Maple Getting Started Guide

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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	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 *live*, you can edit the parameters and, with the click of a button, compute the new results. The *Getting Started Guide* 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**.
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.

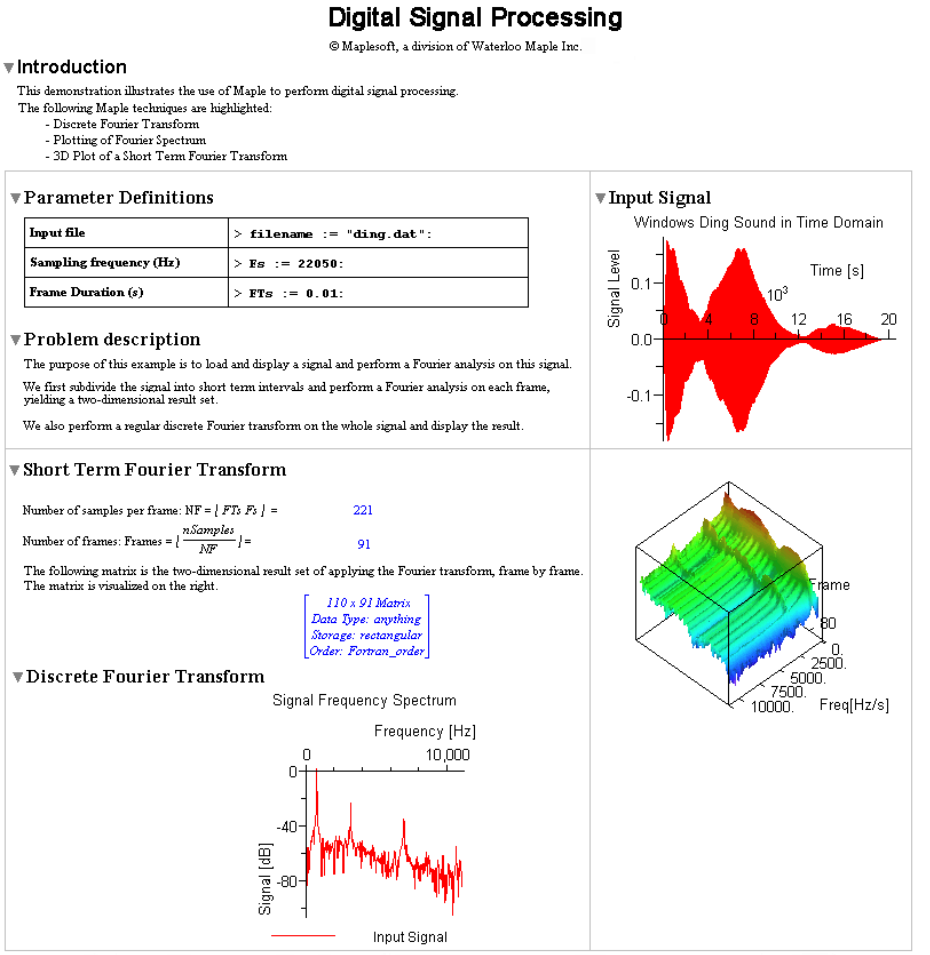


Figure 1.1: Example Interactive Document in Maple

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

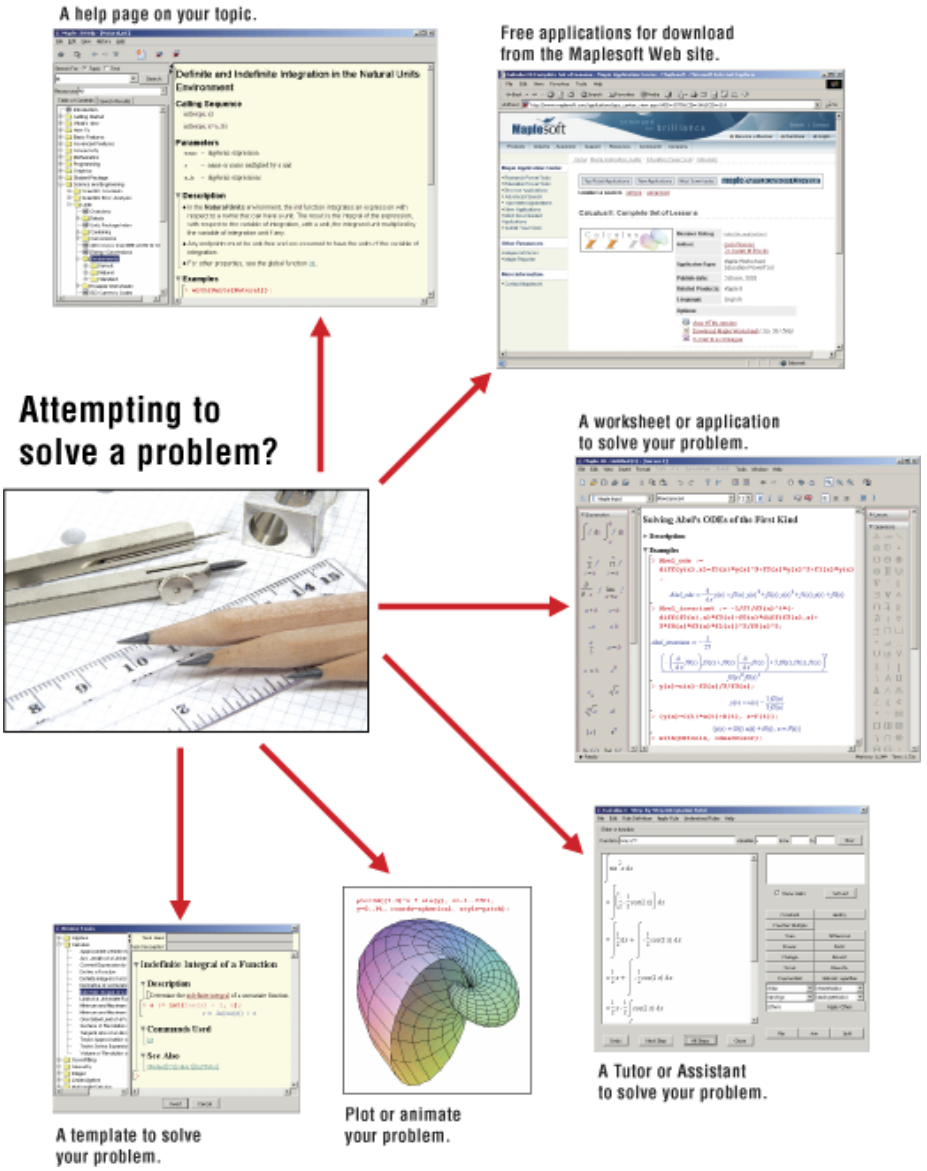
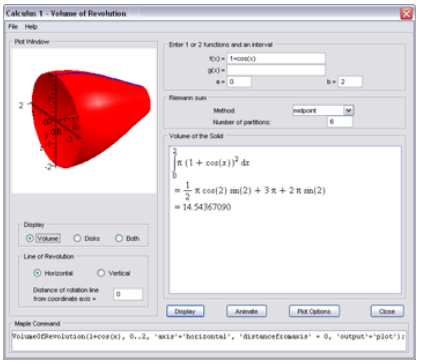
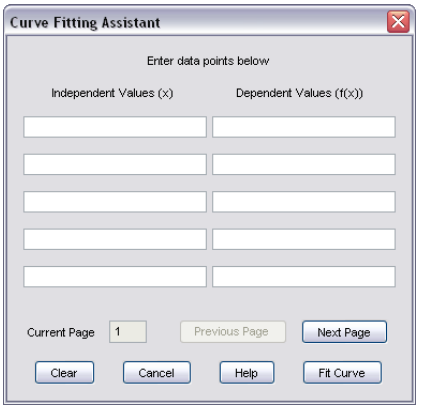
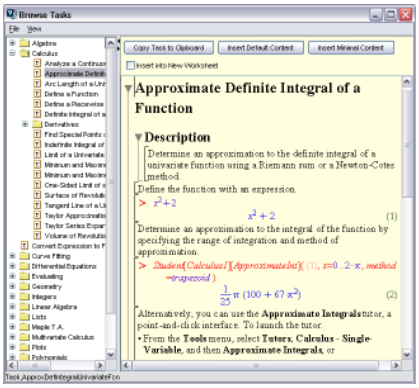
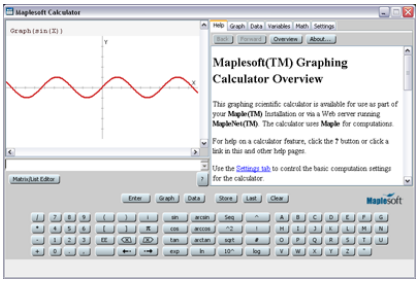


