

Maple Getting Started Guide

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Contents

Preface	v
1 Introduction to Maple	1
1.1 How Maple Helps You	1
Creating Interactive Documents	3
Exploring or Visualizing Problems	3
Computing Numeric and Symbolic Solutions	4
Solving a Problem	4
Accessing Resources	6
2 Maple Tools and Resources	15
2.1 Starting Maple	15
Starting the Standard Worksheet Interface	16
The Maple Worksheet	16
2.2 The Maple Help System	18
Accessing the Help System	19
Using the Help Navigator	20
Viewing Help Pages as Worksheets	21
Copying Examples	21
2.3 Point-and-Click Interaction	22
Assistants	22
Tutors	26
Context Menus	27
Task Templates	31
Palettes	34
Maplet Applications	39
2.4 Commands	40
The Maple Library	40
Commands in the Worksheet	40
Learning About Commands and Packages	50
Using Examples to Learn about Commands	53
Equation Labels	54
2.5 Worksheet Formatting Features	57
Markers	57
Document Blocks	57
Bookmarks	58

2.6 Working in Document Mode	58
Starting a New Document	59
Entering Math	59
Common Key Strokes for Symbols and Formats	60
Opening Documents	61
Viewing Maple Code in Document Mode	61
3 Using Maple	63
3.1 Calculus Example	63
Check for Existing Tools: Tutor	64
Check for Existing Tools: Task Template	65
Check for Instructions: Help Page and Example Worksheet	67
Other Ready-To-Use Resources	69
3.2 Optimization Example	71
Check for Existing Tools: Assistant	72
Check for Instructions: Help Page	75
4 The Next Step	79
4.1 Top Packages	79
4.2 Top Commands	81
Index	83

Preface

The Maple Software

The Maple™ software is a powerful system that you can use to solve complex mathematical problems. You can also create professional quality documents, presentations, and custom interactive computational tools in the Maple environment.

You can access the power of the Maple computational engine through a variety of interfaces.

Interface	Description
Standard Worksheet	<p>Full-featured graphical user interface offering features that help you create electronic documents that show all your assumptions, the calculations, and any margin of error in your results; or hide the computations to allow your reader to focus on the problem setup and final results. The advanced formatting features help you create the customized document you need. Because the documents are <i>live</i>, you can edit the parameters and, with the click of a button, compute the new results.</p> <p>The <i>Getting Started Guide</i> was created using the Standard Worksheet interface to Maple. An interactive version of this manual is available in the Standard Worksheet interface. From the Help menu, select Manuals, Dictionary, and more>Manuals>Getting Started Guide.</p>
Classic Worksheet	Basic worksheet environment for older computers with limited memory.
Command-line version	Command-line interface, without graphical user interfaces features, for solving very large complex problems or batch processing with scripts.
Maplesoft™ Graphing Calculator (Microsoft® Windows® only)	Graphical calculator interface to the Maple computational engine. Using it, you can perform simple computations and create customizable, zoomable graphs.

Interface	Description
Maplet™ Applications	Graphical user interface containing windows, textbox regions, and other visual interfaces, which gives you point-and-click access to the power of Maple. You can perform calculations and plot functions without using the worksheet or command-line interfaces.

This manual describes how to use the Standard Worksheet interface. Not all features are available in the Classic Worksheet interface and Command-line version. The Standard Worksheet interface has two modes: *Document* mode and *Worksheet* mode.

Document Mode - Using the Document mode, you can perform quick calculations. You can enter a mathematical expression, and then evaluate, manipulate, solve, or plot with a few keystrokes or mouse clicks.

Worksheet Mode - The Worksheet mode is designed for:

- Interactive use through Maple commands, which may offer advanced functionality or customized control not available using context menus or other syntax-free methods
- Programmatic use of the powerful Maple language

Using either mode, you can create high quality interactive mathematical presentations or documents.

In This Manual

This manual provides an introduction to the following Maple features.

- Worksheets and powerful interactive documents
- The help system
- Point-and-click interaction with various interfaces to help you solve problems quickly
- Maple commands and standard math notation
- A road map for solving problems

For a complete list of manuals, study guides, toolboxes, and other resources, visit the Maplesoft Web site at <http://www.maplesoft.com>

Audience

The information in this manual is intended for first time Maple users.

Conventions

This manual uses the following typographical conventions.

- **bold** font - Maple command, package name, option name, dialog, menu, and text field
- *italics* - new or important concept
- **Note** - additional information relevant to the section
- **Important** - information that must be read and followed

Customer Feedback

Maplesoft welcomes your feedback. For suggestions and comments related to this and other manuals, contact doc@maplesoft.com

1 Introduction to Maple

Don't worry about your difficulties in Mathematics. I can assure you mine are still greater.

~Albert Einstein

Mathematics touches us every day—from the simple chore of calculating the total cost of our purchases to the complex calculations used to construct the bridges we travel.

To harness the power of mathematics, Maplesoft provides a tool in an accessible and complete form. That tool is Maple.

1.1 How Maple Helps You

With Maple you can create powerful interactive documents. You can visualize and animate problems in two and three dimensions. You can solve complex problems with simple point-and-click interfaces or easy-to-modify example worksheets. You can also devise custom solutions using the Maple programming language. While you work, you can document your process, providing text descriptions.

Digital Signal Processing

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Introduction

This demonstration illustrates the use of Maple to perform digital signal processing.

The following Maple techniques are highlighted:

- Discrete Fourier Transform
- Plotting of Fourier Spectrum
- 3D Plot of a Short Term Fourier Transform

Parameter Definitions

Input file	> filename := "ding.dat":
Sampling frequency (Hz)	> Fs := 22050:
Frame Duration (s)	> FTs := 0.01:

Problem description

The purpose of this example is to load and display a signal and perform a Fourier analysis on this signal.

We first subdivide the signal into short term intervals and perform a Fourier analysis on each frame, yielding a two-dimensional result set.

We also perform a regular discrete Fourier transform on the whole signal and display the result.

Short Term Fourier Transform

Number of samples per frame: $NF = \lfloor FTs \cdot Fs \rfloor =$ 221

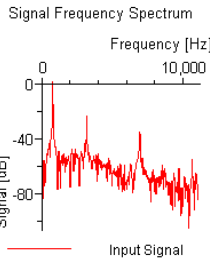
Number of frames: $Frames = \lfloor \frac{nSamples}{NF} \rfloor =$ 91

The following matrix is the two-dimensional result set of applying the Fourier transform, frame by frame. The matrix is visualized on the right.

```

110 x 91 Matrix
Data type: anything
Storage: rectangular
Order: Foran_order
    
```

Discrete Fourier Transform



Input Signal

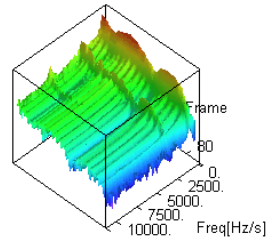
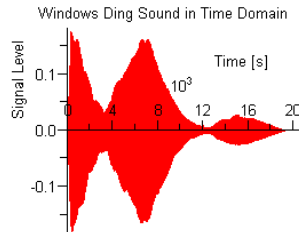


Figure 1.1: Example Interactive Document in Maple

Creating Interactive Documents

Maple allows you to create powerful documents for use as business and education tools, technical reports, presentations, assignments, and handouts.

You can:

- Include instructions and equations beside your computations
- Integrate calculations, spreadsheets, and equations
- Format text for reports, academic papers, or books
- Insert hyperlinks to other files, Web sites, or email addresses
- Insert images, spreadsheets, tables, and symbols
- Embed graphical user interface components
- Generate two- and three-dimensional plots and animations
- Sketch ideas in the worksheet
- Copy, cut, and paste information
- Bookmark specific areas
- Insert symbols from over 20 palettes
- Easily update, revise, and distribute your documents

Exploring or Visualizing Problems

Maple has many tools to help you examine and demonstrate concepts.

You can:

- Solve problems using point-and-click tutors, assistants, and Maplet applications
- Create plots and animations in two and three dimensions
- Right-click (**Control**-click, for Macintosh) to export, convert, manipulate, plot, and more, using context menus

Computing Numeric and Symbolic Solutions

Maple is an analytic computation system. It performs mathematical computations and manipulations to solve problems from various technical disciplines. Maple computes both **numeric** and **symbolic** solutions to mathematical problems. For example, Maple performs computations on expressions that contain symbols, such as π , and returns exact symbolic results.

You can:

- Instantly simplify large equation sets
- Derive sophisticated equations
- Compute parametric solutions to problems
- Use precision control for maximum accuracy
- Include units, measurement of error, and tolerance management within an expression and perform calculations on this expression
- Process large datasets for industrial, engineering, and research applications

Solving a Problem

When solving a problem, you can:

- Select the best resource to quickly find the solution or the right guidelines to a step-by-step process
- Document the solution as you work through the problem

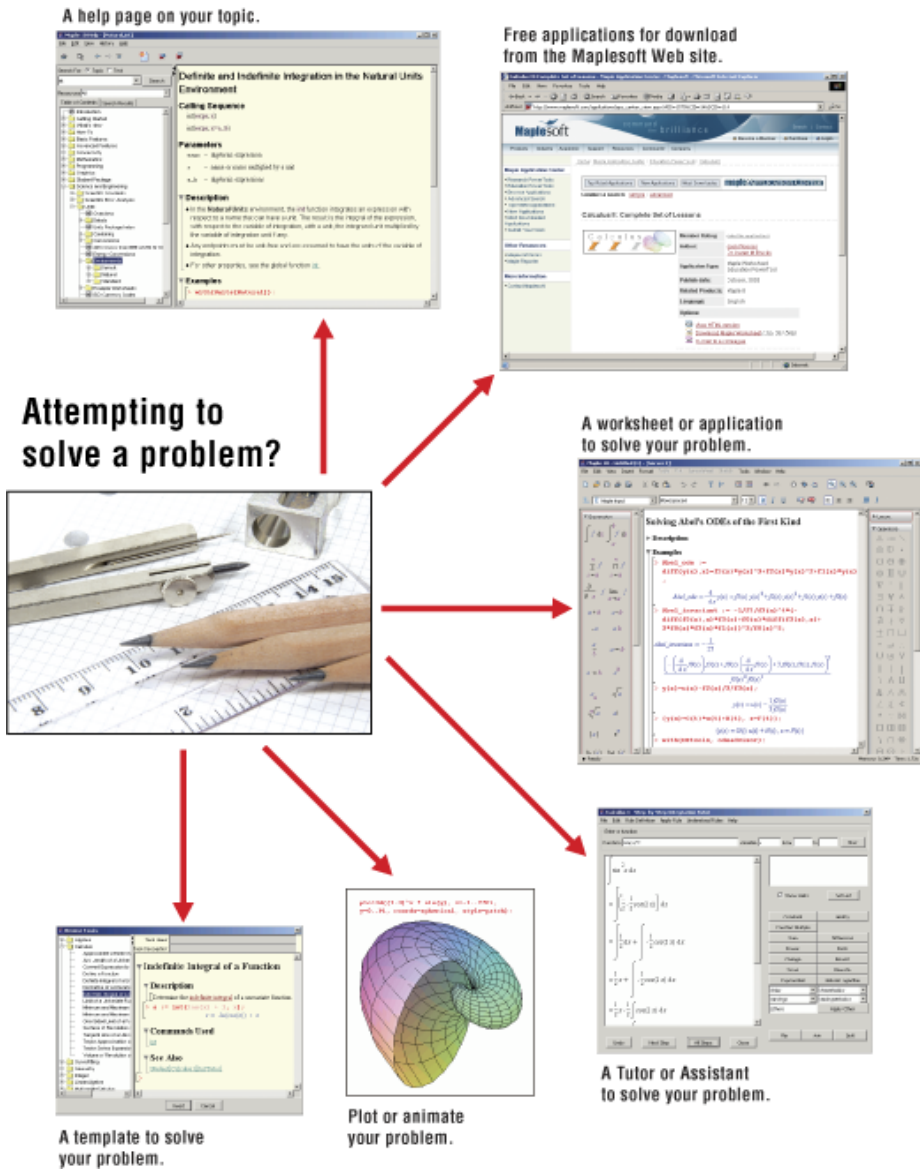
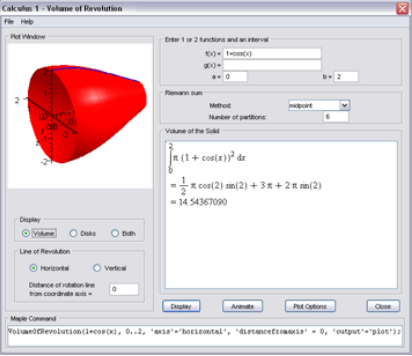
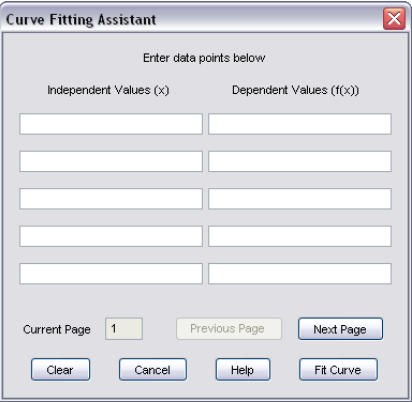


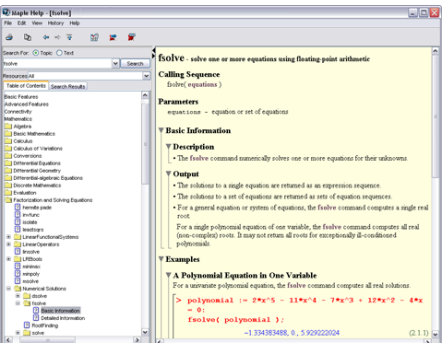

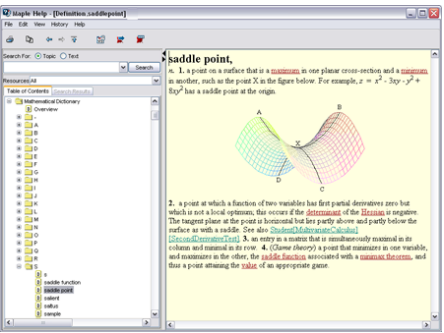
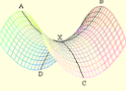
Figure 1.2: A Selection of Maple Resources for Solving Problems


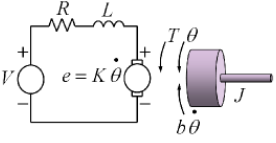

Accessing Resources

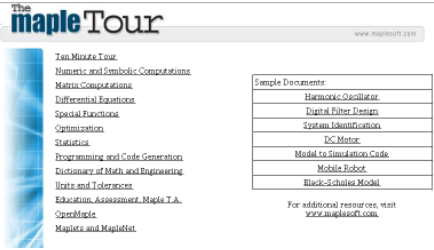
Your work with the Maple program is supported by numerous resources.

