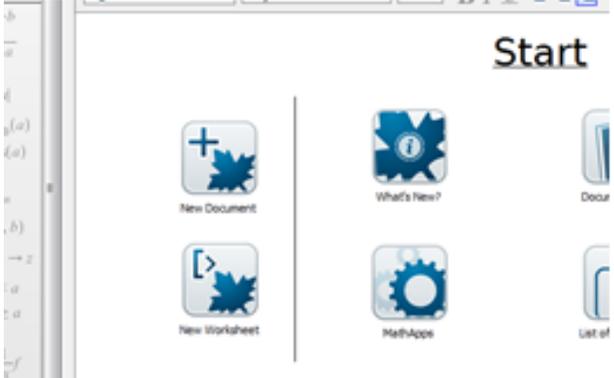


Maple Fundamentals Guide

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This tutorial is designed to help you become familiar with the Maple environment and teach you the few fundamental concepts and tools you need to become productive quickly. To try this material on your own, start with an empty Maple document. Perform the steps found in the left column of each table below. The results of each step are displayed in the right column for your reference.

Talking to Maple

Steps	Results
<p>Start Page</p> <p>When you first start Maple, you will see the Start page. This page points you to a variety of resources for both new and more experienced users.</p> <p>Click on the New Document icon, on the top left of the page to open a blank document.</p>	

Using [ENTER]

You can start by typing math into your Maple document and pressing [ENTER] in order to see the result.

Example: Type "1+2 [ENTER]".

Notice that the result appears on the next line.

$$1 + 2$$

3

(1.1)

Using [Alt]+[ENTER]

If you would like to have the result returned on the same line, press [ALT]+[ENTER].

Example: Type "x+5-2" then [Alt]+[ENTER].

$$x + 5 - 2 = x + 3$$

Context Panel

Maple's context panel is one of the most important tools in Maple. It can be used to perform a wide variety of operations, and the options change depending on what expression or object your cursor is on. The context panel is on the right side of your Maple workspace.

Example: If you place your cursor on the last result. The context panel offers several operations to choose from according to the expression that you are using. To integrate this expression, select **Integrate**, then **x**.

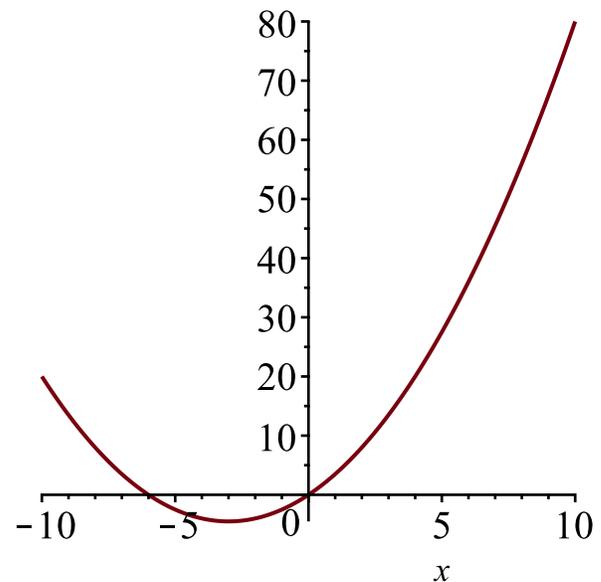
It is also possible to generate plots from the context menu;

Example: To plot the result of the integration, click on the result, and then select **Plots > 2-D Plot**.

$$x + 5 - 2 = x + 3 \xrightarrow{\text{integrate w.r.t. } x} \frac{1}{2} x^2 + 3x$$

$$x + 5 - 2 = x + 3 \xrightarrow{\text{integrate w.r.t. } x} \frac{1}{2} x^2 + 3x$$

→



Changing the Problem

Math in a Maple document is *live*. You can go back, make changes, and re-execute the problem to obtain a new result.

Example: Go back to your original calculation of "1 + 2", change the number "1" to a "3" and press **[ENTER]**. Note the change in output.

Example: In the context panel example, above, change the "x" to "10 x". Highlight the entire line, including the plot, then click the **Execute selection** button,



, found on the toolbar at the top of the Maple window. All selected calculations are updated.

