but some years you find yourself wondering if it's worth the bother of upgrading.

People use Maple to do many different things, so it's inevitable that each new release will include some features you care about and some features you really don't need.

But no matter what you use Maple for, this is not a release to skip.

Maple 2018 contains a large number of substantial enhancements to **how** you interact with Maple, which means you'll benefit from this release no matter what you use Maple for.

(These are, of course, in addition to the usual extensive collection of improvements, in mathematics, visualization, specialized application areas, education, and more, some subset of which will be useful, too!)





A Few Highlights

▶ Do More with Less Effort

The new Context Panel brings together and enhances some of Maple's most powerful Clickable Math™ tools, so you can perform even more tasks, even more simply.

▶ Code Smarter, Not Harder

Whether you are writing two lines or two thousand, significant enhancements to Maple's code editor makes writing and debugging Maple code much easier.

▶ Let Maple Keep Track of Your Units

Deeper integration of units into the mathematics engine and improved conversion tools significantly simplify units-based calculations.

▶ Streamline Your Application Development

From defining the behavior of your buttons and sliders to changing the appearance of tables, the Context Panel also supports a streamlined workflow that makes creating your own applications a smoother experience.

▶ Protect Your Content from Changes

Share your work with confidence, knowing that your users will not be able to accidentally change your content (and then complain to you when it doesn't work!)

▶ Encrypt Your Work

Encrypt procedures to hide their definitions from prying eyes while still making them available for use.

▶ Give Your Students More Practice

Give your students endless practice sheets that Maple will grade automatically, so your students get more practice without giving you more work.

▶ Make Sense of Unstructured Data

Use Maple to interpolate and visualize data from even completely unstructured data sources.

▶ Solve More PDEs

Find solutions to new classes of partial differential equations with boundary conditions.

▶ Play with Points and Polygons

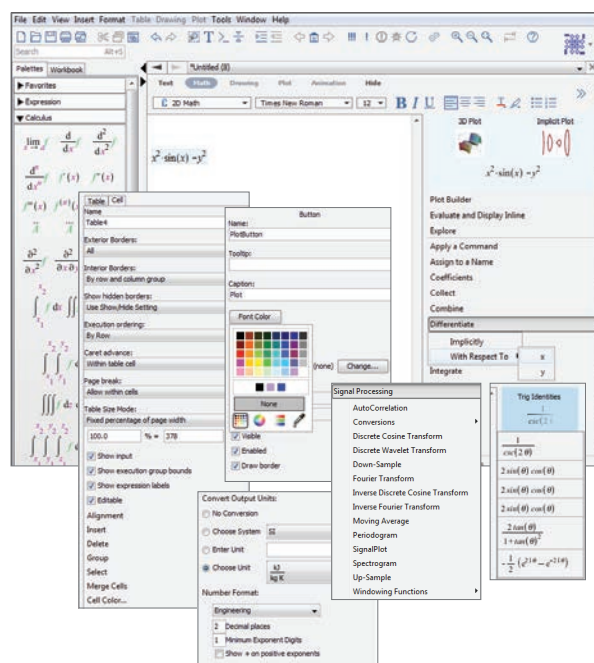
Apply computational methods to polygons and clouds of points with the new Computational Geometry package.

Intelligent Context Panel

The intelligent Context Panel brings together and enhances some of Maple's most powerful Clickable Math tools. The Context Panel offers point-and-click access to a wide variety of mathematical operations as well as other Maple tools, and provides a highly discoverable way of exploring Maple's functionality.

When you click on a mathematical expression, Maple analyzes your expression and then presents you with a list of the most relevant operations and tools. Options could include solving for x , plotting your expression, finding a determinant, converting from one unit to another, applying a Fourier transform, integrating with respect to t , changing the numeric formatting in your result, calculating the average of your data, and much more, all depending on what makes sense. Simply selecting one of these options performs the operation. In addition, you can also use the context panel to customize the appearance of plots, change the properties of tables, and more. No knowledge of Maple syntax or Maple commands is required.