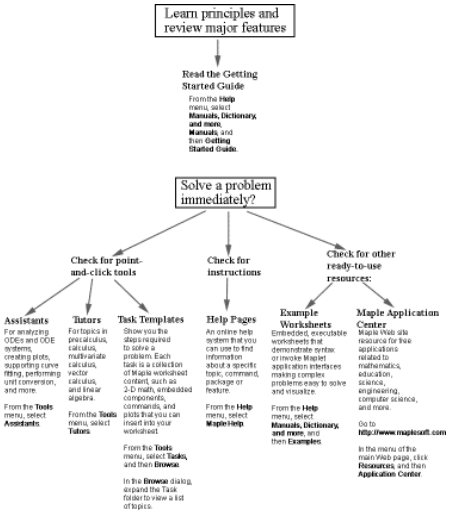
Tutors, Assistants, Task Templates, and Maple Calculator	Description
<p>Tutors</p>  <p>The screenshot shows a window titled 'Calculus 1 - Volume of Revolution'. On the left, there is a 3D plot of a red volume of revolution. The window has several input fields: 'f(x) = 1+cos(x)', 'g(x) =', 'a = 0', and 'b = 2'. There are also radio buttons for 'Volume', 'Disks', and 'Both'. Below the plot, there are options for 'Line of Revolution' (Horizontal or Vertical) and 'Distance of rotation line from coordinate axis = 0'. The 'Volume of the Solid' section shows the integral $\int_0^2 \pi (1 + \cos(x))^2 dx$ and its numerical value 14.54367090. At the bottom, there is a 'Maple Command' section with the command <code>VolumeOfRevolution(1+cos(x), 0..2, "axis"="horizontal", "distanceFromAxis" = 0, "output"="plot");</code></p>	<p>Over 40 interactive tutors help beginner users gain insight and understanding of topics in precalculus, calculus, multivariate calculus, vector calculus, and linear algebra courses. Some tutors help you work through a problem step-by-step.</p> <ul style="list-style-type: none"> From the Tools menu, select Tutors, and then one of the topic submenus.
<p>Assistants</p>  <p>The screenshot shows a window titled 'Curve Fitting Assistant'. It has two columns of input boxes: 'Independent Values (x)' and 'Dependent Values (f(x))'. There are five empty input boxes in each column. At the bottom, there are buttons for 'Clear', 'Cancel', 'Help', and 'Fit Curve'. There are also 'Previous Page' and 'Next Page' buttons.</p>	<p>Assistants help you accomplish many tasks, such as solving ODEs and ODE systems, creating plots and matrices, and supporting curve fitting.</p> <ul style="list-style-type: none"> From the Tools menu, select Assistants, and then one of the topic submenus.

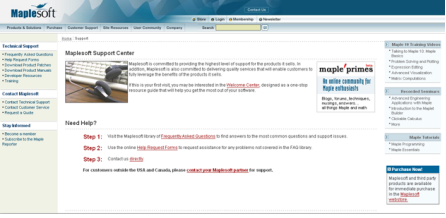

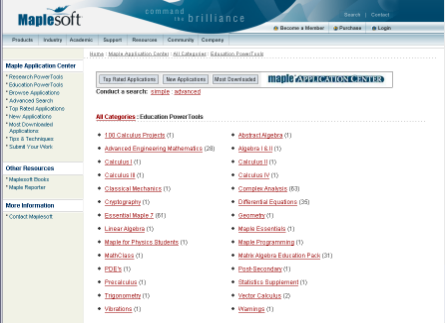
Tutors, Assistants, Task Templates, and Maple Calculator	Description
<p>Task Templates</p>	<p>Tasks show the steps required to solve a problem. Each template is a collection of Maple worksheet content, such as 2-D Math, embedded components, commands, and plots that you can insert into your worksheet.</p> <ul style="list-style-type: none"> From the Tools menu, select Tasks, and then Browse.
<p>Maplesoft Graphing Calculator</p>	<p>Available for use as part of your Maple installation. A convenient calculator (interface) using Maple technology.</p> <p>Microsoft Windows (only)</p> <p>From the Start menu, select Maple, and then Maple Calculator.</p>


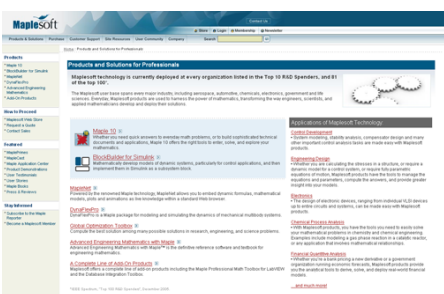
Online Help and Examples	Description
<p>Help Pages</p>  <p>The screenshot shows the Maple Help interface for the 'solve' command. The left sidebar contains a tree view of help topics. The main pane displays the following information:</p> <ul style="list-style-type: none"> Solve solve one or more equations using floating point arithmetic Calling Sequence solve(equations) Parameters equations - equation or set of equations Basic Information <ul style="list-style-type: none"> Description The solve command numerically solves one or more equations for their solutions. Output <ul style="list-style-type: none"> The solutions to a single equation are returned as an expression sequence. The solutions to a set of equations are returned as sets of equation sequences. For a general equation or system of equations, the solve command computes a single real root. For a single polynomial equation of one variable, the solve command computes all real (non-complex) roots. It may not return all roots for exceptionally ill-conditioned polynomials. Examples <ul style="list-style-type: none"> A Polynomial Equation in One Variable For a univariate polynomial equation, the solve command computes all real solutions. <pre> > polynomial := 2*x^3 - 11*x^2 + 14*x - 5; > solve(polynomial); -1.34483488, 0.5929222004 </pre> 	<p>The online help system helps you find information about a specific topic, command, package, or feature. You can access help three ways.</p> <ul style="list-style-type: none"> From the Help menu, select Maple Help. In the toolbar, click the Help icon.  In the worksheet, enter ?topicname. For example, type ?LinearAlgebra, and then press Enter.
<p>Dictionary</p>  <p>The screenshot shows the Maple Dictionary interface for the term 'saddle point'. The left sidebar shows an alphabetical list of terms. The main pane displays the following information:</p> <ul style="list-style-type: none"> saddle point 1. A point on a surface that is a maximum in one planar cross-section and a minimum in another, such as the point X in the figure below. For example, $z = x^2 - 3xy - y^2 + 6xy^2$ has a saddle point at the origin.  2. a point at which a function of two variables has first partial derivatives zero but which is not a local optimizer, that occurs if the determinant of the Hessian is negative. The tangent plane at the point is horizontal but lies partly above and partly below the surface as with a saddle. See also Stationary(StationaryCalculation) and CriticalPoints(Terms). In an entry in a matrix that is simultaneously maximal in its column and minimal in its row. 4. (Game theory) a point that minimizes in one variable, and maximizes in the other, the saddle function, associated with a minimax theorem, not this a point attaining the value of an appropriate game. 	<p>More than 5000 mathematical and engineering terms, and over 300 figures and plots.</p> <ol style="list-style-type: none"> From the Help menu, select Maple Help. In Resources drop-down list, select Definition. Enter search word or expand alphabetical listing.


Online Help and Examples	Description
<p>Applications and Example Worksheets</p> <p>Application Demonstration </p> <p>C-Examples Table of Contents More...</p> <h3>DC Motor Control Design</h3> <p>© MapleSoft, a division of Waterloo Maple Inc., 2005</p>  <p>Section Layout</p> <p>System Definition</p> <p>System Models</p> <ul style="list-style-type: none"> Differential Equation Model Transfer Function Model State Space Model <p>LQR Control</p> <p>Step Responses</p> <p>Effects of R</p> <p>Viewing R through a slider</p> <p>Given a model of a DC motor as a set of differential equations, we would like to obtain both the transfer function and the state space model of the system. Then, we would like to use the state space model to design a LQR controller and study the effect the R parameter in the LQR control design has on the controlled performance of the system.</p> <p>A DC motor converts electrical signals (voltage and current) into mechanical motion. The electrical and mechanical characteristics can be illustrated by a circuit diagram and a free body diagram, respectively (shown in the diagram above).</p> 	<h3>Applications</h3> <p>Sample applications demonstrate how Maple can be used to find and document a solution to a specific problem. Some applications allow for input or contain animations that you can run; however, their primary use is as demonstrations. Topics include:</p> <ul style="list-style-type: none"> DC Motor Control Design Digital Filter Design Frequency Domain System Identification Harmonic Oscillator Mathematical Model to Simulation Code Mobile Robot, Mobile Robot Modeling and Simulation Black-Scholes Model Signal Generation <h3>Example Worksheets</h3> <p>Embedded, executable worksheets covering topics that demonstrate syntax or invoke Maplet applications make complex problems easy to solve and visualize. You can copy and modify the examples as needed.</p> <p>Topics include: Algebra, Applications (Finance, Scientific Constants, Scientific Error Analysis), Calculus, Connectivity (Code Generation, External Calling), Differential Equations, Discrete Mathematics, General Numerics, General Symbolics, Geometry, Integration, Integral Transforms, Language and System, and Mathematical Visualizations.</p> <p>From the Help menu, select Manuals, Dictionary, and more and then Applications and Examples.</p>

Tour and New User Roadmap	Description
<p>Tour</p> 	<p>The Maple Tour consists of interactive sessions on the following topics:</p> <ul style="list-style-type: none"> • Ten Minute Tour • Numeric and Symbolic Computations • Matrix Computations • Differential Equations • Special Functions • Optimization • Statistics • Programming and Code Generation • Dictionary of Math and Engineering Terms • Units and Tolerances • Education Assessment, Maple T.A. • OpenMaple • Maplets and MapleNet <p>From the Help menu, select Take a Tour of Maple.</p>

Tour and New User Roadmap	Description
<p data-bbox="243 252 460 278">New User Roadmap</p>  <pre> graph TD A[Learn principles and review major features] --> B[Read the Getting Started Guide] B --> C{Solve a problem immediately?} C --> D[Check for point-and-click tools] C --> E[Check for instructions] C --> F[Check for other ready-to-use resources] D --> D1[Assistants] D --> D2[Tutors] D --> D3[Task Templates] E --> E1[Help Pages] F --> F1[Example Worksheets] F --> F2[Maple Application Center] </pre> <p data-bbox="400 305 534 340">Learn principles and review major features</p> <p data-bbox="420 372 514 460">Read the Getting Started Guide From the Help menu, select Manuals, Dictionary, and more, and then New User Roadmap.</p> <p data-bbox="420 481 514 516">Solve a problem immediately?</p> <p data-bbox="313 557 487 583">Check for point-and-click tools</p> <p data-bbox="245 613 286 820">Assistants For analyzing ODEs and ODE systems, creating plots, supporting curve fitting, performing unit conversion, and more. From the Tools menu, select Assistants.</p> <p data-bbox="313 613 353 710">Tutors For topics in precalculus, calculus, multi-variable calculus, vector calculus, and linear algebra. From the Tools menu, select Tutors.</p> <p data-bbox="366 613 434 820">Task Templates Show you the steps required to solve a problem. Each task is a collection of Maple worksheet content, such as 2-D plots, embedded components, commands, and plots that you can insert into your worksheet. From the Tools menu, select Task Templates, and then Browse. In the Browse dialog, expand the Task folder to view a list of topics.</p> <p data-bbox="447 613 487 737">Help Pages An online help system that you can use to find information about a specific topic, comment, package or feature. From the Help menu, select Maple/Help.</p> <p data-bbox="514 613 555 754">Example Worksheets Embedded, executable worksheets that demonstrate syntax or involve Maple applications interfaces making complex problems easy to solve and visualize. From the Help menu, select Manuals, Dictionary, and more, and then Examples.</p> <p data-bbox="568 613 689 781">Maple Application Center Maple Web site resources for new applications related to mathematics, education, science, engineering, computer science, and more. Go to http://www.maplesoft.com. In the menu of the main Web page, click Resources, and then Application Center.</p>	<p data-bbox="713 252 1184 340">Find the most efficient path to solving a problem immediately or learning principles and reviewing major features.</p> <ul data-bbox="713 381 1166 469" style="list-style-type: none"> • From the Help menu, select Manuals, Dictionary, and more, and then New User Roadmap.

Web Site Resources	Description
<p>Technical Support (Online)</p> 	<p>Maple Web site and resource for FAQs, downloads and service packs, links to discussion groups, and request technical support form.</p> <ol style="list-style-type: none"> 1. Go to http://www.maplesoft.com. 2. In the menu of the main Web page, click Customer Support, and then Support and Customer Service.
<p>Application Center</p> 	<p>Maple Web site resource for free applications related to mathematics, education, science, engineering, computer science, statistics and data analysis, finance, communications, graphics. Many applications are available in translation (French, Spanish, and German).</p> <ol style="list-style-type: none"> 1. Go to http://www.maplesoft.com. 2. In the menu of the main Web page, click User Community, and then Application Center.
<p>PowerTools</p> 	<p>Maple Web site resource for free complete course curricula and add-on Maple packages and courses, developed by experts in their fields to help users configure Maple for research in specific application areas.</p> <ol style="list-style-type: none"> 1. Go to http://www.maplesoft.com. 2. In the menu of the main Web page, click User Community, and then Application Center. 3. In the sidebar of the Web page, click Research Powertools or Education Powertools.

Web Site Resources	Description
<p>Corporate and Government</p> 	<p>Maple Web site of productivity tools for engineers and scientists, online seminars and training, subscription information on the Extended Maintenance Plan (EMP), and other resources.</p> <ol style="list-style-type: none"> 1. Go to http://www.maplesoft.com. 2. In the menu of the main Web page, click Site Resources, Welcome Center, and then the Corporate and Government link in the body of the Web page.
<p>Industry and Government</p> 	<p>Maple Web site of productivity tools for engineers, scientists, and applied mathematicians. Covers the following application areas: finance, signal processing and communication, optimization, electronics, chemical and mechanical systems, control systems design, and biotech and pharmaceutical fields.</p> <ol style="list-style-type: none"> 1. Go to http://www.maplesoft.com. 2. In the menu of the main Web page, click Site Resources, Welcome Center, and then the Corporate and Government link in the body of the Web page. 3. In the sidebar of the Web page, click the Industry and Government.

Web Site Resources	Description
<p>Products and Solutions for Students</p> 	<p>Maple Web site of Maple tutorials and graphics, help with classes, student FAQs, instructor pages, applications by students, the newest release of Maple, and Maple books.</p> <ol style="list-style-type: none"> 1. Go to http://www.maplesoft.com. 2. In the menu of the main Web page, click Product and Solutions, and then For Students.

2 Maple Tools and Resources

In this chapter:

Starting Maple	Launching the program and the user interface Note: For installation and licensing instructions, refer to the Install.html file on your Maple Installation CD.
Maple Help System	Accessing help pages and other resources
Point-and-Click Interaction	Accessing various interfaces designed to help you solve problems quickly
Commands	Using Maple commands and language
Worksheet Formatting Features	Interpreting formatting features
Working in Document Mode	Using the (blank sheet) Maple Document environment for quickly solving problems

This guide was created using Maple.

2.1 Starting Maple

In this section:

- Starting the Standard Worksheet Interface
- The Maple Worksheet
- Basics

Starting the Standard Worksheet Interface

To start the Standard Worksheet interface in:

Windows	<ul style="list-style-type: none"> From the Start menu, select Programs, Maple, Maple. <p>Alternatively:</p> <ul style="list-style-type: none"> Double-click the Maple desktop icon.
Macintosh [®]	<ul style="list-style-type: none"> Double-click the Maple application icon in the Finder.
UNIX [®]	<ul style="list-style-type: none"> Enter the full path, for example, /usr/local/maple/bin/xmaple <p>Alternatively:</p> <ol style="list-style-type: none"> Add your Maple directory (for example, /usr/local/maple/bin) to your command search path. Enter xmaple.

The Maple Worksheet

You can access the power of the Maple computation engine through a variety of user interfaces.

- Standard Worksheet
- Command-line version
- Classic Worksheet
- Custom-built Maplet applications
- Calculator interface (Windows only)

In this guide, references to the graphical Maple interface refer to the Standard Worksheet interface. For more information on the various interface options, refer to the **?versions** help page.