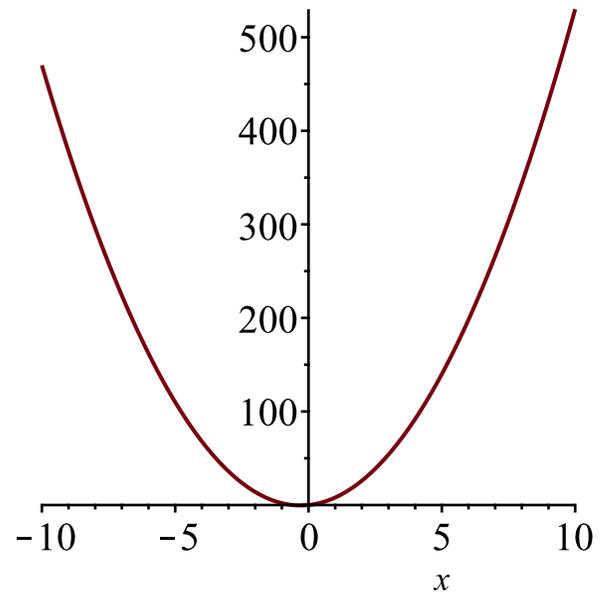
Tip: Clicking the **Execute the entire worksheet** button, , re-calculates the entire document.

$$3 + 2$$

5

(1.2)

$$10x + 5 - 2 = 10x + 3 \xrightarrow{\text{integrate w.r.t. } x} 5x^2 + 3x \rightarrow$$



Smart Popups

At the top of the context panel, you'll find Smart Popups, which give you a preview of the result of an operation before you apply it.

Example: Enter $\sin(2x)$. From the Context Panel, you can convert this expression to an equivalent form using trig identities.

$$\sin(2x)$$

full angle reduction identity: $\sin(2x)=2*\sin(x)*\cos(x)$ →

$$2 \sin(x) \cos(x)$$

Trig Identities	
$\frac{1}{\csc(2x)}$	
$\frac{1}{\csc(2x)}$	
$2 \sin(x) \cos(x)$	
$2 \sin(x) \cos(x)$	
$2 \sin(x) \cos(x)$	
$\frac{2 \tan(x)}{1 + \tan(x)^2}$	
$-\frac{1}{2} (e^{2ix} - e^{-2ix})$	

Entering Math

Steps	Results
<p>Exact Answers and Numeric Approximations</p> <p>Maple calculates exact answers (for example, fractions remain as fractions).</p> <p>Example: On a new line, enter $1/2 + 1/3$.</p> <p>Important! Note that when you enter a fraction, the / automatically moves you into to the denominator. Use the right-arrow key to come out again.</p> <p>Maple also calculates numeric approximations.</p> <p>Example: Click on the result above and select Approximate from the context panel. Select an accuracy of 5 digits.</p> <p>If your problem uses decimal approximations already, Maple will return the answer in the same format.</p> <p>Example: Try the example on the right.</p> <p>You can apply different formatting to numeric results.</p> <p>Example: On the context panel, under Number Format, select Scientific.</p>	$\frac{1}{2} + \frac{1}{3} = \frac{5}{6}$ $\frac{1}{2} + \frac{1}{3} = \frac{5}{6} \xrightarrow{\text{at 5 digits}} 0.83333$ $0.5x + \frac{1}{3}x = 0.8333333333x$ $0.5x + \frac{1}{3}x = 8.33 \times 10^{-1}x$

Palettes

Maple has over 1000 expressions and symbols within its collection of palettes, found on the left side of your Maple window. Some of them insert fill-in-the-blank templates into your document, and are useful for problem entry.

Example: Using the **Expression Palette**, find the definite integral of $x^2 - 3x$ from 0 to 1. Open the expression palette (click **Expression** on the left-hand side of your Maple document) and click

the definite integral () symbol. A

definite integral template will appear in your worksheet. Fill in the place-holders (use **[TAB]** to move to the next placeholder). When done, press **[ENTER]** to evaluate.

Important! Use ^ to create an exponent/superscript, and right-arrow to get out again.

Tip: Put frequently used palette entries on the Favorites Palette. To do so, right-click on the desired expression in the palette and select **Add to Favorites Palette**.

Tip: To see the full list of available palettes and customize their order and visibility, right-click on the palette dock and select **Arrange Palettes...**

$$\int_0^1 x^2 - 3x \, dx$$

$$-\frac{7}{6}$$

(2.1)

Symbol Completion

The symbol completion mechanism provides an alternative to palettes for entering symbols.

Type the first few characters of the symbol name, and press **[Esc]**. Choose the desired symbol from the list.

Important! Use symbol completion to enter single letter symbols, such as the exponential e and the imaginary unit i . If you simply type e , Maple will treat e as a variable, like x . Notice the difference: e^x (symbol) vs. e^x (variable, so e is italicized).

Example: Try entering $\sqrt{e^x + \pi^2}$. For the square root symbol, enter sqrt **[Esc]** and choose the symbol from the menu. Type e **[Esc]** for the exponential constant. To enter π , type pi **[Esc]**. The right-arrow will take you outside the square root symbol.

The same mechanism can be used to enter templates.