- The Context Panel combines and enhances Maple's context-sensitive menus and Smart Popups, and places them together in a side panel so the available options are always visible and easily accessible.
- The Plot Builder, which underwent a major redesign in Maple 2017, has been integrated into the Context Panel. As part of the Context Panel, the Plot Builder gives you the ability to create and customize your plots easily, and see the changes reflected in your document immediately. In addition to that integration, the enhanced Plot Builder in Maple 2018 can now be used to visualize inequalities.
- The Context Panel streamlines your workflow when developing Maple applications. It provides a consistent, more efficient interface for performing common application creation tasks, such as changing the visibility of table borders, customizing plots, and defining the behavior and appearance of interactive components such as buttons and



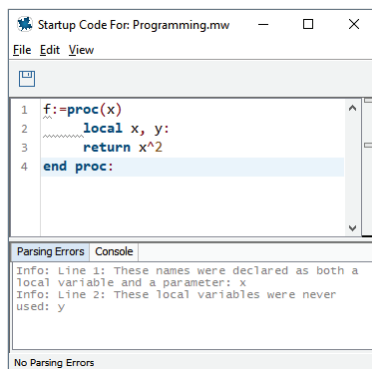
sliders. In addition, instead of navigating through multiple menus and dialog boxes every time, you can modify multiple properties at once and see the results immediately, so you can make your changes more efficiently.

- The numeric formatting tool, which allows you to control how your numbers appear by choosing from variety of customizable display options including scientific, engineering, and fixed decimal notation, is easier to find and use.
- Significant improvements to the units formatting and conversion tool include offering better conversion suggestions, improved display, cleaner layout, and more. In addition, you can now control both numeric and units formatting at the same time.
- Improvements to the collection of mathematical context-sensitive operations include new options for finding the distance between two points and for counting the number of elements of a set, and making the Dynamic Systems operations available even when the package is not loaded.

Code Editor

Many substantial improvements to code editing tools in Maple 2018 make it easier to write, debug, and maintain your code.

- The code analysis tool, *mint*, is now incorporated into Maple's code editing tools, where it automatically provides information about programming issues that go well beyond syntax errors. This tool provides information that assists with both debugging and code maintenance, such as parameter naming conflicts, unreachable code, unused parameters or variables, and more.



- Command completion is displayed automatically as you type, making it faster to enter function names and eliminating problems due to misspelled names.

These changes are available in both the code editor, which is used for start-up code and defining the behavior of interactive components such as buttons and sliders, and in code edit regions, which are used to incorporate blocks of code inside your document.

The code editor also includes additional enhancements that improve your workflow:

- A new console window lets you test the code from directly inside the code editor.
- Errors are marked inline, and the code editor displays a notification strip in the scroll bar for easier navigation to the problems.
- Automatic text wrapping improves readability of your code.

Additional improvements to the code edit regions include:

- The code edit region automatically fits the width of the window and resizes itself as needed.
- Keyboard navigation is now available into and out of a code edit region, so you no longer have to use the mouse.

Units

Most computations in science and engineering, as well as many other applications, are done using quantities that have units associated with them. Maple has many tools to help you keep track of your units and avoid the problems that come from getting them wrong. Maple 2018 provides substantial improvements to unit support in Maple, with even deeper integration of units with the Maple computation engine, as well as improved interface tools for attaching and converting units to your quantities.

- More top level computation functions can now accept expressions involving units as arguments, and return results that include in the appropriate unit information:
 - Solve equations numerically or symbolically (*fsolve*, *solve*)
 - Solve optimization problems using a variety of solvers (Optimization package)
 - Solve integrals numerically or symbolically (*int*)
- When working with units, the solve command returns solutions faster, gives more meaningful error messages, and gives you finer control over the units in the result by allowing you to explicitly specify the units of symbolic parameters.
- The units formatting dialog has been redesigned and moved to the context panel, so it can be accessed more easily, and fewer mouse clicks are required for each unit change.
- Unit and numeric formatting can now be done much more efficiently through the context panel rather than by navigating through two different dialogs.

- The list of suggested unit conversions offers better choices.
- Suggested unit conversions are now presented using standard math notation so they are more recognizable.