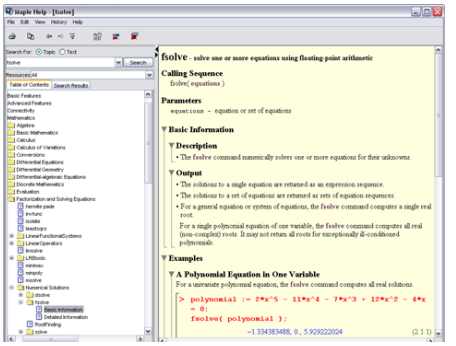
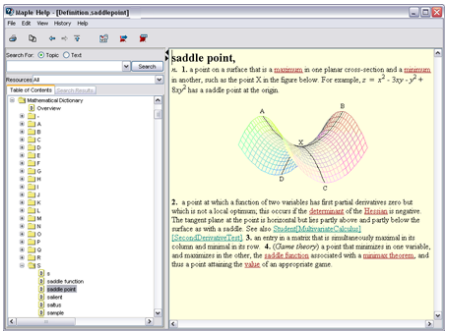
Figure 1.2: A Selection of Maple Resources for Solving Problems

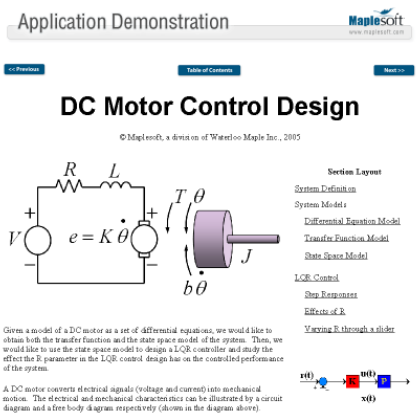
Accessing Resources

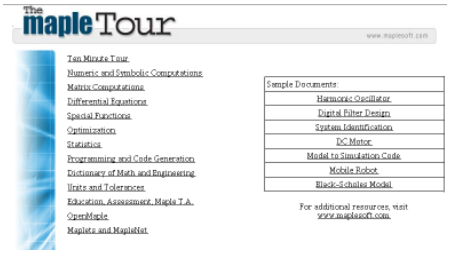
Your work with the Maple program is supported by numerous resources.