The first Maple session opens with the **Startup** dialog, explaining the difference between **Document** mode and **Worksheet** mode. The dialog contains links to items, such as various document options, help resources including updates and other introductory help pages, and application resources on the Web. Subsequent sessions display **Tip of the Day** information.

- Document mode allows you to start solving problems right away, without needing syntax or Maple commands.
- Worksheet mode is the most familiar mode to users of previous versions of Maple. You enter commands at an input prompt to get results.

Basics

Maple documents are saved as **.mw** files. They consist of files created in **Worksheet** or **Document** mode.

To start a Maple session:

- In the **Startup** dialog, select one of the document options: **Blank Document**, **Blank Worksheet**, **Template**, or **Open a File**.

or

1. Close the **Startup** dialog.
2. From the **File** menu, select **New**, and then one of the following: **Worksheet Mode**, **Document Mode**, or **Templates**.
 - This guide discusses features common to Worksheet and Document mode. For information on Templates, see *Task Templates (page 31)*. Instructions for using Document mode are provided in the last section, *Working in Document Mode (page 58)*.
 - In subsequent sessions, Maple starts in Document mode. Every time you open a Document, Maple displays a **Quick Help** pop-up list of important shortcut keys. To invoke **Quick Help** at any time, press the **F1** key.

Important: This guide was created using Maple.

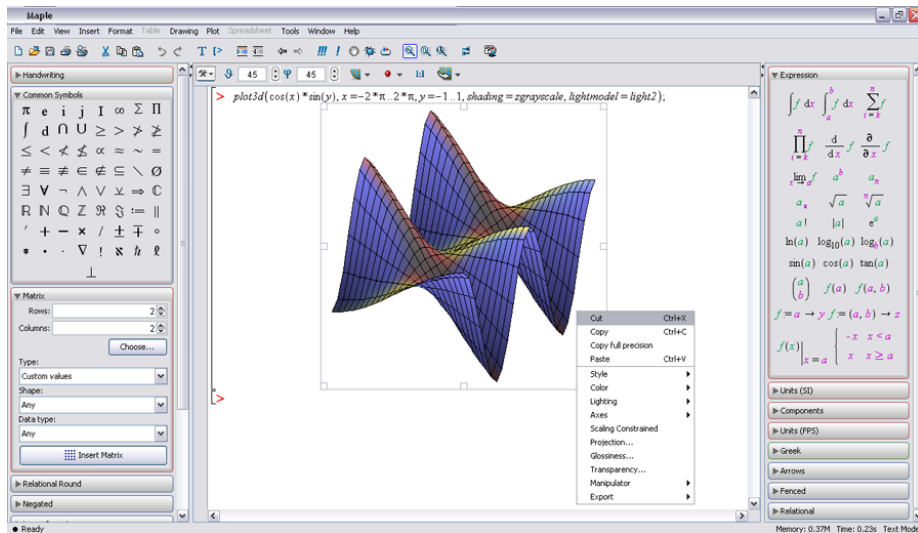


Figure 2.1: The Maple Standard Worksheet Interface in Worksheet Mode

2.2 The Maple Help System

The Maple program provides a custom help system consisting of almost 5000 reference pages. The help system is a convenient resource for determining the syntax of Maple commands and for learning about Maple features.

In this section:

- Accessing the Help System
- Using the Help Navigator
- Viewing Help Pages as Worksheets
- Copying Examples

Accessing the Help System

To access the Maple help system:

- From the **Help** menu in your worksheet, select **Maple Help**.

or

- In the worksheet, enter **?HelpOverview**.

The Maple help system opens in a separate window. The window has two panes. The left pane contains the Help Navigator where you initiate searches, and the right pane displays the final search result, such as a specific help page.

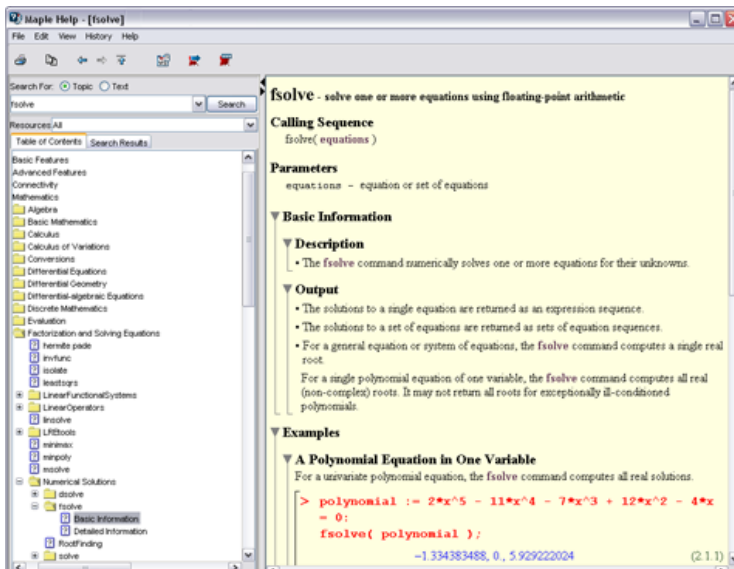







Figure 2.2: Example Help Page

Using the Help Navigator

The Help Navigator contains a field for topic or text-based searches.

- **Topic** searches reveal a list of matching topics sorted by exactness of match.
- **Text** searches reveal a list of topics based on keyword frequency.
- You can search all or specific **Resources** such as Help Pages, Tasks, definitions in the Maple Math and Engineering Dictionary, Tutorials, and Manuals.
- Search results are displayed as a list in the **Search Results** tab of the left pane. Click the **Table of Contents** tab to view a structured list of all topics in the help system.
- A folder icon in the **Table of Contents** tab indicates that a topic can be expanded into subtopics.
- Clicking a topic preceded by a question mark icon displays the associated help page in the right pane.

To display potential matches in the right pane, click a topic preceded by an icon.

	Question mark icon indicates a help page.
	WS icon indicates an example worksheet. Example worksheets open in a new tab in the worksheet window.
	D icon indicates a Definition.
	T icon indicates a Task template.
	M icon indicates a Manual. Manuals open in a new tab in the worksheet window.

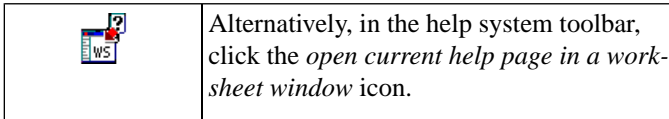
Viewing Help Pages as Worksheets

In help pages, examples are not executable.

The Maple help system allows you to open help pages as worksheets that you can execute.

To open a help page as a worksheet:

- With the help page displayed in the right pane of the help system, from the **View** menu, select **Open Page as Worksheet**. A new worksheet window opens.



Copying Examples

Instead of opening the entire page as a worksheet, you can copy the **Examples** section to a worksheet.

To copy examples:

1. With the help page displayed in the right pane of the help system, from the **Edit** menu, select **Copy Examples**.
2. Close or minimize the Help Navigator and return to your worksheet.
3. In your worksheet, place the cursor at the location where the examples are to be pasted.
4. From the **Edit** menu, select **Paste**. The **Examples** section of the help page is now executable content in your worksheet.

2.3 Point-and-Click Interaction

Maple contains many built-in features that allow you to solve problems quickly without learning new commands.

In this section:

- Assistants
- Tutors
- Context Menus
- Task Templates
- Palettes
- Maplet Applications

Assistants

Using the **Tools>Assistants** menu, you can access tools to help you accomplish various tasks.

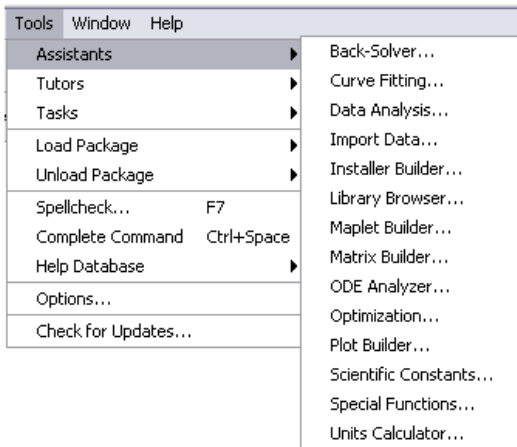


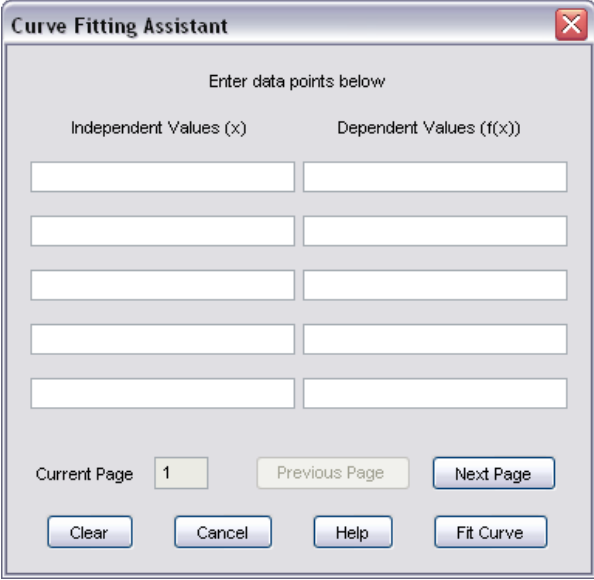
Figure 2.3: Accessing the Assistants from the Tools Menu

The Assistants are graphical user interfaces to various routines.

- **Back-Solver** - a worksheet that allows you to take a mathematical formula, which involves multiple parameters, enter values for all but one of the parameters and solve for the remaining one. You can also produce a graph that shows the behavior of the formula as one of the parameters varies.
- **Curve Fitting** - a graphical user interface to commands in the **CurveFitting** package. Data points can be entered as independent and dependent values.
- **Data Analysis** - a graphical user interface to the data analysis commands in the **Statistics** package.
- **Import Data** - a graphical user interface to read data from an external file into Maple. Output is a Maple Matrix.
- **Installer Builder** - a graphical user interface to the **InstallerBuilder** package in which you can create installers for your Maple toolboxes. For information on toolboxes, go to <http://www.maplesoft.com>.
- **Library Browser** - a graphical user interface to manipulate the libraries in a specified directory.
- **Maplet Builder** - a graphical user interface to the **Maplets** package. The **Maplets** package contains commands for creating and displaying Maplet applications (point-and-click interfaces). For a definition of Maplets, see *Maplet Applications (page 39)*. Using the Maplet Builder, you can define the layout of a Maplet, drag-and-drop elements (visual and functional components of Maplets), set actions associated with elements, and directly run a Maplet application. The Maplet Builder is available only in the Standard Worksheet interface.
- **ODE Analyzer** - a graphical user interface to obtain numeric or symbolic solutions to a single ODE or a system of ODEs. You can also plot the solution.
- **Optimization** - a graphical user interface to the solver commands in the **Optimization** package. The **Optimization** package is a collection of commands for numerically solving optimization problems, which involve

finding the minimum or maximum of an objective function possibly subject to constraints. You can select one of the methods shown in the interface to obtain a minimum (or maximum) of an objective function under the given constraints. When you click the **Solve** button, the problem (the objective function, constraints, bounds, and options) is solved using the indicated method, and the solution is provided in the **Solution** area of the Maplet application. When a solution is obtained, clicking the **Plot** button displays a plot of the objective function in the region of the solution or, if the problem is bounded, a plot of the objective function over the search region.

- **Plot Builder** - a graphical user interface for creating plots, animations, and interactive plots with sliders in two and three dimensions.
- **Scientific Constants** - an interface to the Maple database of scientific constants with over 20000 values of physical constants and properties of chemical elements. All of these constants come with the corresponding unit and, if applicable, with the uncertainty or error, that is, how precisely we know the value of this constant.
- **Special Functions** - an interface to the Maple database of the properties of over 200 special functions, including the Hypergeometric, Bessel, Mathieu, Heun and Legendre families of functions.
- **Units Calculator** - a worksheet that allows you to convert between 500 units of measurement.



The image shows a dialog box titled "Curve Fitting Assistant" with a close button in the top right corner. The main area contains the instruction "Enter data points below" and two columns of input fields. The left column is labeled "Independent Values (x)" and the right column is labeled "Dependent Values (f(x))". There are five rows of input fields, each with one field in each column. At the bottom, there is a "Current Page" label with a text box containing the number "1", and three buttons: "Previous Page", "Next Page", and "Fit Curve". Below these are four buttons: "Clear", "Cancel", "Help", and "Fit Curve".

Independent Values (x)	Dependent Values (f(x))
<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="text"/>

Current Page:

Figure 2.4: Assistant Example: Curve Fitting

Tutors

Using the **Tools>Tutors** menu, you can access over 40 interactive tutors that aid in the learning of precalculus, calculus, multivariate calculus, vector calculus, and linear algebra concepts.

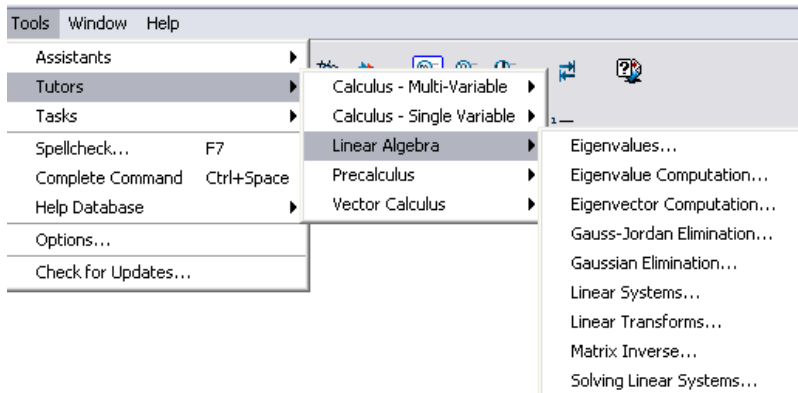


Figure 2.5: Accessing Tutors from the Tools Menu

The Tutors are also accessed through the **Student** package. For a definition of the term *package*, see *Commands* (page 40).

The **Student** package is a collection of subpackages designed to assist with the teaching and learning of standard undergraduate mathematics. The subpackages contain many commands for displaying functions, computations, and theorems in various ways, and support for stepping through important computations.

- The **visualization** commands are tools that create plots and animations showing the geometric interpretation of important concepts.
- The **computation** commands help you study the techniques of computation while solving problems. For example, using the **Calculus1** package, you can differentiate a function one step at a time, specifying the differentiation rule applied at each step. At any time during a single-step computation, you can request a hint about the next step, which you can then apply to the problem, or proceed directly to the final answer.

- The **interactive** commands use Maplet technology to help you explore concepts and solve problems using a point-and-click interface. These commands launch tutors that provide a graphical interface to visualization and computation commands.