Protecting Your Content from Changes

Maple 2018 includes the ability to protect your content from accidental changes. In addition to aiding your content creation process, this ability allows you to share your work without having to deal with users who accidentally break your application (and then complain).

- You can control whether or not entire documents, or the content of individual tables, can be modified.
- Non-editable content is viewed in “Player mode”, where interactive components, such as buttons and sliders, continue to work. As a result, students and colleagues can use your interactive application, with no risk that they will accidentally modify its content, appearance, or behavior.
- For situations where the output can vary every time the commands are executed, you can set your document to non-editable in order to freeze your results at a particular instance. This way, you can be sure your readers will always see the specific example you discuss in the surrounding text.
- If you have spent time laying out information carefully in a table, you can lock down that table while you work on the rest of your document to keep it safe from accidental changes.

Encrypted Procedures

Maple offers several different approaches that enable you to share your work without allowing full access to your work. New in Maple 2018 is the ability to encrypt your procedures, which provides a way to share executable procedures with others while protecting your IP.

- An encrypted procedure acts and behaves like any normal procedure in Maple, but its definition cannot be viewed.

- Encrypted procedures are shared through library archive files (.mla) so the user never has access to the original source.
- Viewing the encrypted procedure, for example using *eval* or *print*, results in only the display of the encrypted definition.
- The debugger cannot be used to step through encrypted procedures.

Differential Equations

Maple 2018 continues to push the frontiers of differential equation solving, with new methods that enable Maple to find closed-form solutions to new classes of problems. Maple can now handle four new classes of nonlinear ordinary differential equations of second order that do not admit point symmetries. In addition, Maple 2018 adds a third state-of-the-art method, Thomas, for performing differential elimination, which is a key process in decoupling systems of differential equations.

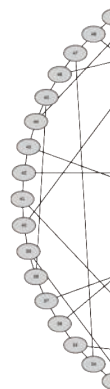
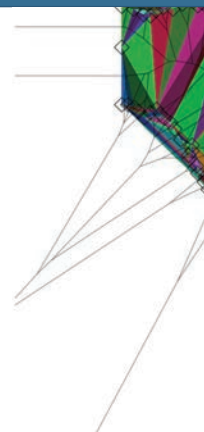
Partial Differential Equations

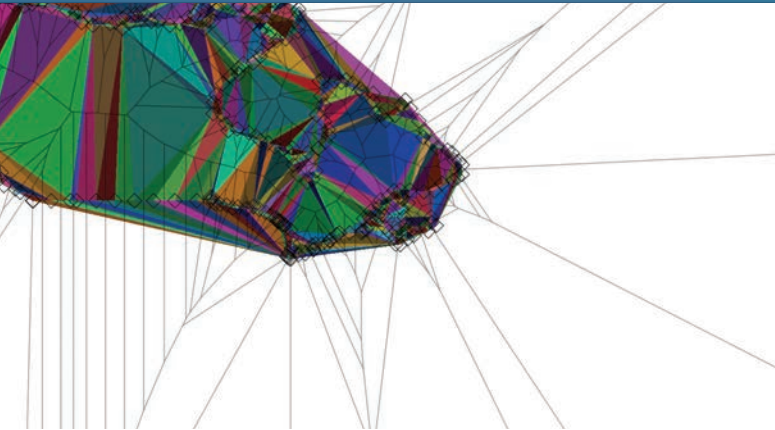
Maple 2018 further expands Maple's ability to find exact solutions to partial differential equations. Maple can now solve PDEs in three independent variables with bounded spatial domains. In addition, new techniques enable Maple to solve even more PDEs with boundary condition problems in two independent variables.

Computational Geometry

Maple 2018 contains a new Computational Geometry package, which applies computational methods to polygons and clouds of points. Computational geometry problems occur in many applications involving points in two- or higher-dimensional spaces, such as feature recognition, predicting vapor-liquid phase diagrams, delineating closely related regions for scattered data, and more.

- Computes convex hulls, Delaunay and polygon triangulations, and Voronoi diagrams.