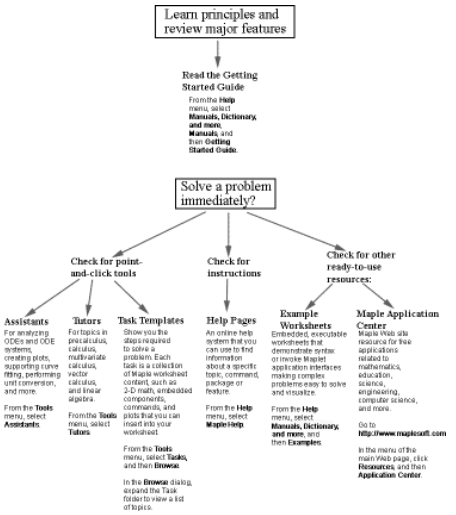
Tutors, Assistants, Task Templates, and Maple Calculator	**Description**
Tutors 	Over 40 interactive tutors help beginner users gain insight and understanding of topics in precalculus, calculus, multivariate calculus, vector calculus, and linear algebra courses. Some tutors help you work through a problem step-by-step. • From the **Tools** menu, select **Tutors**, and then one of the topic submenus.
Assistants 	Assistants help you accomplish many tasks, such as solving ODEs and ODE systems, creating plots and matrices, and supporting curve fitting. • From the **Tools** menu, select **Assistants**, and then one of the topic submenus.

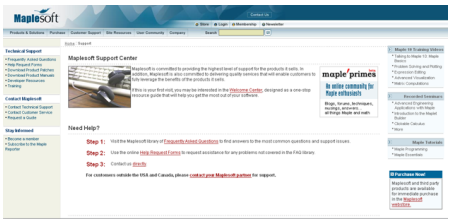
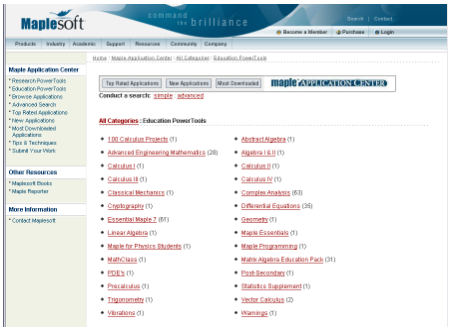
Tutors, Assistants, Task Templates, and Maple Calculator	**Description**
Task Templates 	Tasks show the steps required to solve a problem. Each template is a collection of Maple worksheet content, such as 2-D Math, embedded components, commands, and plots that you can insert into your worksheet. • From the **Tools** menu, select **Tasks**, and then **Browse**.
Maplesoft Graphing Calculator 	Available for use as part of your Maple installation. A convenient calculator (interface) using Maple technology. **Microsoft Windows** (only) From the **Start** menu, select **Maple**, and then **Maple Calculator**.

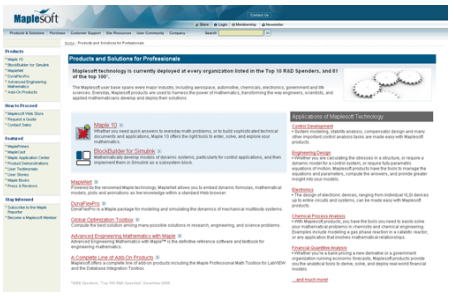
Online Help and Examples	Description
Help Pages 	The online help system helps you find information about a specific topic, command, package, or feature. You can access help three ways. • From the **Help** menu, select **Maple Help**. • In the toolbar, click the **Help** icon.  • In the worksheet, enter **?topicname**. For example, type **?LinearAlgebra**, and then press **Enter**.
Dictionary 	More than 5000 mathematical and engineering terms, and over 300 figures and plots. 1. From the **Help** menu, select **Maple Help**. 2. In **Resources** drop-down list, select **Definition**. 3. Enter search word or expand alphabetical listing.

Online Help and Examples	Description
Applications and Example Worksheets 	**Applications** 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: • 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 **Example Worksheets** 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. 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. From the **Help** menu, select **Manuals, Dictionary, and more** and then **Applications and Examples**.

Tour and New User Roadmap	Description
Tour  	The **Maple Tour** consists of interactive sessions on the following topics: • 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 From the **Help** menu, select **Take a Tour of Maple**.