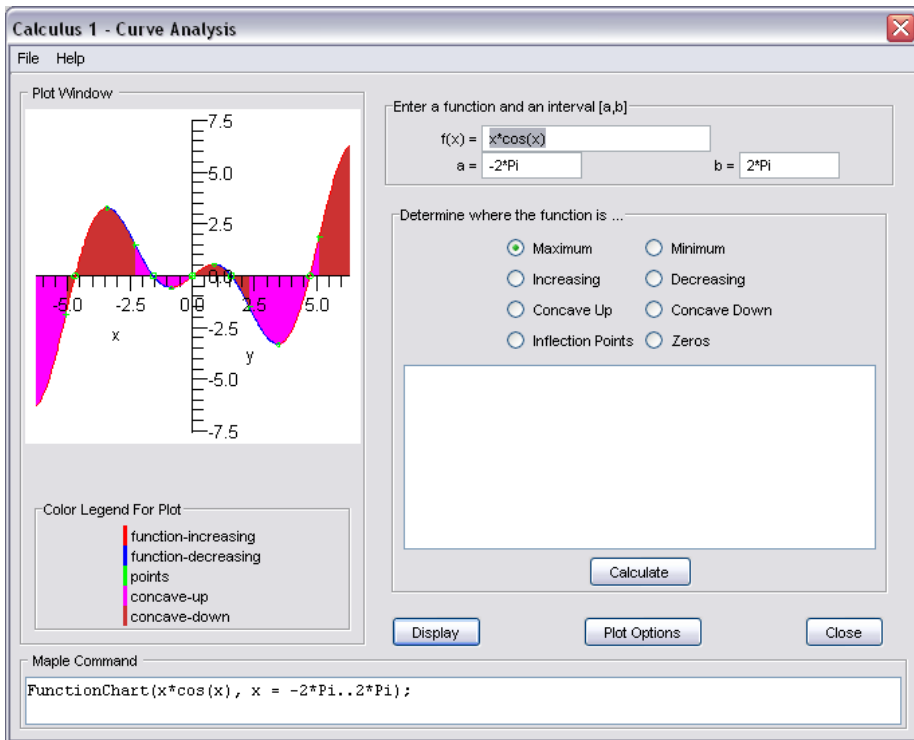


Figure 2.6: Tutor Example: Calculus 1 - Curve Analysis

Context Menus

Maple dynamically generates a context menu when you right-click (for Macintosh, **Control**-click) an object or expression. The actions available on the context menu depend on the properties of the object or expression. For example, you can manipulate and graph expressions, enhance plots, and format text.

Example Context Menus

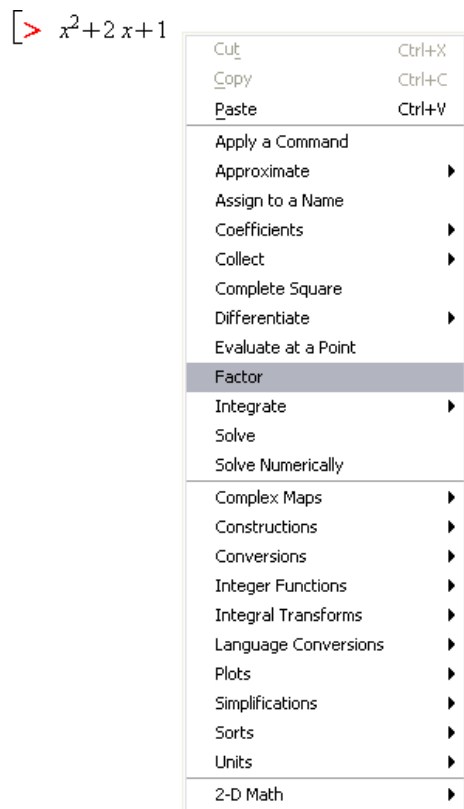


Figure 2.7: Right-click (Control-click) Expressions

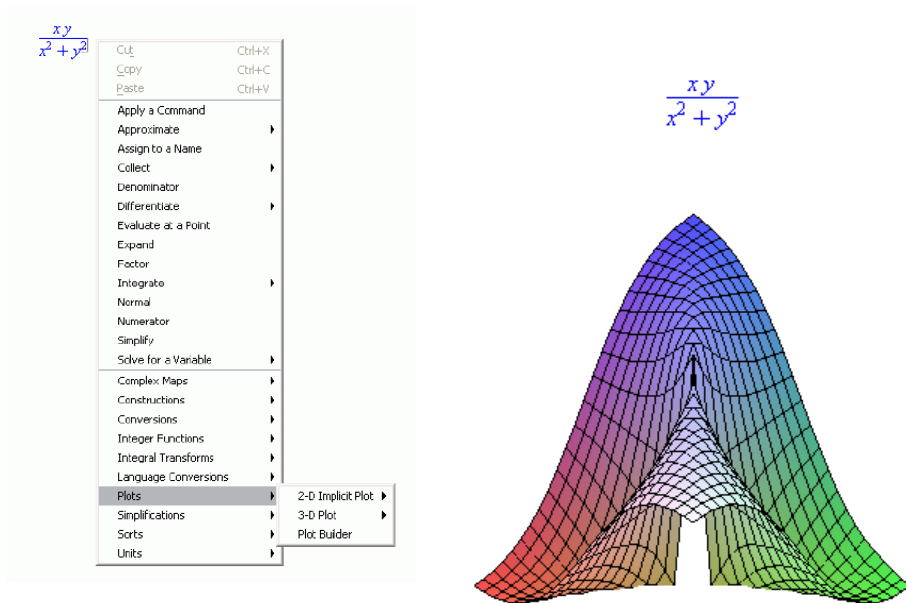


Figure 2.8: Right-click (Control-click) Expressions to Graph Results

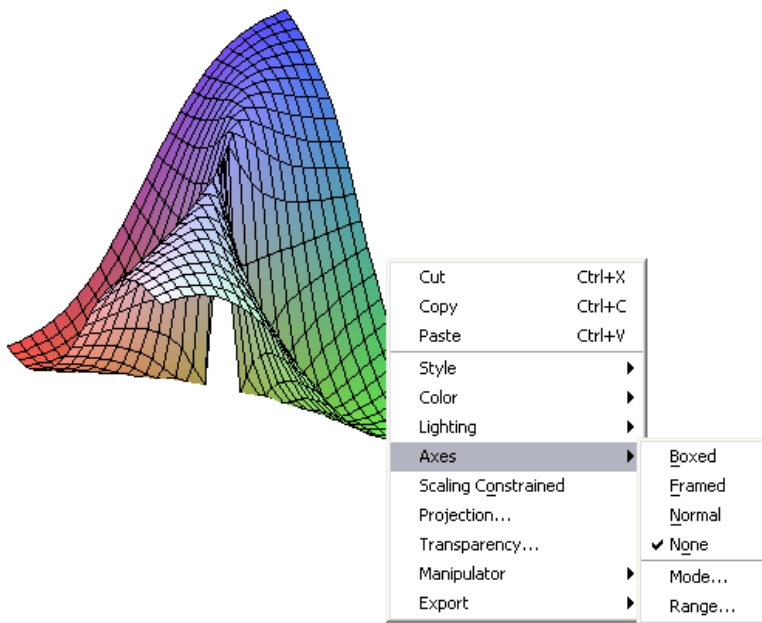


Figure 2.9: Right-click (Control-click) Plots to Change Display Options

[The following text

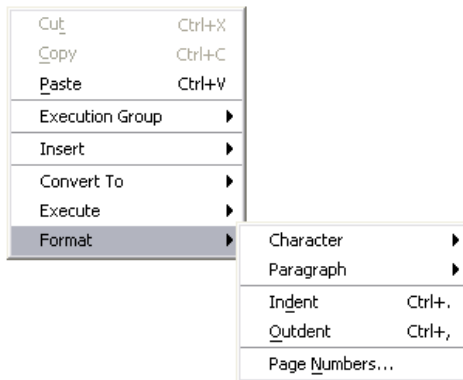


Figure 2.10: Right-click (Control-click) Text

Task Templates

Task templates help you perform a specific task in Maple, such as:

- Performing a mathematical computation, for example, solving an equation symbolically or numerically, or determining the Taylor approximation of a function of one variable
- Constructing a Maple object, for example, a function
- Creating a document, for example, an application

The tasks are organized in the help system by subject, to help you quickly find the appropriate task. Each task is a collection of Maple worksheet content, such as 2-D mathematics, commands, embedded components (for example, buttons) and plots that you can directly insert into your worksheet. You specify the parameters of your problem, and then run the worksheet.

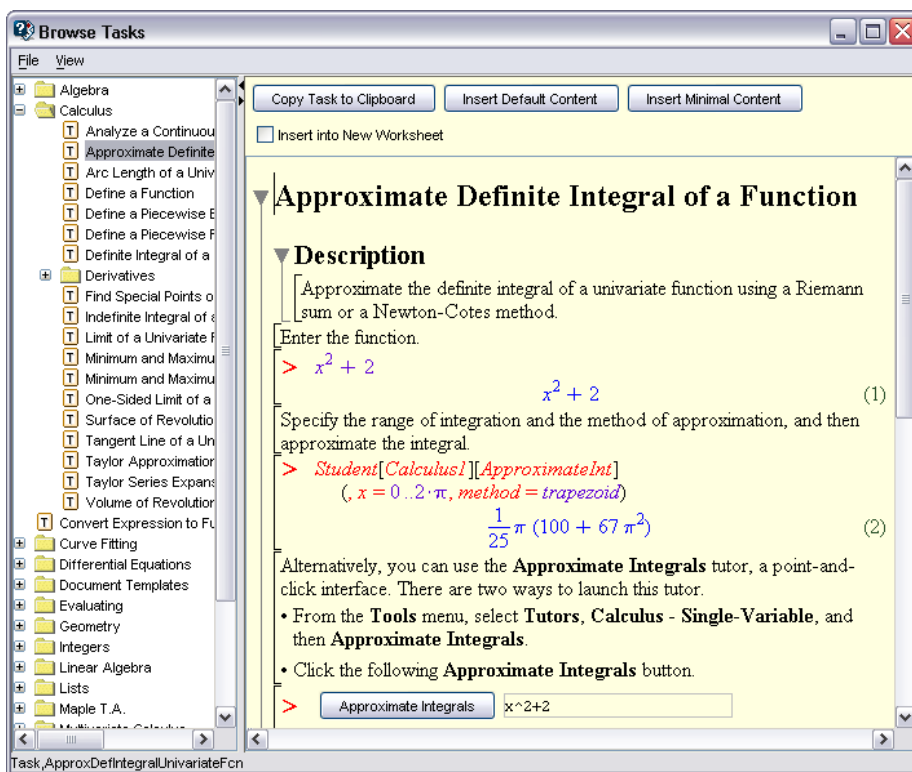


Figure 2.11 Browse Tasks Dialog

Previewing Tasks

Maple tasks can be previewed in three ways.

- From the **Tools** menu, select **Tasks**, and then **Browse**. The **Browse Tasks** dialog opens and displays the list of tasks.
- From the **Help** menu, select **Manuals, Dictionary, and more**, and then **Tasks**. The Help Navigator opens. In the left pane, click the **Tasks** folder to displays the list of tasks.
- From the **File** menu, select **New**, and then **Templates**. The **Browse Tasks** dialog opens and displays the list of tasks.

The tasks are sorted by subject to help you quickly find the desired task. In the **Browse Tasks** dialog or Help Navigator, you can view tasks without inserting them into your worksheet.

Inserting a Task into the Worksheet

From both the **Browse Tasks** dialog and the Help Navigator, you can insert a task into a worksheet.

1. Select the **Insert into New Worksheet** check box.
2. Click **Insert Default Content** or **Insert Minimal Content**.
 - Default content includes the task title and description.
 - Minimal content inserts only the major components (commands and buttons).

Note: You can view the history of previously inserted tasks. From the **Tools** menu, select **Tasks**. Previously selected task names are displayed below the **Browse** menu item.

Before inserting a task, Maple checks whether the task variables have assigned values in your worksheet. If any task variable is assigned, the **Task Variables** dialog opens to allow you to modify the names. Maple uses the edited variable names for all variable instances in the inserted task.

By default, the **Task Variables** dialog is displayed only if there is a naming conflict. You can set it to display every time you insert a task.

To specify that the Task Variables dialog be displayed every time you insert a task:

1. From the **Tools** menu, select **Options**.
2. Click the **Display** tab.
3. In the **Show task variables on insert** drop-down list, select **Always**.
4. Click **Apply to Session**, or **Apply Globally**, as necessary.

Updating Parameters and Running the Commands

In tasks, parameters are marked as placeholders or specified using sliders or other embedded components. Update the parameter values as required.

Note: To navigate between placeholders in the worksheet, press the **Tab** key.

After updating any parameters, perform the task by running the commands or by clicking buttons.

Palettes

The Maple worksheet environment provides access to over 20 palettes. Palettes are collections of related items that you can insert by clicking or drag-and-dropping into a document. Palettes contain:

- Symbols, like π , ∞ , ∇
- Layouts, like an item with a superscript and subscript
- Mathematical operations, like a definite integral with placeholders for the integrand, variable of integration, and endpoints of the interval of integration

You can create a **Favorites** palette of the expressions and entities you use often.

The **Handwriting** palette provides an efficient way to find and insert the desired symbol. You draw the symbol with your mouse and then Maple matches your input against symbols available in the system.

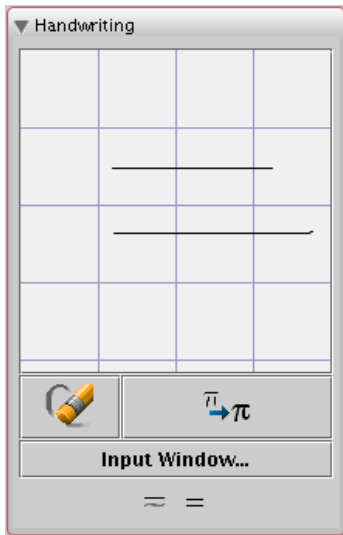


Figure 2.12: Handwriting Palette

By default, palettes are displayed when you launch Maple.

To view palettes:

1. From the **View** menu, select **Palettes**.
2. Select **Expand Docks**.
3. Right-click (**Control-click**, for Macintosh) the palette dock. From the context menu, select **Show All Palettes**.

Alternatively, from the main menu, select **View>Palettes>Arrange Palettes** to display specific palettes.

Important: This section provides an overview of the palettes. For instructions on using palettes with Maple Input (1-D Math) and Standard Math (2-D Math) Input notation, see *Commands* (page 40).

Expression Palettes

- **Expression** - a palette for constructing expressions such as integrals and derivatives.
- **Matrix** - a palette consisting of a dialog that allows you to enter the number of rows and columns required, designate type, such as zero-filled, and designate shape, such as diagonal. See Figure 2.14.
- **Layout** - a palette that allows you to add math content that has specific layout, such as expressions with one or more superscripts and subscripts.
- **Components** - a palette that allows you to embed simple graphical interface components, for example, a button, into your worksheet. You can associate actions with components, for example, a command that is executed when a button is clicked.
- **Handwriting** - a palette that provides an efficient way to find and insert the desired symbol. Draw the symbol with your mouse and Maple matches your input against symbols available in the system.
- **Units (SI)** - a palette that inserts a unit from the International System of Units (SI), or any general unit. For details, refer to the **?Units/SI** help page.
- **Units (FPS)** - a palette that inserts a unit from the Foot-Pound-Second System (FPS), or any general unit. For details, refer to the **?Units/FPS** help page.

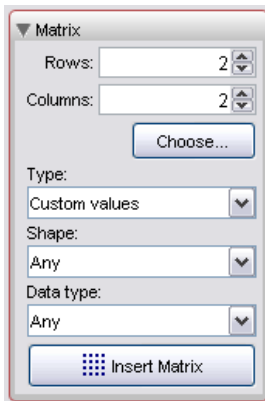


Figure 2.13: Matrix Palette

Mathematical Palettes

- **Common Symbols** - a palette of common symbols for constructing expressions using sums, products, and π among other things. See Figure 2.15.
- **Relation Standard** - a palette of standard relational operator symbols for constructing expressions.
- **Operators** - a palette of operators for constructing expressions.
- **Relational Round** - a palette of round relational operator symbols for constructing expressions.
- **Large Operators** - a palette of large operators for constructing expressions.
- **Negated** - a palette of negation symbols for constructing expressions.
- **Fenced** - a palette of fenced symbols for constructing expressions.
- **Arrows** - a palette of arrow symbols for constructing expressions.
- **Constants and Symbols** - a palette of constants and symbols for constructing expressions.
- **Punctuation** - a palette of various punctuation symbols, such as the registered trademark and copyright symbols, for inserting into text regions.