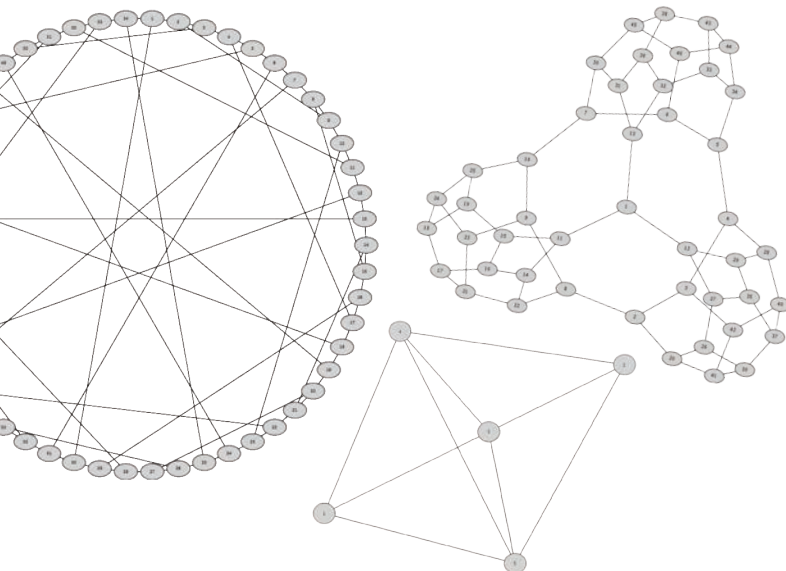




- Works seamlessly with Maple's visualization tools, such as displaying polygons.
- Based on Qhull, the widely respected computational geometry package, and is fully integrated into Maple.

Graph Theory

The Graph Theory package is a collection of routines for creating, drawing, and manipulating graphs, and for testing graphs for particular properties. New abilities in Maple 2018 include computing distance, clique, and independence polynomials, finding cliques, determining the intersection of two or more graphs, determining if there is a path between two vertices, and finding the full list of vertices reachable from a given vertex. In addition, seven new special graphs or families of special graphs are now supported: Doyle, gear, Gray, Nauru, Poussin, Turan, and Tutte.



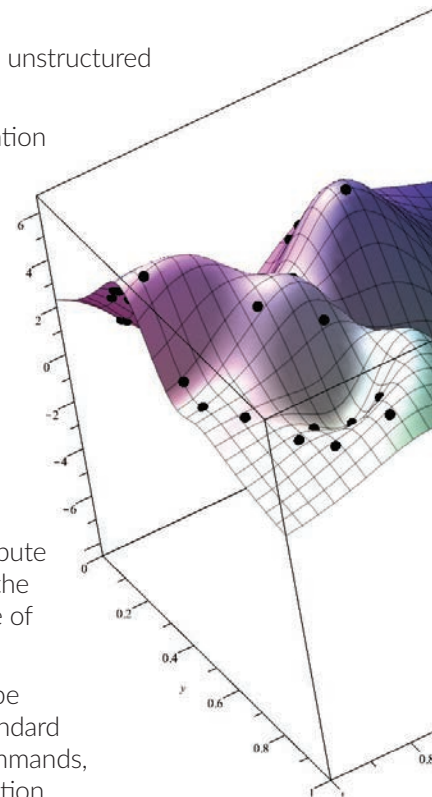
Group Theory

The Group Theory package includes an extensive collection of routines for constructing, computing with, and visualizing finitely generated groups, including permutation groups, finitely presented groups, Cayley table groups, "black-box" user defined groups, and abstract groups depending on symbolic parameters. In Maple 2018, this package has been further augmented with new tests to determine if a subgroup of a finite group is subnormal or permutable, or if a finite group is a p -group, for prime p . New computation commands calculate powers of elements, class numbers, and the number of Abelian groups of a given order.

Interpolation

Maple 2018 expands Maple's interpolation abilities with new functionality capable of interpolating data from points in arbitrary, unstructured locations. This functionality is built into a new Interpolation package, which:

- Supports both structured and unstructured data, in any dimension.
- Provides a variety of interpolation methods, including Kriging, inverse distance weighted, natural neighbor, linear, linear triangular, cubic, nearest neighbor, radial basis function, spline, and more.
- Returns an object that itself can return function values as if it were an ordinary mathematical function
- With the Kriging method, the returned object can also compute the variance associated with the function value to give a sense of the confidence in that value.
- The interpolating object can be passed as an argument to standard computation and plotting commands, just like any other Maple function.