Example: Type int **[Esc]**. Choices include various integration templates.

$$\sqrt{e^x + \pi^2}$$

$$\sqrt{e^x + \pi^2}$$

(2.2)

$$\int f dx$$

Case-Sensitivity

Maple is case-sensitive. This means, for example, that a lower case x and an upper case X will be treated as two different variables.

Example: Enter " $x + x$ ".

Example: Enter " $y + Y$ ".

Compare the results.

$$x + x = 2x$$

$$y + Y = y + Y$$

Multiplication

In the case of a number multiplied by a variable only, you have the option of leaving out the multiplication symbol entirely, as the examples up to now have shown.

Example: Type " $3x + 4x$ ".

Maple will insert a space to indicate the implicit multiplication.

In general, you can **use * or a space to denote multiplication**. When using standard math notation, the * appears as a center dot (\cdot).

Example: Type " 3 [space] $x + 5 * x$ ".

Implicit multiplication offers convenience and additional typesetting options, but if you use spaces for multiplication, be careful.

" $x y$ " means "x times y", but " xy " means the variable whose name is "xy".

Example: Type " x [space] $y + xy$ ".

The result is *not* $2xy$ because the two expressions are not the same. If you choose to **Differentiate** using the context panel, you will see that x , y , and xy all appear as variables in this expression.

$$3x + 4x = 7x$$

$$3x + 5 \cdot x = 8x$$

$$xy + xy = xy + xy$$

Mathematical Notation

Maple understands familiar mathematical notation.

For example, Maple understands that $y'' + y' + y = 0$ is a differential equation in $y(x)$.

Example: Enter the equation listed above (using the single quote key for the prime notation). To verify that it is in fact a differential equation, select **Solve DE** from the context panel.

$$y'' + y' + y = 0 \xrightarrow{\text{solve DE}}$$
$$y(x) = _C1 e^{-\frac{1}{2}x} \sin\left(\frac{1}{2}\sqrt{3}x\right) + _C2 e^{-\frac{1}{2}x} \cos\left(\frac{1}{2}\sqrt{3}x\right)$$

Label References

Maple uses label references.

Whenever you use **[ENTER]** to get a response, the result is automatically given a label reference. To refer to a previous result in a computation, use **[Ctrl]+[L]** and enter the label reference number.

Example: Multiply the result $\pi^2 + \sqrt{x}$ (from above) by x , using labels. Your label number may be different than the one shown.

To reference an equation from another document, use **Insert > Reference...**

$$(2.2) \cdot x^2$$

$$\left(\sqrt{e^x} + \pi^2\right) x^2$$

(2.3)

Variable Assignment

In order to assign a value to a variable name, use the assignment statement, denoted by a colon followed by the equals sign, in the form **var := value**.

Example: To assign the value "10" to the variable name "cost", type "cost := 10". After a value has been assigned to "cost", it can be used in subsequent calculations.

You can see any assigned variables and their respective values in the Variables palette.

$cost := 10$

$cost := 10$ (2.4)

$2 \cdot cost$

20 (2.5)

Defining Functions

To define a function, use arrow notation, such as $x \rightarrow x^2$. Enter the arrow operator by typing a hyphen [-] followed by a greater than sign [>]. Maple automatically reformats those characters as a single arrow character.

Example: Define a function f to take a value, w , and return its square.

You can then call the function, as shown.

$f := w \rightarrow w^2$

$f := w \mapsto w^2$ (2.6)

$f(2)$

4 (2.7)

$f(x)$

x^2 (2.8)

Combining Text and Math

In Maple you can combine math and text in the same paragraph.

Steps	Results
<p>Example: Start by entering a simple computation.</p> <p>Go back to the start of your computation (place the cursor to the left of your expression), press [F5] to change from math input to text input, and start typing text.</p>	$\int x^3 + x^2 + 3 \, dx = \frac{1}{4} x^4 + \frac{1}{3} x^3 + 3x$ <p>The integral $\int x^3 + x^2 + 3 \, dx =$</p> $\frac{1}{4} x^4 + \frac{1}{3} x^3 + 3x$
<p>Place your cursor at the end of the output, press [F5], and complete the rest of the sentence.</p>	<p>The integral $\int x^3 + x^2 + 3 \, dx =$</p> $\frac{1}{4} x^4 + \frac{1}{3} x^3 + 3x, \text{ as you can see.}$
<p>Modify some of the terms in the problem, highlight the entire sentence and click execute all selected groups () to re-execute the computation.</p>	<p>The integral $\int 5x^3 + x^2 + 4 \, dx =$</p> $\frac{5}{4} x^4 + \frac{1}{3} x^3 + 4x, \text{ as you can see.}$

If you do not wish the mathematics that appears in your text to be executable, you can make your mathematical expressions inert. This means that when you execute a document or region that contains these expressions, they are treated as static text rather than a computation.