- **Miscellaneous** - a palette of miscellaneous math and other symbols outside the above categories.

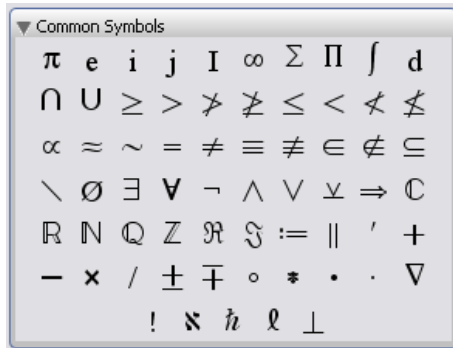


Figure 2.14: Common Symbols Palette

Alphabetical Palettes

- Roman Extended Upper Case, Roman Extended Lower Case, Diacritical Marks, Greek (Figure 2.15), Cyrillic, Script, Open Face, and Fraktur.

Note: Use the Roman Extended Upper Case and Lower Case palettes for accents, such as grave or umlaut.






Figure 2.15: Greek Alphabet Palette

Placeholders and the Tab Key

As an illustration, click the exponent button in the **Expression** palette. The expression is displayed with the first placeholder highlighted. To move to the next placeholder, use the **Tab** key.

The Tab icon in the toolbar allows you to set the **Tab** key to move between placeholders or to indent.

	Tab icon off . Allows you to move between placeholders using the Tab key.
	The Tab icon is disabled when using 2-D Math (Math mode), and as such, the Tab key allows you to move between placeholders. For details about 2-D Math, see <i>Commands</i> (page 40) .
	Tab icon on . Allows you to indent in the worksheet using the Tab key.

Maplet Applications

A Maplet application is a graphical user interface containing windows, textbox regions, and other visual interfaces, which gives you point-and-click access to the power of Maple. You can perform calculations, plot functions, or display dialogs without using the worksheet interface.

The following simple Maplet contains a textbox region, a button, and a label prompting you to enter an equation.



Figure 2.16: Maplet Application Example

You can create custom Maplets using the **Maplets** package (syntax-based) or the **Maplet Builder** (a graphical user interface tool). For details, refer to the *Maple User Manual*.

2.4 Commands

Maple is powerful, flexible, and customizable. In addition to the point-and-click features, Maple contains a set of commands and a programming language.

In this section:

- The Maple Library
- Commands in the Worksheet
- 2-D Math Input
- Maple Input (1-D Math Input)
- Learning about Commands and Packages
- Using Examples to Learn About Commands
- Equation Labels

The Maple Library



Commands are contained in the Maple library, which is divided into two groups: the *main library* and *packages*.

- The main library contains the most frequently used Maple commands.
- Packages contain related specialized commands for performing tasks from disciplines such as Student Calculus, Statistics, or General Relativity Theory.

Commands in the Worksheet

In Worksheet mode, a new worksheet opens with a Maple prompt in the upper left-hand corner. Enter Maple commands at this prompt for Maple to recognize your entry as Maple Input (1-D Math) or 2-D Math and execute the command.

Basic Usage	Description
Maple prompt	>
Running the entire worksheet (executing all commands)	<ul style="list-style-type: none"> • In the toolbar, click the !!! icon. • From the Edit menu, select Execute>Worksheet.
Executing one command	Place the cursor in any Maple input region in the execution group and press the Enter key.
Executing selected area	<ul style="list-style-type: none"> • In the toolbar, click the ! icon. • From the Edit menu, select Execute>Selection.
Semicolon	Statement separator. Terminate a 1-D or 2-D command with a semicolon ; and output is displayed. Important: All 1-D commands must terminate with a semicolon or colon.
Colon	Statement separator. Terminate a 1-D or 2-D command with a colon : and output is not displayed. Important: All 1-D commands must terminate with a semicolon or colon.
restart;	<p>The restart command causes Maple to clear its internal memory.</p> <p>Alternatively, in the toolbar, click the restart icon.</p> <div data-bbox="857 1037 917 1095" data-label="Image"> </div> <p>For specific details, refer to the <i>Maple User Manual</i>.</p>

Basic Usage	Description
2-D Math	<p><i>Default setting.</i> Executable standard math notation. Displayed in a format similar to that found in business and education documents.</p> <p>$> \int f(x) dx$</p> <p>Access from the Insert>2-D Math menu.</p> <p>To switch between 1-D and 2-D Math, press the F5 key.</p> <p> When using 2-D Math, the Math mode icon is highlighted in the toolbar.</p>
Maple Input (1-D Math)	<p>Executable Maple notation. Usually an expression that Maple can evaluate.</p> <p>$> \mathbf{factor(x^2 + 2*x + 1);}$</p> <p>$(x + 1)^2$</p> <p>Access from the Insert>Maple Input menu.</p> <p>To switch between 1-D and 2-D Math, press the F5 key.</p> <p> When entering Maple Input or text in a text region, the Text mode icon is highlighted in the toolbar.</p>

2-D Math

The *default* 2-D Math feature allows you to enter content in standard math notation.

> restart

> factor($x^2 + 2x + 1$)

$$(x + 1)^2$$

Tip: Use the ^ key, that is x^2 , to enter x^2 . Use the right arrow key to leave the exponent.

Basic Maple Functions:

The following are examples of basic Maple functions.

> $\cos(\alpha)^2 + \sin(\alpha)^2$

$$\cos(\alpha)^2 + \sin(\alpha)^2$$

> $a \int e^{(\sqrt{2} x)} dx$

$$\frac{1}{2} a \sqrt{2} e^{(\sqrt{2} x)}$$

> $\lim_{x \rightarrow \infty} f(x)$

$$\lim_{x \rightarrow \infty} f(x)$$

> $\sum_{k=0}^m a_k x^k = \prod_{j=0}^n (b_j x^j)$

$$\sum_{k=0}^m a_k x^k = \prod_{j=0}^n (b_j x^j)$$

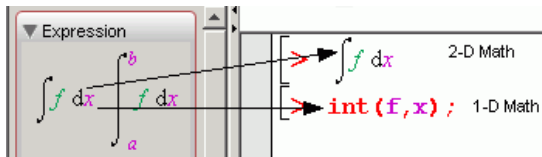
To use a palette with 2-D Math:

1. Ensure the palette you require is visible. If necessary, from the **View** menu, select **Palettes**, and then **Arrange Palettes**.
2. Ensure that you are in **Math** mode. If necessary, press **F5** to switch between 1-D Math (Text mode) and 2-D Math (Math mode).
3. With your mouse, click a palette expression. The expression is displayed in 2-D Math notation in the execution group of the worksheet.
4. The first placeholder is highlighted. Enter your expression, and if necessary, use the **Tab** key to move to the next placeholder.
5. Press **Enter**.

Why Use Palettes in 2-D Math?

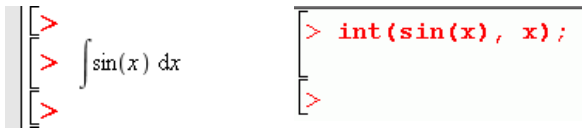
- If you are a new Maple user, palettes make entering expressions easier than entering syntax and reduce the possibility of introducing typing errors.
- Your worksheet uses standard notation for mathematical content.

In the following figure, compare the 2-D and 1-D Math input.



You can control the appearance of expressions in the worksheet. You can convert 2-D Math to 1-D Math.

1. Enter an expression in 2-D Math notation.
2. Select the expression and then right-click (**Control**-click, Macintosh) to open the context menu.
3. Select **2-D Math, Convert To**, and then **1-D Math Input**. The expression is displayed in 1-D Math input notation.
4. Press **Enter** to evaluate the expression.



You can change the default math input notation for your Maple session for future use.

To change math input notation for a session or globally:

1. From the **Tools** menu, select **Options**. The **Options Dialog** opens.
2. Click the **Display** tab.
3. In the **Input Display** drop-down list, select **2-D Math Notation**.
4. Click the **Apply to Session** or **Apply Globally** button.

Important: The selected input display becomes available *after* the current execution group.

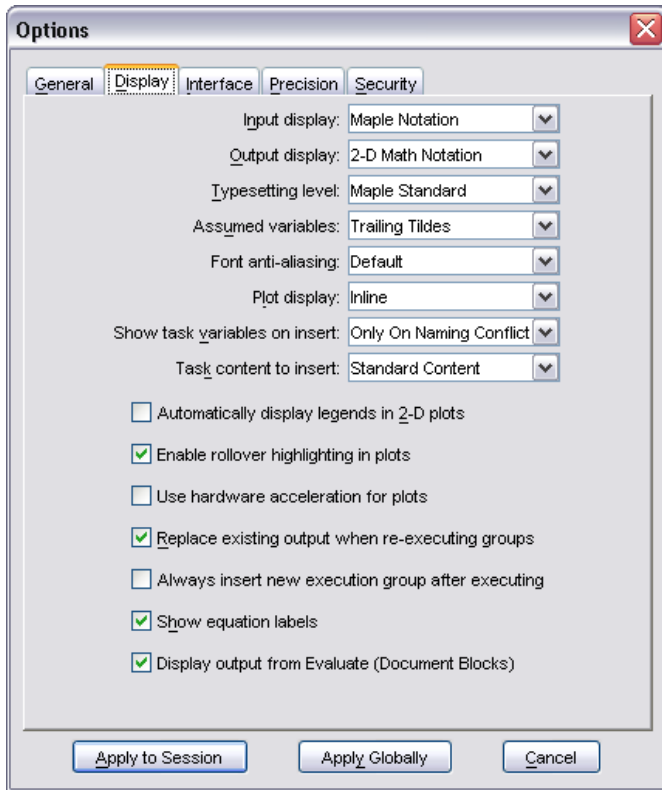


Figure 2.17: Options Dialog: Input Display

Maple Input (1-D Math)

Important: With Maple Input, you must terminate commands with a semicolon or colon.

> restart;

Enter the Maple input followed by a semicolon. If the input ends with a semicolon, the result is usually displayed, as seen below.

> factor(x² + 2*x + 1);

$$(x + 1)^2$$

However, if the input ends with a colon, the result is computed but the result is *not* displayed.

> factor(x^2 + 2*x + 1):

Define custom functions.

> f := x -> x * 2;

$$f := x \rightarrow 2x$$

> f(3);

$$6$$

> f(y + 1);

$$2y + 2$$

Basic Computations:

The following are examples of basic computations using Maple Input (1-D Math).

> cos(alpha)^2+sin(alpha)^2;

$$\cos(\alpha)^2 + \sin(\alpha)^2$$

> a*x^2+b*x=c;

$$ax^2 + bx = c$$

> **a*int(exp(sqrt(2)*x),x);**

$$\frac{1}{2} a \sqrt{2} e^{\sqrt{2} x}$$

> **restart;**

> **limit(f(x),x=infinity);**

$$\lim_{x \rightarrow \infty} f(x)$$

> **sum(a[k]*x^k, k=0..m)=product(b[j]*x^j, j=0..n);**

$$\sum_{k=0}^m a_k x^k = \prod_{j=0}^n (b_j x^j)$$

To use a palette with 1-D Math Input:

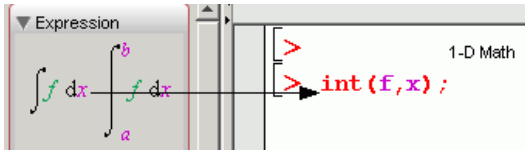
1. Ensure the palette you require is visible. If necessary, from the **View** menu, select **Arrange Palettes**.
2. Ensure that you are in **Text** mode. If necessary, press **F5** to switch between 1-D Math (Text mode) and 2-D Math (Math mode).
3. With your mouse, click a palette expression. The expression is displayed in 1-D Math notation in the execution group of the worksheet.
4. The first placeholder is highlighted. Enter your expression, and if necessary use the **Tab** key to move to the next placeholder.

Important: Ensure that your **Tab** key is set to move to the next placeholder and not indent. For details, see *Placeholders and the Tab Key (page 39)*.

5. Press **Enter**.

Why Use Palettes in 1-D Math?

- Using a palette that uses standard notation, teaches you the related Maple command syntax.



You can control the appearance of expressions in the worksheet. You can convert 1-D Math to 2-D Math.

To convert 1-D to 2-D math input:

1. Enter an expression in 1-D Math notation.
2. Select the expression and then right-click (**Control**-click, Macintosh) to open the context menu.
3. Select **Convert To**, and then **2-D Math Input**. The expression is displayed in 2-D Math input notation.
4. Press **Enter** to evaluate the expression.

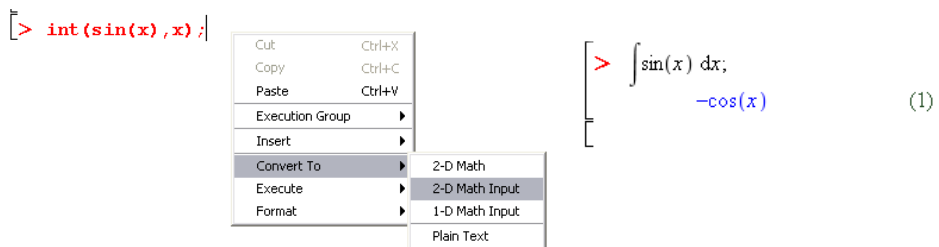


Figure 2.18: 1-D Math Input Converted to 2-D Math Input

Learning About Commands and Packages

Each help page contains the correct syntax for a command: calling sequences, parameters, and description of use. Examples and links to related subjects are provided at the bottom of each help page. Many topics include more examples, which are presented in example worksheets.

To view a list of top-level commands:

1. From the **Help** menu, select **Manuals, Dictionary, and more**.
2. Select **List of Commands**.

A Maple package is a group of related commands. For example, the **Optimization** package contains commands for numerically solving optimization problems.

To view a list of packages:

1. From the **Help** menu, select **Manuals, Dictionary, and more**.
2. Select **List of Packages**.

To use a package command, specify both the package and command names using the syntax *package[command](arguments)*.

If you are using a number of commands in the package, load the package using the **with** command.

To load a package:

- At the Maple prompt, enter the **with** command, followed by the package name enclosed in parentheses and terminated with a semicolon (1-D Math input). Then press **Enter**.

Using the with command to load the Optimization package

```
> with(Optimization);
[ImportMPS, Interactive, LPSolve, LSSolve, Maximize,
 Minimize, NLPsolve, QPSolve]
```

A list of all commands in the package is displayed. To suppress the display of all command names, end the **with(Optimization)** command with a colon.

```
> with(Optimization):
```

After loading a package, you can use the short-form names, that is, the command names, without the package name.

```
> LSSolve([x-2,x-6,x-9]):
```

Automatic Command Completion

By default, automatic command completion is enabled. If it is not enabled, from the main menu, select **Tools>Options>Interface** tab. Select the **Automatic command completion** check box.

1. Begin entering a command in the worksheet. Maple compares your entry with Maple packages, commands, functions, and other assigned names. If the entered text has a unique completion, a tool tip containing the matching command name is displayed above the entry.
2. You can continue typing the command or press **Enter** to insert the command.

```
>
>
> LinearAlgebra
> LinearA
```

To disable automatic command completion:

- From the main menu, select **Tools>Options>Interface** tab. Clear the **Automatic command completion** check box.