Tour and New User Roadmap	Description
New User Roadmap  	Find the most efficient path to solving a problem immediately or learning principles and reviewing major features. • From the **Help** menu, select **Manuals, Dictionary, and more**, and then **New User Roadmap**.

Web Site Resources	Description
Technical Support (Online) 	Maple Web site and resource for FAQs, downloads and service packs, links to discussion groups, and request technical support form. 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**.
Application Center 	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). 1. Go to **http://www.maplesoft.com**. 2. In the menu of the main Web page, click **User Community**, and then **Application Center**.
PowerTools 	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. 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
Corporate and Government 	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. 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.
Industry and Government 	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. 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
Products and Solutions for Students 	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. 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	• From the **Start** menu, select **Programs**, **Maple**, **Maple**. Alternatively: • Double-click the **Maple** desktop icon.
Macintosh®	• Double-click the **Maple** application icon in the Finder.
UNIX®	• Enter the full path, for example, **/usr/local/maple/bin/xmaple** Alternatively: 1. Add your Maple directory (for example, **/usr/local/maple/bin)** to your command search path. 2. 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.

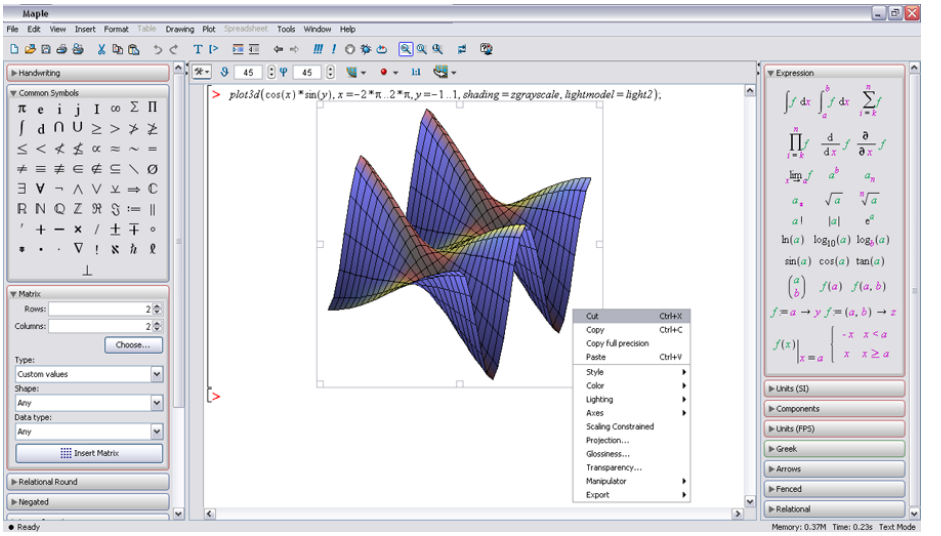


Figure 2.1: The Maple Standard Worksheet Interface in Worksheet Mode

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.

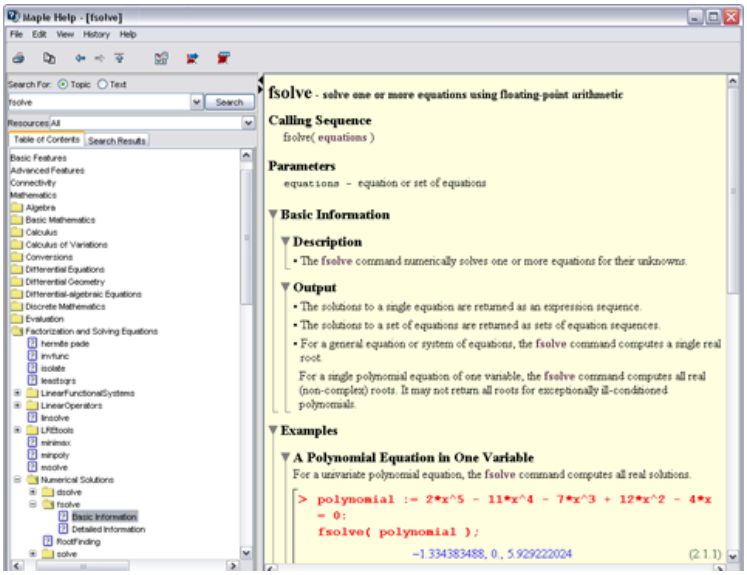


Figure 2.2: Example Help Page

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.