Advanced Mathematics

In addition to the many mathematical advances detailed elsewhere, Maple 2018 also includes improvements across many other areas of the mathematics engine.

- More integration problems can be solved because of enhancements made to several different solving methods.
- The *simplify* command is more powerful, with improvements to dealing with logarithms, exponentials, trigonometric expressions, and more.
- When working with assumptions, the *is* and *coulditbe* commands both offer improved handling of inequalities, and *is* also performs more simplifications and takes into account more function properties.
- The *sum* command has been improved for the case of hypergeometric sums with more than one parameter.
- Generalized polylogarithms, multiple polylogarithms, and multiple zeta functions were added as high level functions.
- Two new commands for performing and testing weighted homogenization were added to the Polynomial Tools package.
- The *signum* command, the sign function for real and complex expressions, can now handle more problems.
- The *Re* and *Im* commands handle more problems than before.
- The *max* and *min* commands can now recognize some numbers as real even though they are composed from nonreal ingredients.
- The commands *sturm* and *sturmseq* have been extended to support polynomials with real algebraic number coefficients.
- The *arctan* command now performs more automatic simplifications, and the *combine* command performs more simplifications on *arctan* functions.

Practice Sheets for Students

Student packages in Maple offer focused learning environments in which students can explore and reinforce fundamental concepts in the same way their instructor does in class. Student packages are available for a variety of core subjects, including calculus, precalculus, linear algebra, statistics, vector calculus, multivariate calculus, numerical analysis, and more. In Maple 2018, the Student Basics package had been expanded to give instructors a way to provide drill-and-practice exercises for students that Maple will grade automatically, giving the students immediate feedback.

Integration - Power Rule
Integrate each expression using the power rule.

Do not include a constant of integration in your solution.

$\int x^{14} dx = \frac{x^{15}}{15}$	$\int x^3 dx = \frac{x^4}{4}$
$\int x^{12} dx = \frac{x^{13}}{13}$	$\int x^8 dx = \frac{x^9}{9}$
$\int x^{11} dx = \frac{x^{12}}{12}$	$\int x^{15} dx =$
$\int x^{17} dx =$	$\int x^4 dx =$
$\int x^5 dx =$	$\int x^{20} dx =$

The new *PracticeSheet* command generates a grid of practice problems for drilling math skills. You can create practice sheets that test arithmetic basics, algebra skills, calculus problems, factorization, and more. Each problem is generated using randomized parameters. Students complete the problems, and then simply click on a button to find out how they did. If a student wants more practice, another click brings up a new sheet of problems to try.

Dates and Times

With a new Calendar package, Maple 2018 makes it easier to work with dates and times, such as analyzing time-dependent data, or calculating the flight duration to your next conference.

- New fundamental Maple objects represent dates, times, and clocks.
- Arithmetic with dates and times is built in, so you can, for example, compute the duration between two dates by subtracting them.
- Time zones and daylight savings time are supported.
- Built-in operations include computing the day of week of a given date, determining if a given date falls on a weekend, calculating the Julian day number, and more.
- The Finance package has been extended so that it can work with date objects seamlessly.

Thermophysical Data and Scientific Constants

With Maple 2018, you can perform calculations involving the thermodynamic properties of over 2000 chemical species.

- Properties are available for over 2000 gases, liquids, and crystalline species.
- The data can be used to study chemical equilibrium composition, reaction constants and spontaneity, rocket performance, flame temperatures, explosion and detonation pressures, and many other applications.

The Thermophysical Data package also includes new fluids and updated routines for calculating fluid properties.

In addition, the values of the physical constants in the Scientific Constants package have been updated to reflect the *CODATA Recommended Values of the Fundamental Physical Constants (2014)*.