Manual Command Completion

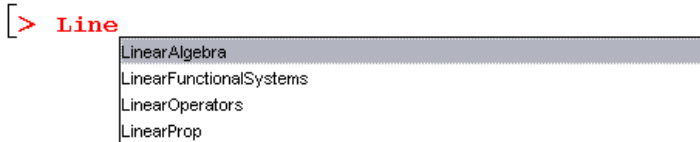
Manual command completion is always enabled.

To use manual command completion:

1. Begin entering a command in the worksheet.
2. To list all Maple packages, commands, and functions that match the entered text, select **Tools>Complete Command** or use short cut keys.
 - **Escape**, Macintosh
 - **Ctrl + Space**, Windows
 - **Ctrl + Shift + Space**, UNIX

If there is a unique completion, it is inserted. Otherwise, a list of matches is displayed.

3. Select the correct completion from the list.



Using Examples to Learn about Commands

Most help pages contain examples you can copy and run in the worksheet. However, some topics also provide example worksheets that demonstrate the power of Maple commands. You can use the example worksheets to learn how commands and options behave.

To access example worksheets:

- In the worksheet, enter **?examples/index**. The **Index to Example Worksheets** opens.

Topics presented include:

- Algebra
- Applications (finance, scientific constants, scientific error analysis)
- Calculus
- Connectivity (code generation, external calling)
- Differential Equations
- Discrete Mathematics
- General Numerics
- General Symbolics
- Geometry
- Integration
- Integral Transforms
- Language and System
- Mathematical Visualizations

Elliptic Integration

Elliptic integrals are of the form $\int_a^b \frac{a(x)}{b(x) \sqrt{y(x)}} dx$, where $y(x)$ is a polynomial of degree 3 or 4, and $a(x)$ and $b(x)$ are polynomials.

> restart;

Complete Elliptic Integrals

Maple recognizes the complete elliptic integrals

$\int_0^{\frac{\pi}{2}} \frac{1}{\sqrt{1-k^2 \sin^2(t)}} dt$ (First Kind),

$\int_0^{\frac{\pi}{2}} \sqrt{1-k^2 \sin^2(t)} dt$ (Second Kind),

$\int_0^{\frac{\pi}{2}} \frac{1}{(1-a \sin^2(t)) \sqrt{1-k^2 \sin^2(t)}} dt$ (Third Kind)

where $0 < k < 1$. We see this as follows:

First, we tell Maple that the usual parameter k lies between 0 and 1.

> assume(0<k,k<1);

Figure 2.19: Example Worksheet

Note: You can also use the **Help** menu to access **Applications**—sample applications that demonstrate how Maple can be used to find and document a solution to a specific problem.

To access Applications from the Help menu:

- From the **Help** menu, select **Manuals, Dictionary, and more**, and then **Applications and Examples**. The **Applications and Examples** help page opens.

Equation Labels

Equation labeling allows you to reference Maple output in text and math of your worksheet. The label is associated with all output within an execution group. You cannot apply equation labels to the following.

- Error, warning, and information messages
- Tables, images, plots, sketches, or spreadsheets

By default, equation labels are displayed. If equation labels are not displayed, verify the following.

- From the **Tools** menu, select **Options**, and click the **Display** tab. Ensure that the **Show equation labels** check box is selected.
- From the **Format** menu, select **Labels**. Ensure that **Worksheet** is selected.

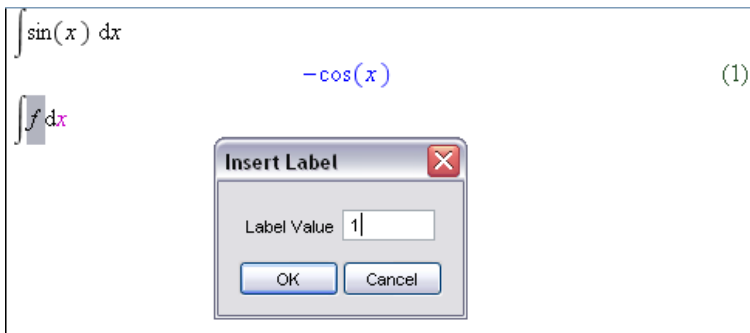


Figure 2.20 Inserting an Equation Label

$$\int \sin(x) dx \qquad -\cos(x) \qquad (1)$$

$$\int (1) dx \qquad -\sin(x) \qquad (2)$$

Figure 2.21: Equation Label

To apply equation labels:

1. Enter an expression and press **Enter**. Note that the equation label is displayed to the right of the answer in the worksheet.
2. In a new execution group, enter another expression that will reference the output of the previous execution group.

3. From the **Insert** menu, select **Label**. Enter the label number in the **Insert Label** dialog and click **OK**. Alternatively, press **Ctrl+L** (**Command+L**, Macintosh) to open the **Insert Label** dialog.

4. The item is now a label. Press **Enter** to obtain the result.

You can change the formatting of equation labels.

- From the **Format** menu, select **Labels**, and then **Label Display**. In the **Format Labels** dialog, select one of the numbering schemes.
- Optionally, enter an appropriate numbering prefix.

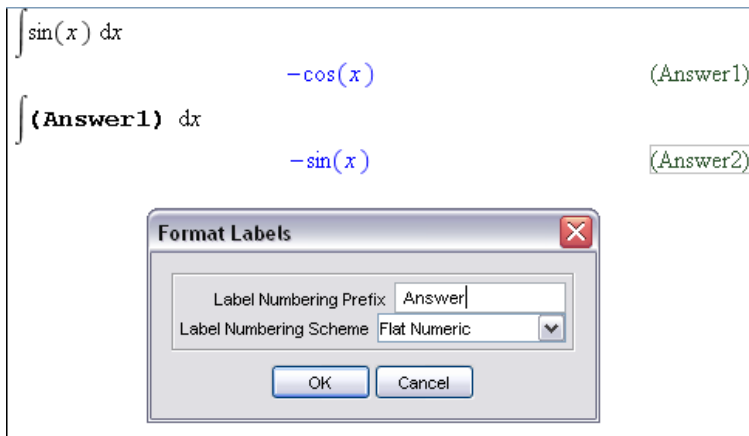


Figure 2.22 Format Labels Dialog: Adding a Prefix

The **Format>Labels>Label Reference** menu item allows you to switch between the label name and its reference content.

$$\int \sin(x) \, dx = -\cos(x) \quad (1)$$

$$\int -\cos(x) \, dx = -\sin(x) \quad (2)$$

Figure 2.23: Label Reference

2.5 Worksheet Formatting Features

Markers

Maple displays **markers** for formatting features in a vertical bar along the left pane of the worksheet. These markers (icons) indicate the presence of hidden attributes in the worksheet such as Document block boundaries, execution groups marked for autoexecute, annotations, bookmarks, and numeric formatting.

To activate markers:

- From the **View** menu, select **Markers**.

Document Blocks

In Worksheet mode, document blocks allow you to hide input or output (1-D and 2-D content) within a specified area. You can combine text and 2-D content in the same line. Document blocks can be collapsed to hide input or output, or expanded to reveal Maple code. This feature is useful when creating a presentation where, for example, the Maple programming language is not essential to the concept and only output, such as a plot, the final answer, or explanatory text must be displayed. **Markers** indicate the boundaries of the document block. Input prompts and execution groups are not displayed in document blocks.



For details on using document blocks, see the *Maple User Manual*.

Bookmarks

A bookmark designates a location in an active worksheet that can then be accessed from other regions in your worksheet or by using hyperlinks in other worksheets. Markers indicate the location of the bookmark.

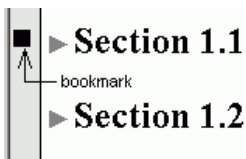


Figure 2.24: Bookmarks

2.6 Working in Document Mode

Document mode allows you start solving problems right away, free of the syntax of the worksheet environment.

Document mode is described as follows.

- A blank work area
- An input prompt or execution group is *not* displayed, although it can be inserted
- You can combine text and math in the same line
- As with Worksheet mode, you can insert images, plots, tables, sketches, and Maple spreadsheets
- All math is entered as 2-D Math

You execute 2-D Math in Document mode by using any of the following methods.

- Pressing **Ctrl** + = (**Command** + =, for Macintosh). This evaluates and displays results inline.
- Using the context-menu item **Evaluate and Display Inline**.
- Pressing the **Enter** key. This evaluates and displays results on the next line, or if set in the **Options** dialog simply evaluates.
- Using the context-menu item **Evaluate**.
- Command completion is supported. For specific platform shortcut keys, see *Common Key Strokes for Symbols and Formats* (page 60).

Starting a New Document

To start a new document in Document mode:

- From the **File** menu, select **New**, and then **Document Mode**.

Note: By default, Maple opens in Document mode.

Entering Math

Review the following example.

$$x^2 + y^2$$

Entering the expression:

1. Enter **x**.
2. Press the **^** key. The cursor moves to superscript position. Enter **2**.
3. Press the right arrow key. The cursor moves right. Enter the **+** symbol, and then enter **y**.
4. Press the **^** symbol. The cursor moves to superscript position. Enter **2**.

Evaluating the expression:

1. Right-click (**Control**-click, for Macintosh) the expression.


2. From the context menu, select **Evaluate and Display Inline**.

The result is displayed with an = sign.

$$x^2 + y^2 = x^2 + y^2$$

Common Key Strokes for Symbols and Formats

Palettes are the quickest way to enter special formats; however, you can also use the following key strokes.

Symbol/Formats	Key	Automatically Generated in Document
enter/exit 2-D Math	F5	Example using fraction: $\frac{1}{4}$ versus 1/4
command/symbol completion	<ul style="list-style-type: none"> • Escape, Macintosh • Ctrl + Space, Windows • Ctrl + Shift + Space, UNIX 	 <p>The screenshot shows a command completion palette with the following entries: 'ab', 'about', 'about', 'abreve', 'ã', 'abs', ' x ', 'abs', 'abs'.</p>
fraction	/ (forward slash)	$\frac{1}{4}$
exponent (superscript)	^ (caret)	x^2 Use right arrow key to leave superscript area.
subscript	_ (Shift + underscore)	x_a
square root	<i>sqr</i> , and then command-symbol completion shortcut key	$\sqrt{25}$
navigating the expressions	Arrow keys	

Opening Documents

Like in Worksheet mode, in Document mode documents are saved as **.mw** files.

Files saved in Document mode open automatically in Document mode and not in Worksheet mode.

Viewing Maple Code in Document Mode

In Document mode, documents are created as a series of document blocks. As such, you can expand document blocks to view hidden code.

To view code in Document mode:

1. Ensure that the **Markers** feature is activated. From the **View** menu, select **Markers**. Document block markers are displayed in the left side bar.
2. Insert the cursor in a document block to be expanded.
3. From the **View** menu, select **Expand Document Block**.
4. To hide the code again, from the **View** menu, select **Collapse Document Block**.

For more information on document blocks, see the *Maple User Manual*.

3 Using Maple

Maple is a powerful application with many resources to guide you. The following examples provide you with scenarios to learn about using Maple resources and the Maple program.

When using Maple to solve a problem, consider the following process.

1. Formulate your problem.
2. Obtain Maple resources that allow you to solve it.

3.1 Calculus Example

Problem

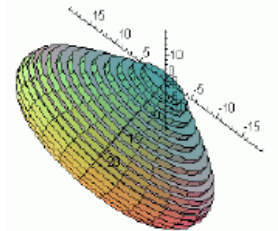
Scenario A:

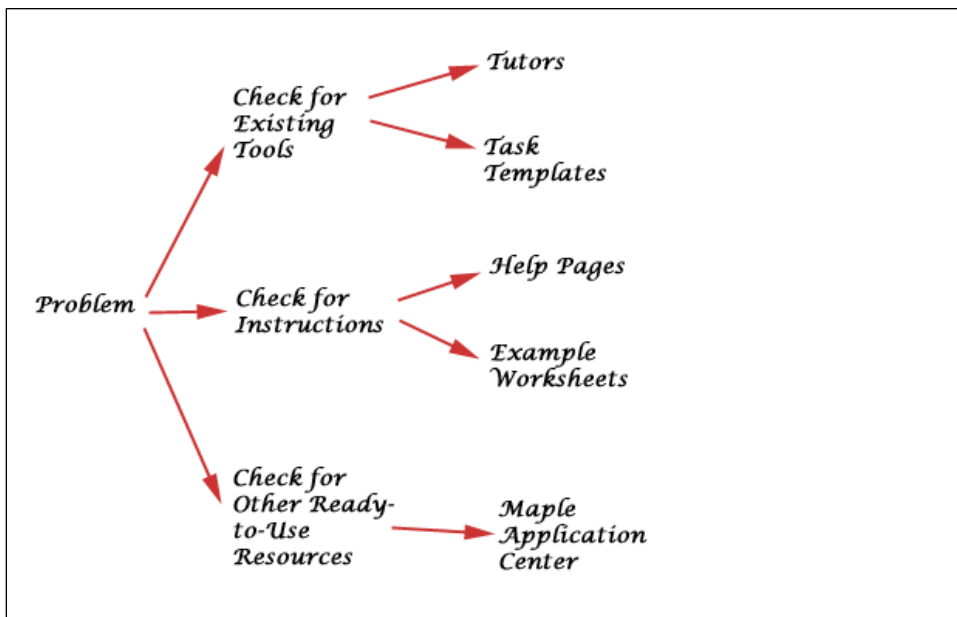
Your company is designing a bottle for its new spring water product. The bottle must contain 18 ounces of water and the height is fixed. The design includes an undulating curved surface. You know the amplitude and equation of the curve, but you must find the radius. You require the **Volume of Revolution**.



Scenario B:

You want to teach your students the concept of a **Volume of Revolution**. Specifically, you want to plot and compute the volume of a solid of revolution generated by rotating $f(x)$, $a \leq x \leq b$, about an axis or a line parallel to an axis.





Check for Existing Tools: Tutor

Begin by examining the **Tools** menu for a **Tutor** (graphical user interface) to a Volume of Revolution problem.

To access a Tutor for the Volume of Revolution:

1. From the **Tools** menu, select **Tutors**, and then **Calculus-Single Variable**. Notice that a **Volume of Revolution** tutor exists.
2. Click the **Volume of Revolution** menu item. The worksheet is populated with the following Maple command.

> `Student[Calculus1][VolumeOfRevolutionTutor]();`

The **Volume of Revolution Tutor** is displayed. (See Figure 3.1) The tutor is a graphical user interface that allows you to enter a function and an interval, view and manipulate the corresponding plot, and view the full Maple command associated with your entries and selections.