Example: Using **[F5]** to toggle back and forth between math and text as you type, create the sentence "The expression $x^2 + 2x^2$ is easy to simplify.". Highlight the entire sentence and click **execute all selected groups** (). The math in

the sentence gets executed and the results are displayed. Now enter it again, but this time use **[Shift] [F5]** to enter math mode. This time when you execute the sentence, nothing happens. The math is treated as static text, not executable math.

Click on the two expressions. Note that the live math has a blue background and the inert math has a gray background.

You can also convert live math to inert math by highlighting the expression and then pressing **[Shift] [F5]**.

The expression $x^2 + 2x^2$ is easy to simplify.

$$3x^2 \quad (3.1)$$

The expression $x^2 + 2x^2$ is easy to simplify.

Tip: If you are trying to enter math but it doesn't seem to be formatting properly, you are most likely in text mode. In math mode, the cursor is slanted and has a dotted box around it. In text mode, the cursor appears as a vertical bar. You can also check what mode you are in by looking at the top left of the toolbar. In text mode it will look like



. In math mode it will look like

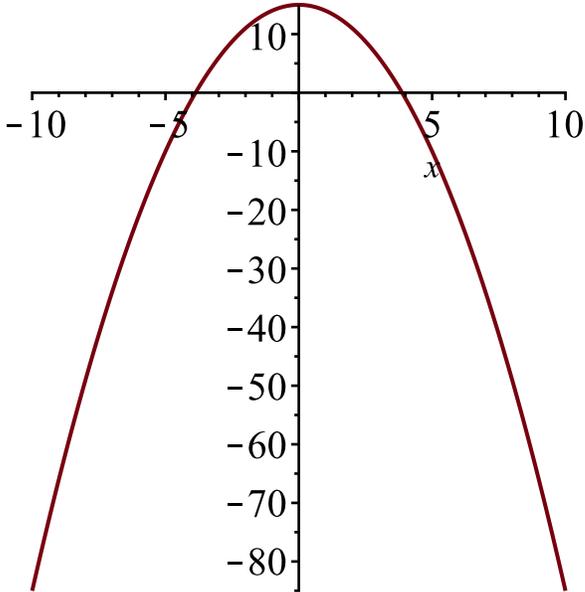


. You can use

these toolbar buttons to change modes as an alternative to pressing **[F5]**.

Plotting

Maple can produce a large variety of 2-D and 3-D plots and animations.

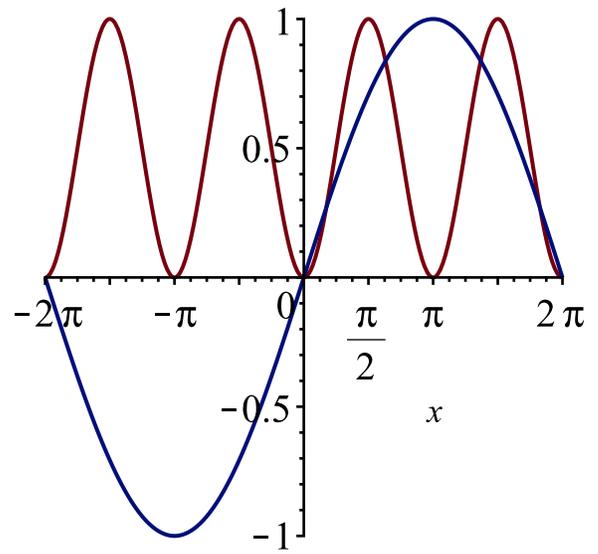
Steps	Results
<p>2-D Plots</p> <p>The fastest way to plot an expression in Maple is to use the context panel.</p> <p>Example: Enter an expression in x (for example, $-x^2 + 15$), then select Plots > 2-D Plot from the context panel.</p> <p>You can manipulate this plot in several ways using the Plot Manipulator tools, found on the Plot toolbar and also on the context panel.</p> <p>Example: To pan the plot, click on  (or select Manipulator>Pan from the context panel). Hold down the left mouse button and use the mouse to move the plot around.</p> <p>Example: To zoom in and out, use . Hold down the left mouse button and draw a rectangle around the area you wish to zoom in on.</p> <p>Example: To find the coordinates of points on your curve, select Manipulator>Point Probe and Probe Info>Nearest point on line, or select the corresponding options using .</p>	<p>$-x^2 + 15 \rightarrow$</p> 

Combining Plots

You can easily add another plot on the same set of axes.

Example: Plot $\sin^2(x)$. Then enter another equation in x into your worksheet (e.g. $\sin\left(\frac{x}{2}\right)$), highlight the new expression with your mouse, hold down the **[Ctrl]** key and drag it onto the plot.