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 2018 includes many significant enhancements, including automatic handling of collisions of indices in tensorial expressions, automatically setting the algebras for the Dirac, Pauli and Gell-Mann matrices when the Physics package is loaded, improved handling of differential tensorial operators, new ways to minimize the number of tensor components taking symmetries into account, automatically setting the energy momentum tensor when loading solutions to Einstein's equations from the database, improved simplification of Dirac matrices, and more.

Performance

Each Maple release includes speed and efficiency improvements that make Maple run faster. Performance improvements in Maple 2018 include both broad-based and targeted enhancements. The following operations are all faster in Maple 2018:

- Fundamental operations involving Gröbner bases. Gröbner bases lie at the heart of many higher level computations in Maple, such as solving systems of equations and integration, so performance improvements in Gröbner bases result in faster calculations in many areas of Maple. Maple 2018 includes new optimizations that increase parallel speedup when computing large total degree Gröbner bases. In tests, the new implementation runs 33 percent faster and parallel speedup increases from 1.94x to 2.84x. Maple 2018 also includes a new implementation of the FGLM algorithm for converting total degree Gröbner bases to lexicographical order, with improved performance and lower memory requirements.
- Replacing variables in polynomials with products using subs.
- Type checking tests for detecting polynomials and rational functions, a step found in many math engine algorithms.

WHAT'S NEW

- New algorithms for solving sparse linear equations mod p .
- Satisfiability tests in the Logic package.
- Finding the inverse of a matrix whose entries involve trigonometric functions.
- The *timelimit* command, which is useful for putting a time bound on a computation, now has virtually no overhead.

Visualization

Maple provides an extensive suite of visualization tools for plots and animations, with over 200 plot types and options. Plots can be created and modified interactively and through commands. Maple 2018 includes a variety of improvements to visualization in Maple.

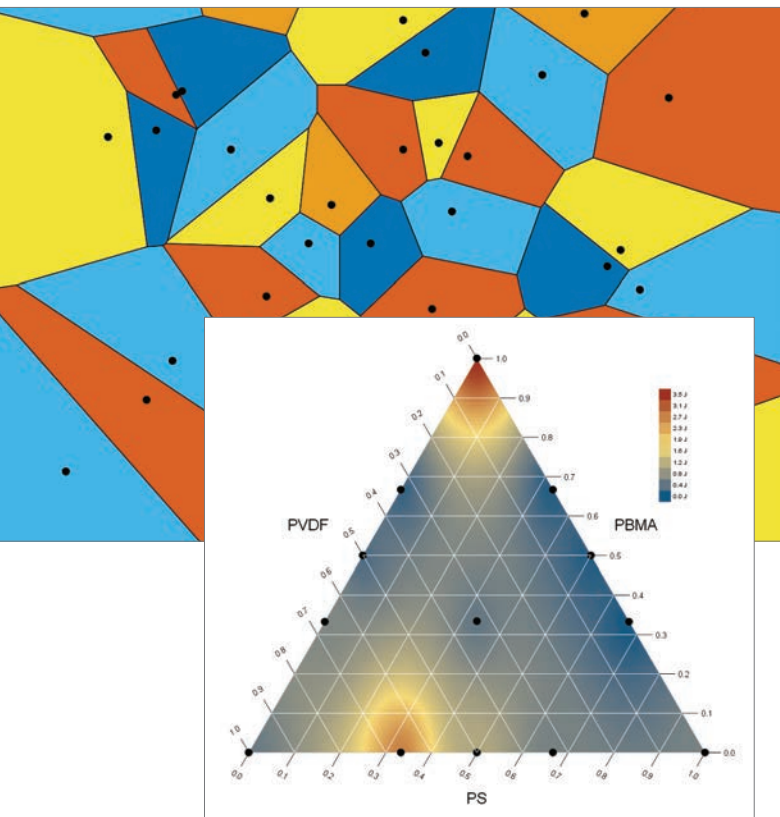
- The Plot Builder, a point-and-click tool for creating and customizing a variety of 2-D and 3-D plots, has been further expanded so that it now also handles inequalities.