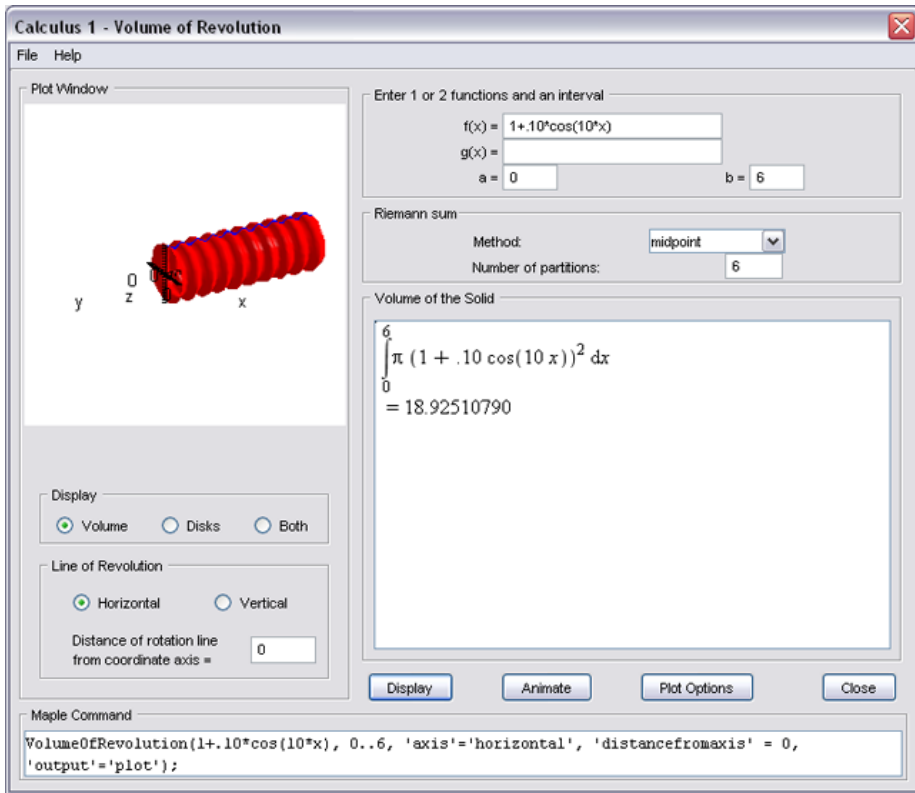


Figure 3.1: Volume of Revolution Tutor

After you **Close** the tutor, the plot is inserted into your worksheet.

Check for Existing Tools: Task Template

To access a task template for the volume of revolution:

1. From the **Tools** menu, select **Task**, and then **Browse**. The **Browse Tasks** dialog opens, displaying a list of tasks. The tasks are sorted by subject to help you quickly find the desired task.
2. Expand the **Calculus** folder.

3. From the displayed list, select **Volume of Revolution**. The **Volume of Revolution** task is displayed in the right pane of the **Browse Tasks** dialog. (See Figure 3.2)

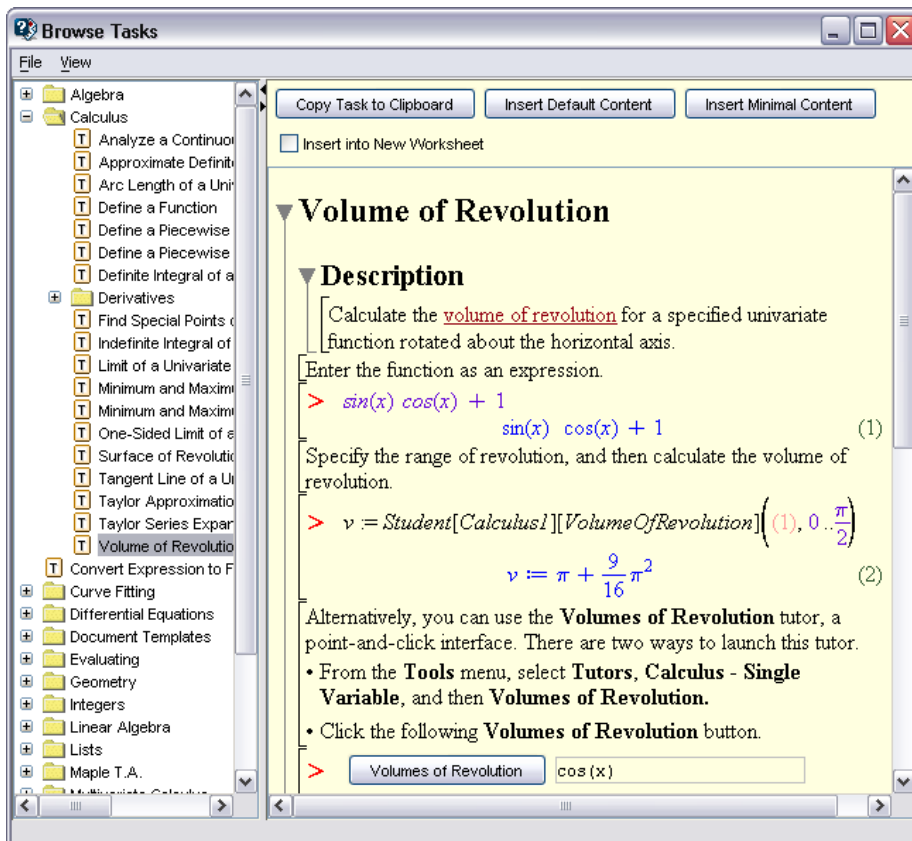


Figure 3.2: Task Template for Volume of Revolution

4. Select the **Insert into New Worksheet** check box.

5. Click **Insert Default Content**. Before inserting a task, Maple checks whether the task variables have assigned values in your worksheet. If any task variable is assigned, the **Task Variables** dialog opens allowing you to modify the names. Maple uses the edited variable names for all variable instances in the inserted task.

The command is inserted into your worksheet.

Volume of Revolution

Calculate the volume of revolution for a specified univariate function rotated about the horizontal axis.

Enter the function as an expression.

> $\sin(x) \cos(x) + 1$

$\sin(x) \cos(x) + 1$

Specify the range of revolution, and then calculate the volume of revolution.

> $v := \text{Student}[\text{Calculus1}][\text{VolumeOfRevolution}]\left(2, 0, \frac{\pi}{2}\right)$

$v := \pi + \frac{9}{16}\pi^2$

Alternatively, you can use the **Volumes of Revolution** tutor, a point-and-click interface. There are two ways to launch this tutor.

- From the **Tools** menu, select **Tutors, Calculus - Single Variable**, and then **Volumes of Revolution**.
- Click the following **Volumes of Revolution** button.

- Parameters are marked as placeholders. Update the parameter values as required.
 - To navigate between placeholders in the worksheet, press the **Tab** key.
6. After updating any parameters, run the command by pressing **Enter**.

Check for Instructions: Help Page and Example Worksheet

The help system provides command syntax information.

To access a help page:

1. From the **Help** menu, select **Maple Help**. The Help Navigator opens.
2. In the search field, enter *volume of revolution* and click **Search**. The search results include the command help page, the dictionary definition, and the associated tutor help page.
3. Review the calling sequence, parameters, and description in the **Student[Calculus1][Volume of Revolution]** help page. (See Figure 3.3)
4. Copy the examples into your worksheet: From the help system **Edit** menu, select **Copy Examples**.
5. Close the Help Navigator.

6. In your worksheet, from the **Edit** menu, select **Paste**. The examples are pasted into your worksheet.

7. Run the examples and examine results.

Student[Calculus1][VolumeOfRevolution] - find the volume of revolution of a curve

Calling Sequence

```
VolumeOfRevolution(f(x), x = a..b, opts)
VolumeOfRevolution(f(x), g(x), x = a..b, opts)
VolumeOfRevolution(f(x), a..b, opts)
VolumeOfRevolution(f(x), g(x), a..b, opts)
```

Parameters

$f(x)$, $g(x)$ - algebraic expressions in variable 'x'
 x - name; specify the independent variable
 a,b - algebraic expressions; specify the end points of the curve
 opts - equation(s) of the form **option=value** where **option** is one of **axis**, **distancefromaxis**, **functionoptions**, **function2options**, **lineoptions**, **numpoints**, **output**, **revolutionpoints**, **showfunction**, **showrotationline**, **showvolume**, **volumeoptions**, **volume2options**, **title**, **view**, or [Student plot options](#); specify output options

Description

- The **VolumeOfRevolution(f(x), x=a..b)** command returns the volume of revolution of the expression $f(x)$ from a to b .
- The **VolumeOfRevolution(f(x), g(x), x=a..b)** command returns the volume of revolution between the expressions $f(x)$ and $g(x)$ from a to b .
- By using options, you can specify that the command returns a plot or inert integral instead.
- If the independent variable can be uniquely determined from the expression, the parameter x need not be included in the calling sequence.

Figure 3.3: Student Package Help Page for VolumeOfRevolution Command

To access an example worksheet:

1. In the worksheet, enter **?index/examples**. The **Example Worksheet Index** opens.
2. Expand the **Calculus** topic.

3. Click the **Calculus1IntApps** link. The **Calculus1: Applications of Integration** worksheet opens. (See Figure 3.4)
4. Expand the **Volume of Revolution** topic.
5. Examine and run the examples.

Calculus 1: Applications of Integration

The **Student[Calculus1]** package contains four routines that can be used to both work with and visualize the concepts of function averages, arc lengths, and volumes and surfaces of revolution. This worksheet demonstrates this functionality.

For further information about any command in the **Calculus1** package, see the corresponding help page. For a general overview, see [Calculus1](#).

Getting Started

While any command in the package can be referred to using the long form, for example, **Student[Calculus1][DerivativePlot]**, it is easier, and often clearer, to load the package, and then use the short form command names.

```
> restart;
> with(Student[Calculus1]);
```

The following sections show how the routines work. In some cases, examples show to use these visualization routines in conjunction with the single-stepping **Calculus1** routines.

- ▶ **Function Average**
- ▶ **Volume of Revolution**
- ▶ **Arc Length**
- ▶ **Surface of Revolution**

Main: [Visualization](#)
 Previous: [Integration](#)

Figure 3.4: Example Worksheet

Other Ready-To-Use Resources

The Maple Application Center contains free user-contributed applications related to mathematics, education, science, engineering, computer science, statistics and data analysis, finance, communications, graphics, and more.

To access a free application for volume of revolution:

1. Go to the Maplesoft Web site, <http://www.maplesoft.com>.
2. In the menu of the main Web page, click **User Community**, and then **Application Center**.
3. In the sidebar, click **Education PowerTools**.

4. Click the **Calculus II** link, and then the **CalculusII: Complete Set of Lessons** link.
5. Scroll to the **Options** area and click **Download Maple Worksheet**. (See Figure 3.5.)
6. Login in as a guest or Maplesoft Member.
7. Download the **.zip** file.
8. Extract the **L2-volumeRevolution.mws** file.
9. Run the worksheet and examine the results.

The screenshot shows the Maple Application Center website. The header includes the Maplesoft logo and navigation links like Store, Login, Membership, and Newsletter. The main content area displays the title 'Calculus II: Complete Set of Lessons' with a member rating of 4.00 (7 ratings). The author is listed as Jack Wagner and Dr. Karen M Brucks. The application type is 'Maple Worksheet' and 'Education PowerTool'. The publish date is 'October, 2003'. The language is 'English'. There are three options: 'View HTML version', 'Download Maple Worksheet (.zip, 391.5kb)', and 'E-mail to a colleague'. The abstract states that this is a complete set of Maple lessons for a Calculus 2 course, developed by the University of Wisconsin-Milwaukee Department of Mathematics, with 24 lessons and 12 new additions by Dr. Jack Wagner.


Figure 3.5: Maple Application Center: PowerTools

3.2 Optimization Example

PROBLEM

When sharpening ice-skates, figure skates, speed skates, and hockey skates each must be processed by three machines.

The following table shows the time in hours required by each machine to process a pair of skates as well as the (constraints) maximum time in hours, per day each machine can operate.

	Figure skates	Speed skates	Hockey skates	Maximum operation	
Machine A	1	1/2	1	22	
Machine B	1	1	1/3	23	
Machine C	1/4	1	1	21	

The profit on sharpening figure skates is \$7 per pair, speed skates is \$6 per pair, and hockey skates is \$5 per pair.

- How many pairs of each should be sharpened per day to obtain maximum profit?
- What is the profit?

PROCESS

Formulate the Problem:

f = number of figure skates per day

s = number of speed skates per day

h = number of hockey skates per day

Objective function is $7f + 6s + 5h$

Constraints are:

$$f + \frac{1}{2}s + h \leq 22, f + s + \frac{1}{3}h \leq 23, \frac{1}{4}f + s + h \leq 21$$

Obtain Resources:

- Check for existing tools
- Follow instructions
- Consider ready-to-use resources

Check for Existing Tools: Assistant

To access an Assistant (graphical user interface) to the optimization functionality:

- From the **Tools** menu, select **Assistants**, and then **Optimization**. (See Figure 3.6.)

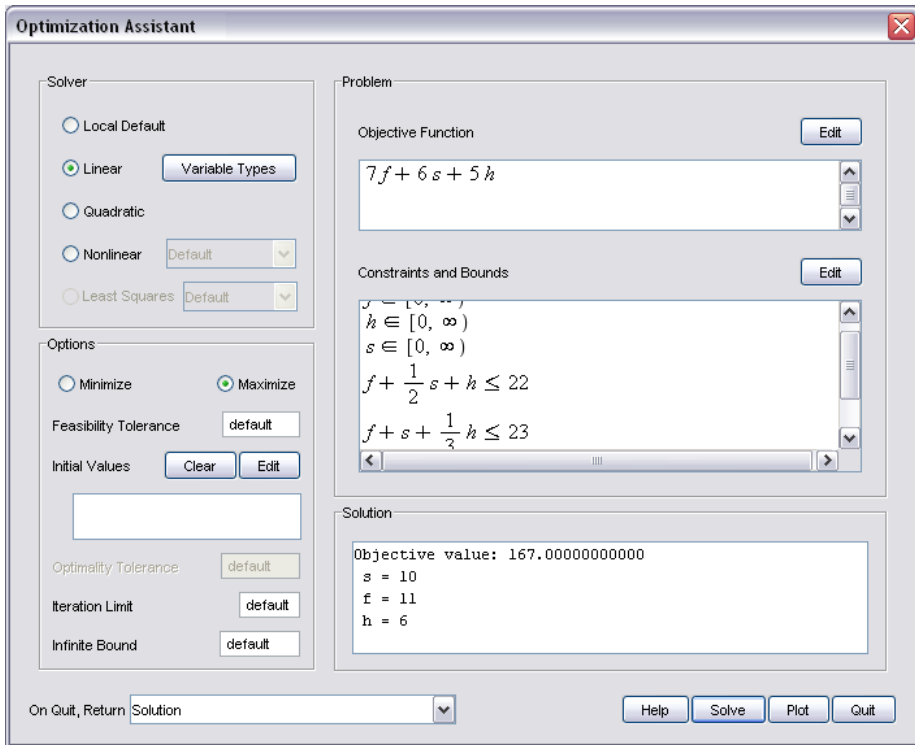


Figure 3.6: Optimization Assistant with Values Entered

To enter values for the problem:

Enter the objective function and constraints:

1. In the **Problem** group box, click **Edit** in the **Objective Function** group box.
2. In the dialog that returns, enter $7*f+6*s+5*h$. Click **Done**.
3. Click **Edit** in the **Constraints and Bounds** group box. The **Constraints** dialog opens.
4. In the **Add Constraint** field:
 - Enter $f + 1/2*s + h \leq 22$. Click **Add**.
 - Enter $f + s + 1/3*h \leq 23$. Click **Add**.
 - Enter $1/4*f + s + h \leq 21$. Click **Add**.
 - 5. In the **Add Bound** group box, click **Assume all variables nonnegative**.
6. Click **Done** to return to the **Optimization Assistant** dialog.
7. In the **Solver** group box, select **Linear**.
8. Click **Variable Types**. In the **Variable Types** dialog, select the **Integer** check boxes for all variables.
9. In the **Options** group box, select **Maximize**.
10. Click **Solve**.
11. Click **Done** to return to the **Optimization Assistant**.
12. Click **Quit** to return the solution **167** and the values for **f**, **s**, and **h** to the Maple document.