$\sin^2(x) \rightarrow$

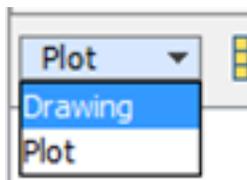


$\sin\left(\frac{x}{2}\right)$

Annotating Plots

You can add additional information to plots by using the drawing tools. Lines, arrows, text, 2-D math, and shapes are available.

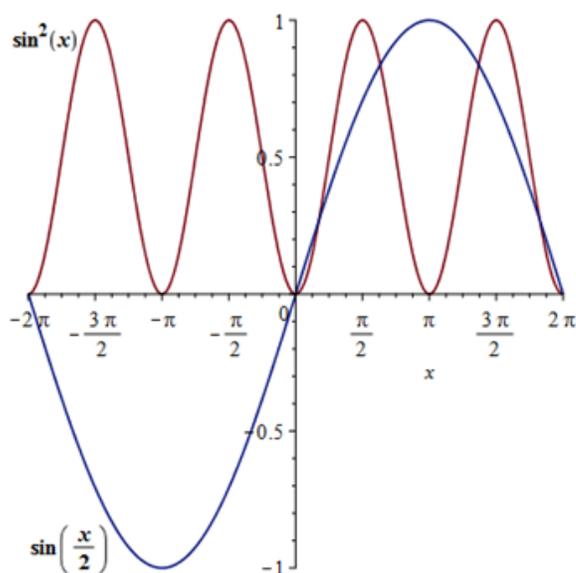
Example: Click on the plot, then select **Drawing** from the drop-down menu on the left side of the toolbar:



. Use the **Text Tool (T)**

to enter labels for the curves. Use **[F5]** to toggle between text and math, and standard Maple math editor entry keystrokes.

When you are finished, select **Plot** from the drop-down menu to exit Drawing mode.



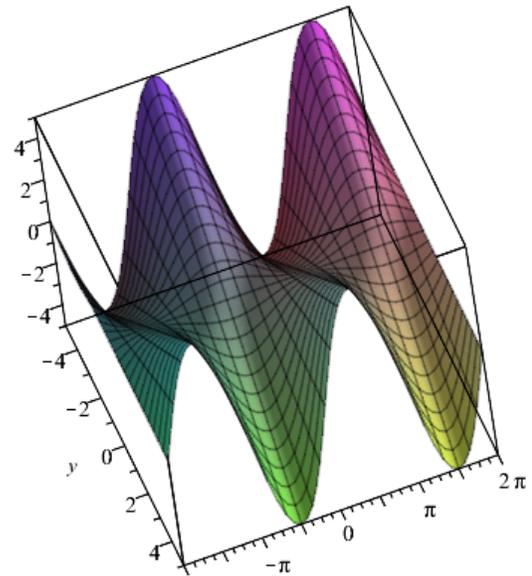
3-D Plots

Example: Enter an expression in x and y (e.g. $\sin(x) \cdot y$). Select **Plots > 3-D Plots > x,y** from the context panel.

Example: To rotate the plot: Click on the plot, and then hold down the left mouse button and move the mouse.

Example: Pan and zoom the plot by selecting the appropriate tool from the toolbar or the **Manipulator** list on the context panel. Now when you hold down and move the mouse, the new action is performed.

$$\sin(x) \cdot y \rightarrow$$



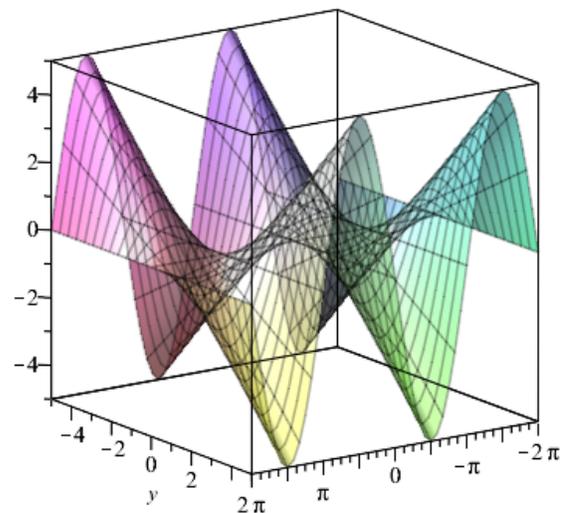
Plot Options

You can modify the look of your plot in a variety of ways.

Plot options can be changed using the context panel. The available options depend on the type of plot.