- More control over the appearance of arrows is available with a new borderless option that draws an arrow of the desired color without a black border.
- The new Computational Geometry package can be used to generate geometric visualizations, including Voronoi diagrams.
- A new plotting option lets you control the rotation of the tickmark labels on your axes. Plots from the Time Series Analysis package now take advantage of this new option by default to accommodate the typically longer tickmark labels in those plots.
- The *textplot* command has a new rotation option.
- The new *ParetoChart* command in the Statistics package generates a plot of a tagged histogram of decreasing values and a curve indicating the percentage cumulative sum of the values.

Image Tools

Maple 2018 includes a new set of drawing tools you can use to annotate images, generate diagrams, and more, all programmatically. These tools are in addition to the interactive drawing tools already available with the Drawing Canvas.

- Supports lines, multi-segment lines, closed shapes, rectangles, circles, and text as drawing primitives.
- Can be used to create images from scratch or add to an existing image.
- Provides control over color, thickness, fill color, line style, fill style, and the appearance of segment ends.
- Allows tapered lines between two points.
- Supports the combination of drawing operations with other image manipulation techniques.
- Uses continuous mathematical coordinates, not discrete pixels.
- Renders using anti-aliasing.
- Enables text annotations using a variety of character sets and customizations, including ASCII, Greek, Cyrillic, many Japanese characters, and a large collection of symbols, with control over font, font size, color, rotation, weight and more.



Connectivity

Maple provides numerous connectivity options with other software tools, from data import and export using a wide variety of formats, to code generation, external calling, internet connectivity, and much more. Maple 2018 expands and enhances Maple's connectivity toolset in several ways.

- In addition to providing code generation to Python, Maple now provides access to a Python interpreter, so you can execute Python scripts and get the results, all within Maple.
- The OpenMaple™ API for Java includes several new commands, including tools to convert numeric objects to *BigInteger* and *BigDecimal*, handling relations such as equalities and inequalities, and representing sets.
- A new Deep Learning package provides an API to a subset of the TensorFlow toolset for machine learning using neural networks.
- File handling tools now include a *CanonicalPath* command that returns a file path that is independent of the value of the current directory, in which any symbolic links and special directories have been resolved.
- The *MapleTA* package can now convert IMS Question & Test Interoperability (QTI) files into Maple T.A.™ and Möbius™ course modules.
- XML Tools has a new command that formats an XML tree as a nested record.

Programming

In addition to substantial improvements to the code editor, Maple 2018 also includes many other enhancements to its language and programming tools.

- You can now add an *until* clause to loop structures, allowing many variations of a do-while loop.
- The code analysis tool *mint*, which works on text files, and *maplemint*, for use inside Maple, have both been improved and consolidated. As a result, *maplemint* now works on modules and reports a wider class of warnings, and the external tool *mint* now provides additional warnings.

- The *select*, *remove*, and *selectremove* commands can now perform substitutions in-place with arrays, matrices, vectors, tables, and objects, simplifying many common use cases involving these functions.
- Assignments can now be used as, or embedded within, expressions.
- The String Tools package can decode and encode strings with HTML entities.
- The new *SameStructure* command compares the value and structure of two expressions.
- The Random Tools package provides new options, including the ability to generate random variable names.

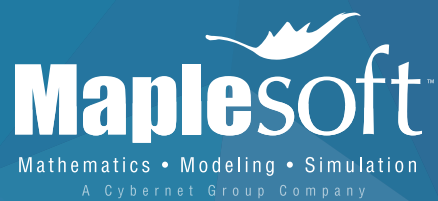
Interface

In addition to the new context panel, code editor improvements, tools for encrypting and protecting your content, and other changes detailed elsewhere in this document, Maple 2018 also includes a variety of smaller interface changes that further streamline your workflow. Enhancements include:

- Reorganized and consolidated top level menus that make it easier to find what you need.
- Command completion that helps you enter a string that specifies the path to a file.
- New shortcut keys for opening, navigating, using, and exiting the Maple Help Browser.

Applications and Examples

Maple 2018 includes many new examples and applications, which you can use to learn about new features, explore different ways of applying Maple, and as a starting point for your own work. Topics include analyzing the performance of a chemical rocket, studying the spontaneity of the reaction between oxygen and nitrogen, calculating the stub match of a transmission line, and interpolating irregularly spaced data.



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