Check for Instructions: Help Page

The help system provides command syntax information.

To access a help page:

1. From the **Help** menu, select **Maple Help**. The Help Navigator opens.
2. In the search field, enter **Optimization** and click **Search**.
3. The search results include the **Overview of the Optimization Package** help page, dictionary definitions, and example worksheets.
4. With the Overview page displayed in the right pane, review the description. (See Figure 3.7)

Overview of the Optimization Package

Calling Sequence

```
Optimization[command](arguments)
command(arguments)
```

Description

- The Optimization package is a collection of commands for numerically solving [optimization](#) problems, which involve finding the [minimum](#) or [maximum](#) of an [objective function](#) possibly subject to [constraints](#). The package takes advantage of built-in library routines provided by the Numerical Algorithms Group (NAG).
- The package solves [linear programs](#) (LPs), [quadratic programs](#) (QPs), [nonlinear programs](#) (NLPs), and both linear and nonlinear [least-squares](#) problems. Both constrained and unconstrained problems are accepted. In general, variables are assumed to be continuous, and [local](#) solutions are computed for problems that are not [convex](#). However, the [LPSolve](#) command does accept [integer programs](#) and the [NLPSolve](#) command provides a [global](#) search algorithm for limited situations.
- You can choose the easy-to-use [Minimize](#) and [Maximize](#) commands, the [Interactive](#) Maplet, or the specialized commands for the various problem classes.
- Some commands allow alternatives to the default method of specifying an optimization problem. Matrix form, described on the [Optimization/MatrixForm](#) help page, is more complex but offers greater flexibility and efficiency. The [Optimization/InputForms](#) help page summarizes all the forms of input that the solvers in the Optimization package allow.
- The [Optimization/Options](#) help page summarizes common options accepted by the commands in the Optimization package. The [Optimization/Methods](#) help page summarizes methods used by the commands for solving optimization problems.
- The solvers perform computations in either the hardware floating-point environment or the arbitrary-precision software floating-point environment. The [Optimization/Computation](#) help page describes the computation environment in more detail and offers suggestions on how to obtain the best performance from the solvers.

▶ **Accessing Optimization Package Commands**

▶ **List of Optimization Package Commands**

▶ **Notes**

Figure 3.7: Help Page: Overview of the Optimization Package

In general, you can:

- Review the calling sequence, parameters, and description.
- Copy the examples into your worksheet. From the help system **Edit** menu, select **Copy Examples**. Close or minimize the Help Navigator. In your worksheet, from the **Edit** menu, select **Paste**. The examples are pasted into your worksheet. Run the examples and examine results.

In this case, you can also open the many dictionary definitions and additional help pages.

1. In the **Overview of the Optimization Package** help page, click the **linear programs** link. (See Figure 3.8. The dictionary link is indicated by one of the arrows in the figure.)

- The **linear programming** definition is displayed.

Note: The definition also contains a link to the associated Maple **Optimization** package command, **LPSolve**.

linear programming,

n. a branch of [mathematical programming](#) involving the minimization or maximization of a continuous real linear [objective function](#), subject to linear [constraints](#). This is of considerable practical and theoretical importance in operations research and in economics. For more information about the theory, applications, and methods of linear programming, see [duality theory of linear programming](#), [input-output models](#), and [simplex method](#). See also [Optimization\[LPSolve\]](#), [integer programming](#).

Figure 3.8: Definition of Linear Programming

2. Click the **Optimization[LPSolve]** link in either the definition or overview help page. (See Figure 3.9)

Optimization[LPSolve] - solve a linear program**Calling Sequence**

LPSolve(obj, constr, bd, opts)

Parameters

obj - algebraic; linear objective function

constr - (optional) set(relation) or list(relation); linear constraints

bd - (optional) sequence of name = range; bounds for one or more variables

opts - (optional) equation(s) of the form option = value where option is one of assume, binaryvariables, depthlimit, feasibilitytolerance, infinitebound, initialpoint, integertolerance, integervariables, iterationlimit, maximize, nodelimit or output; specify options for the LPSolve command

Description

- The LPSolve command solves a [linear program](#) (LP), which involves computing the [minimum](#) (or [maximum](#)) of a linear [objective function](#) subject to linear [constraints](#).
- Continuous, integer, mixed-integer and binary (or zero-one) LPs can be solved. Throughout this page, the term [integer programming](#) is used to represent all forms of integer programs. Integer programs are specified using the [assume](#), [integervariables](#) or [binaryvariables](#) options. See the following [Integer Programming Options](#) section for more information.
- This help page describes the use of the LPSolve command when the LP is specified in algebraic form. A summary of this form is given in the [Optimization/AlgebraicForm](#) help page. LPSolve also recognizes the problem in Matrix form (see the [LPSolve \(Matrix Form\)](#) help page). Matrix form leads to more efficient computation, but is more complex.
- The first parameter **obj** is the objective function, which must be a linear algebraic expression. The second parameter **constr** is optional and is a set or list of relations (of type `<=` or `=`), linear in the problem variables. The problem variables are the indeterminates of type [name](#) found in **obj** and **constr**.

Figure 3.9: Optimization[LPSolve]

You can use one Maple command to solve the skating problem. For information on using commands in packages, see *Maple Tools and Resources* (page 15).

> with(Optimization):

The same solution is returned using the **LPSolve** command.

> $constraints := \left\{ f + \frac{s}{2} + h \leq 22, f + s + \frac{h}{3} \leq 23, \frac{f}{4} + s + h \leq 21 \right\};$

> $LPSolve(7f + 6s + 5h, constraints, assume = nonnegint, maximize)$

$[167.000000000000, [s = 10, f = 11, h = 6]]$

The **assume = nonnegint** and **maximize** options are described in the help page.

- **assume = nonnegint** - Assume all variables are non-negative integers.
- **maximize** or **maximize = true** - Maximize the objective function. By default, that is, if you exclude the **maximize** option, the **LPSolve** command computes the minimum.

4 The Next Step

After you have reviewed the contents of the first three chapters, you can scan the top Maple packages (topics) and commands.

Additionally, for detailed information about features you have reviewed in this book, and other advanced features, refer to the *Maple User Manual*.

To access the Maple User Manual:

1. From the **Help** menu, select **Manuals, Dictionary, and more**.
2. Select **Manuals**, and then **User Manual**.

4.1 Top Packages

Package Name	Description
CodeGeneration	The CodeGeneration package is a collection of commands and subpackages that enable the translation of Maple code to other programming languages, such as C, Fortran, Java, MATLAB [®] , and Visual Basic.
LinearAlgebra	The LinearAlgebra package contains commands to construct and manipulate Matrices and Vectors, and solve linear algebra problems. LinearAlgebra routines operate on three principal data structures: Matrices, Vectors, and scalars.
Maplets	<p>A Maplet application is a graphical user interface containing windows, textbox regions, and other visual interfaces, which gives a user point-and-click access to the power of Maple. Users can perform calculations, plot functions, or display dialogs without using the worksheet interface.</p> <p>The Maplets package contains commands and subpackages to create a Maplet application. To create Maplet applications in a graphical user interface environment, use the Maplet Builder. The Maplet Builder is available only in the Standard Worksheet interface. From the Tools menu, select Assistants, and then Maplet Builder.</p>

RealDomain	The RealDomain package provides an environment in which the default Maple behavior of assuming that the basic underlying number system is the complex field is replaced by the assumption that the basic underlying number system is the field of real numbers.
ScientificConstants	<p>The ScientificConstants package provides access to the values of various physical constants, for example, the velocity of light and the atomic weight of sodium. These values are required to solve equations in fields such as chemistry and physics. The ScientificConstants package provides the units for each of the constant values, allowing for greater understanding of the equation. The package also provides units matching for error checking of the solution.</p> <p>The quantities available in the ScientificConstants package are divided into two distinct categories.</p> <ul style="list-style-type: none"> • Physical constants • Properties of chemical elements (and their isotopes)
ScientificErrorAnalysis	The ScientificErrorAnalysis package provides representation and construction of numerical quantities that have a central value and an associated uncertainty (or error), which is a measure of the degree of precision to which the quantity's value is known. Various first-order calculations of error analysis can be performed with these quantities.
Student	<p>The Student package is a collection of subpackages designed to assist with the teaching and learning of standard undergraduate mathematics. Many commands display functions, computations, and theorems in various ways, including stepping through important computations.</p> <p>The Student package contains the following subpackages.</p> <ul style="list-style-type: none"> • Calculus1 - single-variable calculus • LinearAlgebra - linear algebra • MultivariateCalculus - multivariate calculus • Precalculus - precalculus • VectorCalculus - multivariate vector calculus

Units	The Units package accepts approximately 300 distinct unit names (for example, meters and grams) and over 550 units with various contexts (for example, standard miles and U.S. survey miles). Maple also contains Units palettes that allow you to quickly enter the unit for an expression.
VectorCalculus	The VectorCalculus package is a collection of commands that perform multivariate and vector calculus operations. A large set of predefined orthogonal coordinate systems is available. All computations in the package can be performed in any of these coordinate systems. It contains a facility for adding a custom coordinate system and using that new coordinate system for your computations.

4.2 Top Commands

Command Name	Description
plot	Create a two-dimensional plot of functions.
solve	Solve one or more equations or inequalities for their unknowns.
fsolve	Solve one or more equations using floating-point arithmetic.
eval	Evaluate an expression at a given point.
evalf	Numerically evaluate expressions.
dsolve	Solve ordinary differential equations (ODEs).
int	Compute an indefinite or definite integral.
diff	Compute an ordinary or partial derivative, as the context dictates.
limit	Calculate the limiting value of a function.
sum	For symbolic summation. It is used to compute a closed form for an indefinite or definite sum.
assume/is	Set variable properties and relationships between variables. Similar functionality is provided by the assuming command.
assuming	Compute the value of an expression under assumptions.
simplify	Apply simplification rules to an expression.
expand	Distribute products over sums.

normal	Normalize a rational expression.
convert	Convert an expression to a different type.
type	Type-checking command. In many contexts, it is not necessary to know the exact value of an expression; it suffices to know that an expression belongs to a broad class, or group, of expressions that share some common properties. These classes or groups are known as <i>types</i> .
series	Generalized series expansion.
map	Apply a procedure to each operand of an expression.

Index

Symbols

!

icon, 41

!!!

icon, 41

1-D Math, 46

using palettes, 48

2-D Math Input, 43

using palettes, 44

?

help page icon, 20

help topic, 8, 19

A

accents, 38

alphabetical

palettes, 38

Application Center

description, 12

applications, 54

Help menu, 54

Assistants

Back-Solver, 23

CurveFitting, 23

Data Analysis, 23

description, 6

Import Data, 23

Installer Builder, 23

Library Browser, 23

Maplet Builder, 23

menu access, 6

ODE Analyzer, 23

Optimization, 23, 72

Plot Builder, 24

Tools menu, 22

automatic command completion, 51

B

bookmark, 58

bottle

volume of revolution, 63

C

calculus example, 63

Classic Worksheet, 16

CodeGeneration

package description, 79

colon

usage, 41

command completion

automatic, 51

manual, 52

command-line interface, 16

commands

LPSolve, 77

Optimization, 75

restart, 41

top, 81

VolumeOfRevolution, 64

computation commands

Student, 26

context menus

using, 27

convert

1-D to 2-D, 49

copy

examples, 21

corporate

Web site, 11, 13

curve analysis
 example, 27
Curve Fitting Assistant, 23

D

D
 icon, 20
Definition
 linear programming, 76
document blocks, 57
Document mode, 58
documents
 running, 41

E

Edit menu
 in help system, 21
example
 calculus, 63
 optimization, 71
example worksheets
 copy, 21
 description, 9
 menu access, 9
examples
 index, 53
exclamation point, 41
execute command, 41
execution group, 41
expressions
 graph results, 29
 palettes, 36
 right-click, 28

F

Favorites palette, 34

format labels, 56

G

government
 Web site, 13

H

Handwriting palette, 34
Help Navigator
 using, 20
help system
 accessing, 19
 description, 8
 dictionary, 20
 Edit menu, 21, 76
 Help Navigator, 19
 icon, 8
 manuals, 20
 search, 20
 table of contents, 20
 tasks, 20
 topic search, 20
 tutorials, 20
 View menu, 21
 volume of revolution, 67

I

icons
 1 exclamation point, 41
 3 exclamation points, 41
 in help system, 20
 open as example worksheet, 21
 Tab, 39
industry
 Web site, 13
installation, 15

Installer Builder Assistant, 23

interactive commands

 Student, 27

interfaces

 list, 16

K

key strokes, 60

L

library, 40

library browser assistant, 23

LinearAlgebra

 package description, 79

LPSolve command, 76

M

M

 icon, 20

Macintosh

 command complete, 52, 60

 context menus, 27

 start Maple, 16

manual command completion, 52

Maple Application Center

 solids of revolution, 69

Maple Web site resources, 12

Maplet Builder Assistant, 23

Maplets

 create, 39

 top package, 79

markers

 displaying, 57

math dictionary

 description, 8

 help system, 20

mathematical

 palettes, 37

N

numeric

 compute, 4

O

ODE Analyzer Assistant, 23

Optimization

 Assistant, 23, 72

 example, 71

 LPSolve, 77

Options dialog, 45

 auto command complete, 51

 command complete, 51

P

packages

 definition, 40

 top, 79

palettes

 1-D Math, 48

 2-D Math Input, 44

 accents, 38

 alphabetical, 38

 arrange, 48

 expression, 36

 favorites, 34

 mathematical, 37

 overview, 34

 symbol recognition, 34

paste

 examples, 21

Plot Builder Assistant, 24

plots

- right-click, 30
- point-and-click, 22
- PowerTools, 69
 - description, 12

Q

- question mark
 - icon, 20

R

- RealDomain
 - package description, 80
- resources
 - access, 6
 - diagram, 5
 - in help system, 20
- right-click
 - expressions, 28
 - graphic results, 29
 - plots, 30
 - text, 30
- running
 - documents, 41
 - worksheets, 41

S

- Scientific Constants, 24
 - package description, 80
- ScientificErrorAnalysis
 - package description, 80
- search
 - help system, 20
- selection
 - execute, 41
- semicolon
 - usage, 41

- skates
 - optimization example, 71
- solids of revolution
 - example, 64
- solutions
 - overview, 4
- Special Functions, 24
- Standard Worksheet, 16
- start Maple
 - standard worksheet, 16
- statement separator, 41
- Student
 - Center, 14
 - package, 26
 - top packages, 80
- symbolic
 - compute, 4

T

- Tab icon, 39
- Tab key, 39
- table of contents
 - help system, 20
- task
 - menu access, 7
 - volume of revolution, 65
- task template, 31
- technical support
 - description, 12
- text
 - right-click, 30
- tools
 - visualization, 3
- Tools menu
 - assistants, 22
 - tutors, 26

topic search, 20

tour, 10

tutorials

 help system, 20

tutors

 accessing, 26

 curve analysis example, 27

 description, 6

 menu access, 6

 Tools menu, 26

 using, 26

 volume of revolution, 64

 start Maple, 16

Worksheet mode, 17–18, 58

worksheets

 running, 41

WS

 icon, 20

U

Units

 package description, 81

Units Calculator, 24

UNIX

 command complete, 52, 60

 start Maple, 16

V

VectorCalculus

 package description, 81

View menu

 in help system, 21

 markers, 57

 using palettes, 48

visualization commands

 Student, 26

volume of revolution

 example, 64

W

Windows

 command complete, 52, 60