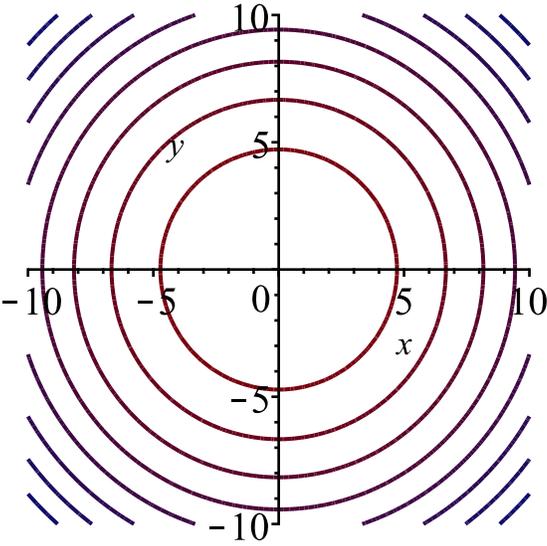
Example: Click **Transparency** and modify the plot transparency.

$$\sin(x) \cdot y \rightarrow$$



Assistants, Tutors, and Math Apps

Maple includes many interactive tools for performing simple and complex tasks, as well as for exploring concepts. See the Tools menu for the full list.

Steps	Results
<p data-bbox="207 514 673 604">Using the Plot Builder Assistant</p> <p data-bbox="207 693 815 961">Plots can easily be created and customized in Maple using the Plot Builder. Using the Plot Builder, you can choose the type of plot you want and set options all at the same time. The plot is updated instantly so you can see the results of your choices.</p> <p data-bbox="207 1045 820 1239">Example: Enter the expression you want to plot, for example, $x^2 + y^2$. From the context panel, select Plot Builder, then choose 2-D contour plot as the plot type.</p>	<p data-bbox="857 478 998 520">$x^2 + y^2 \rightarrow$</p> 

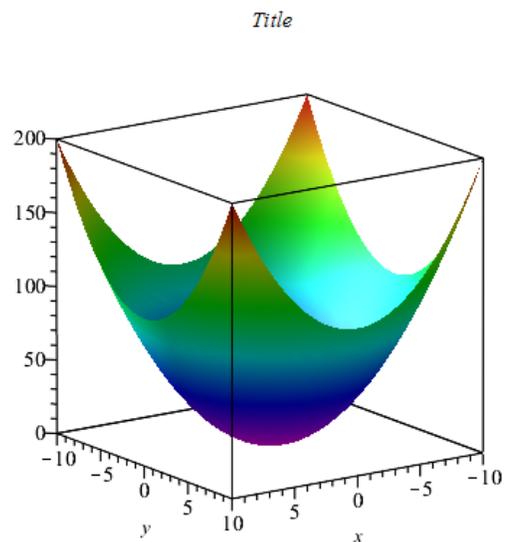
Example: Using the drop-down menu, change the plot type to **3-D plot**. The plot changes from a contour plot to a 3-D plot. Then use the options to customize the plot. For example:

Under Basic Options, for shading, select **zhue**, and set style to **surface**.

Under **Axes and Text**, enter a title for the plot and press **[ENTER]**.

Tip: You can use the Plot Builder to create and customize your plot, and then use the **show command** option under Basic Options to see the corresponding Maple command the produces exactly that plot.

$$x^2 + y^2 \rightarrow$$

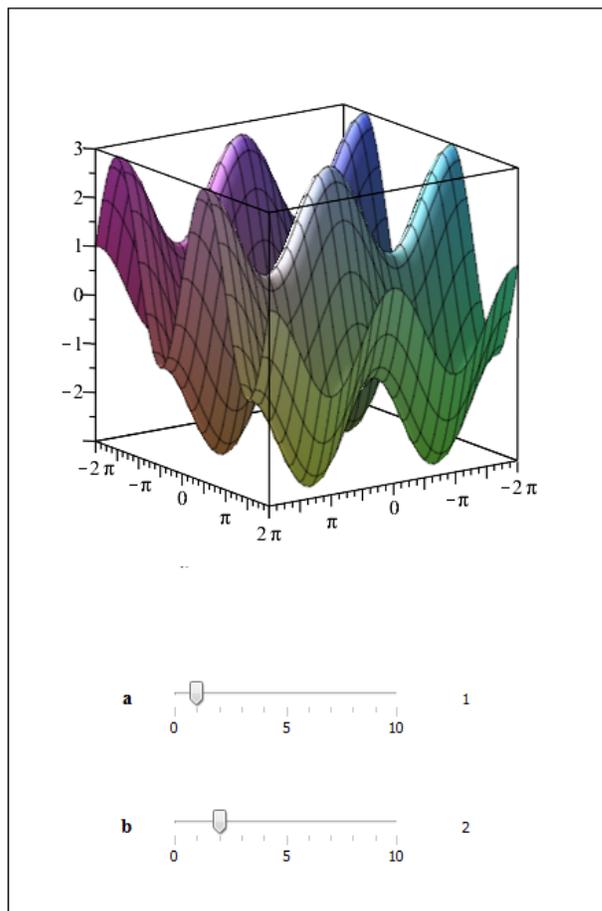


Using the Exploration Assistant

The **Exploration Assistant** allows you to instantly create interactive mini-applications used to explore the parameters of an expression, even if that expression involves Maple commands. Explore generates a user interface with interactive sliders, dials or gauges that can vary the values for the parameters and show the results.

Example: Enter $\text{plot3d}(\cos(ax) + b \sin(y))$. Select **Explore** from the context panel. From here, you can set the range of values you want to explore, as well as specify any variables to *skip*. When you select **skip**, that parameter remains as a symbolic unknown in the expression; no slider will be created to control that value. With this expression, choose to skip x and y . Move the sliders to change the plot.

$\text{plot3d}(\cos(ax) + b \sin(y))$



Using Tutors in Maple

Maple provides many tutors, which are useful for teaching and exploring mathematical concepts in calculus, precalculus, linear algebra, statistics, and more.

Example: From the menu, select **Tools > Tutors > Calculus - Single Variable > Integration Methods**. Enter a function and follow the example through by applying the correct rule at each step and using **Get Hint** for help.

The screenshot shows the 'Calculus 1 - Integration Methods' tutor window. The function entered is $\sin(x)^2$ and the variable is x . The solution steps are:

$$\begin{aligned} & \int \sin^2 x \, dx \\ &= \int \left(\frac{1}{2} - \frac{1}{2} \cos(2x) \right) dx \\ &= \int \frac{1}{2} dx + \int -\frac{1}{2} \cos(2x) dx \\ &= \frac{1}{2} x + \int -\frac{1}{2} \cos(2x) dx \\ &= \frac{1}{2} x - \frac{1}{2} \int \cos(2x) dx \\ &= \frac{1}{2} x - \frac{1}{2} \int \frac{1}{2} \cos(u) du \\ &= \frac{1}{2} x - \frac{1}{4} \int \cos(u) du \\ &= \frac{1}{2} x - \frac{1}{4} \sin(u) \\ &= \frac{1}{2} x - \frac{1}{4} \sin(2x) \end{aligned}$$

The right side of the window contains a 'Show Hints' checkbox and a 'Get Hint' button. Below these are buttons for various integration rules: Constant, Identity, Constant Multiple, Sum, Difference, Power, Parts, Partial Fractions, Change, Revert, Solve, Rewrite, Exponential, and Natural Logarithm. At the bottom are buttons for 'Undo', 'Next Step', 'All Steps', and 'Close'. There are also dropdown menus for selecting rule categories like '<trig>' and '<hyperbolic>'.

Math Apps

Math Apps in Maple provide interactive explorations of various mathematical and scientific concepts. Math Apps are available for many different fields including algebra, functions, calculus, discrete math, engineering, finance, statistics, and more.

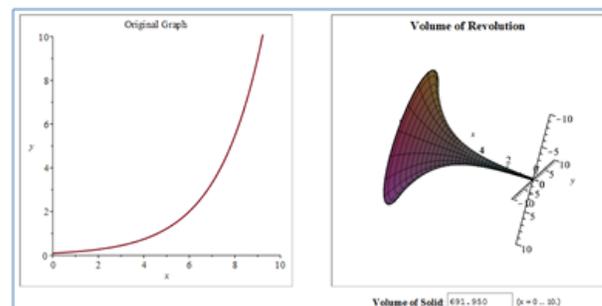
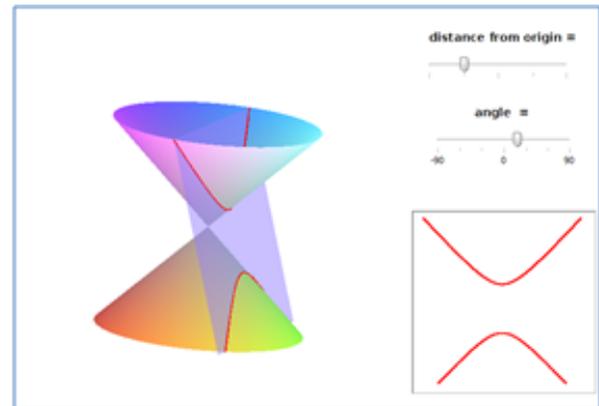
Examples: From the menu, select **Tools > Math Apps**. Choose from the different categories by clicking on the corresponding icon.

For instance, click on **Algebra and Geometry**, and then click on **Conic Sections**, which is in the Geometry section. Move the sliders to see how the intersection of the plane through the cone results in different curves.

From the **Calculus>Integral** section, choose **Solids of Revolution: Volume by Disks**, and then enter, or even draw a curve and see an animation of its revolution.

In addition to interactive Math Apps, in the **Engineering and Applications** section, you will also find example applications that illustrate how to solve and explore particular problems using a command-driven approach.

Tip: You can also view Math Apps online in the MapleCloud (at maple.cloud), using only a web browser.



Tip: For more task-specific help, choose **Tools>Tasks...** to browse through a large collection of task templates for solving problems from calculus, algebra, geometry, differential equations, statistics, and more.

Entering Commands

While many operations in Maple can be done through the use of the context panel and other interactive tools, Maple also has an extensive set of commands, as well as a rich programming language.

Steps	Results
<p>Entering Maple Commands</p> <p>Many commands are grouped together in packages.</p> <p>Example: Using the Matrix palette, create a Matrix, M, and then use the command <code>LinearAlgebra[Determinant](M)</code> to find the determinant of M.</p> <p>Note: If you do not provide the package name, Maple does not know the definition of this function, and so it simply returns the unevaluated expression, as shown. If you see something like this, it usually means that you need to tell Maple what package the command comes from, or that you have mistyped the command name.</p> <p>You can avoid having to type the long-form of each command by loading the desired package using <code>with(Package)</code>. This command loads the package and returns a list of all the commands in that package. You can put a colon at the end of any command to suppress its output.</p>	$M := \begin{bmatrix} 1 & 2 \\ 3 & 5 \end{bmatrix} \tag{6.1}$ $\text{LinearAlgebra}[Determinant](M) \tag{6.2}$ -1 $\text{Determinant}(M) \tag{6.3}$ $\text{Determinant}\left(\begin{bmatrix} 1 & 2 \\ 3 & 5 \end{bmatrix}\right)$

Example: Load the LinearAlgebra package. Now add a colon to the end to see the difference.

Example: Now calculate the Determinant of M using the short-form of the command.

Command completion is very useful when typing long command names.

Example: Type Gau, then press **[Esc]** to see a list of possible completions. Use the arrow key to select the desired command and press **[Enter]**, or select the command with the mouse.

Tip: Many packages can be loaded through **Tools > Load Package**. See **Tools > Load Package > List All Packages...** to see the complete list of packages.

with(LinearAlgebra) :

Determinant(M)

-1

(6.4)

GaussianElimination(M)

$$\begin{bmatrix} 1 & 2 \\ 0 & -1 \end{bmatrix}$$

(6.5)

Getting Help

Many resources are available to help you find your way around Maple, from "How do I?" guides for new users to information for advanced Maple programmers.

Steps	Results
<p>Using the Help System</p> <p>You can open the help system at any time from the Help menu, Help>Maple Help. From here, you can browse the entire help system through the Table of Contents, or search for what you need.</p> <p>If you know the name of the command you are interested, you can bring up its help page using the ? command.</p> <p>Example: Type ?isprime to bring up the help page for the primality test command</p> <p>Tip: You can place your cursor on a Maple command in your worksheet and press [F2] to bring up the help page for that command.</p>	 <p><i>?isprime</i></p>

Maple Portal

The Maple Portal brings together a collection of useful resources for learning about Maple, including:

- Getting started resources
- How do I...? mini-tutorials
- Training videos
- User and programming manuals
- Examples and applications
- Additional resources for students and educators
- How to get additional help

Example: Type ?MaplePortal to open the Portal.

The Maple Portal is designed as a starting place for any Maple user.

[New to Maple?](#)
[Learn More About Maple](#)
[How do I...?](#)
[Training Videos](#)
[User and Programming Manuals](#)
[Examples and Applications](#)
[Additional Resources for Students and Educators](#)
[Getting Additional Help](#)

► **New to Maple?**

▼ **Learn more about Maple**

▼ **How Do I...?**

Use these shorter tutorials to get build out your knowledge of specific topics and functions. (After you know the basics, refer to [Help](#) or [Quick Reference](#) when you need a quick reminder.)

Tutorials		How do I...
Each tutorial will take approximately 1-10 minutes to complete.		Topics covering essentials for working in Maple
Talking to Maple	How to Get Started Entering Math	How do I...? ...with a string expression?
Putting Your Pieces Together	Combining Text and Math Solving Equations Expressions, Functions, and Procedures	How do I...? ...with a string? ...with a table or expression? ...with a label data? ...with a function?
Commands and Packages	Using Top Commands and Packages Getting Help	How do I...? ...with multiple functions? ...with a string? (2) ...with a column matrix?