	Alternatively, in the help system toolbar, click the *open current help page in a worksheet window* icon.

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.

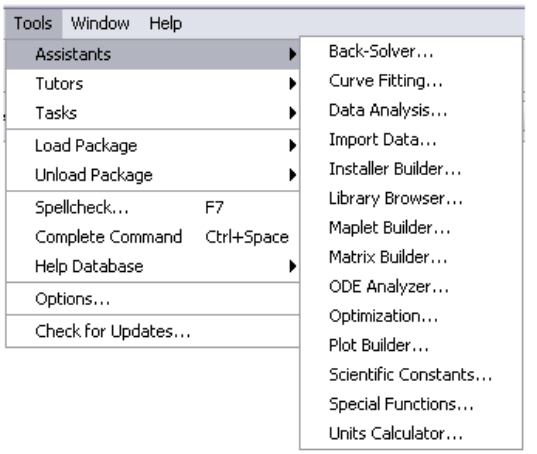


Figure 2.3: Accessing the Assistants from the Tools Menu

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.

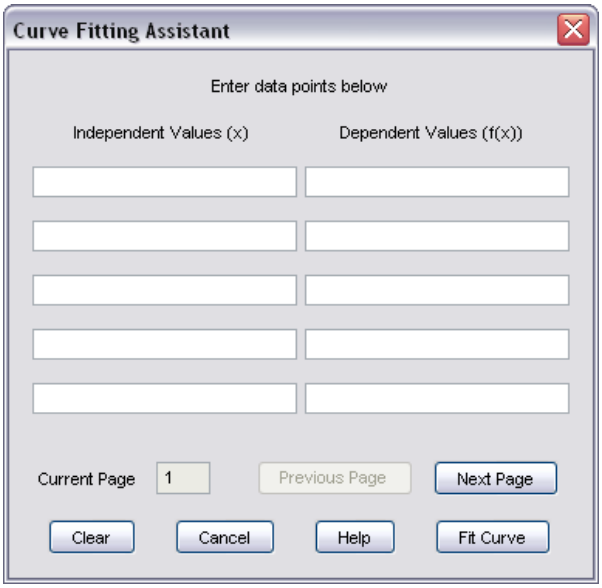


Figure 2.4: Assistant Example: Curve Fitting

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.

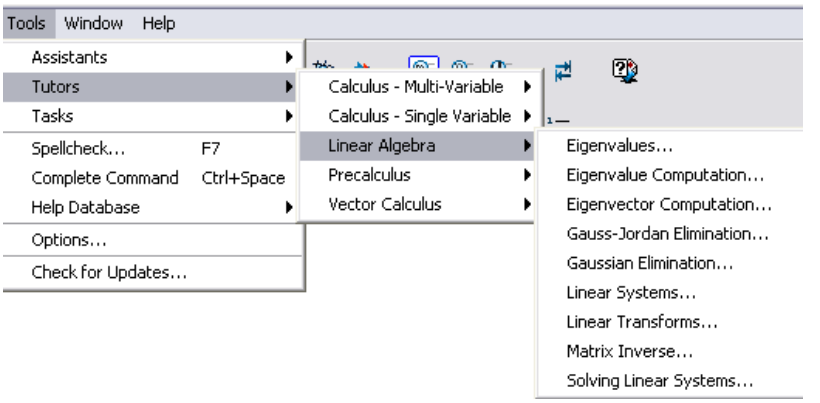


Figure 2.5: Accessing Tutors from the Tools Menu

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.

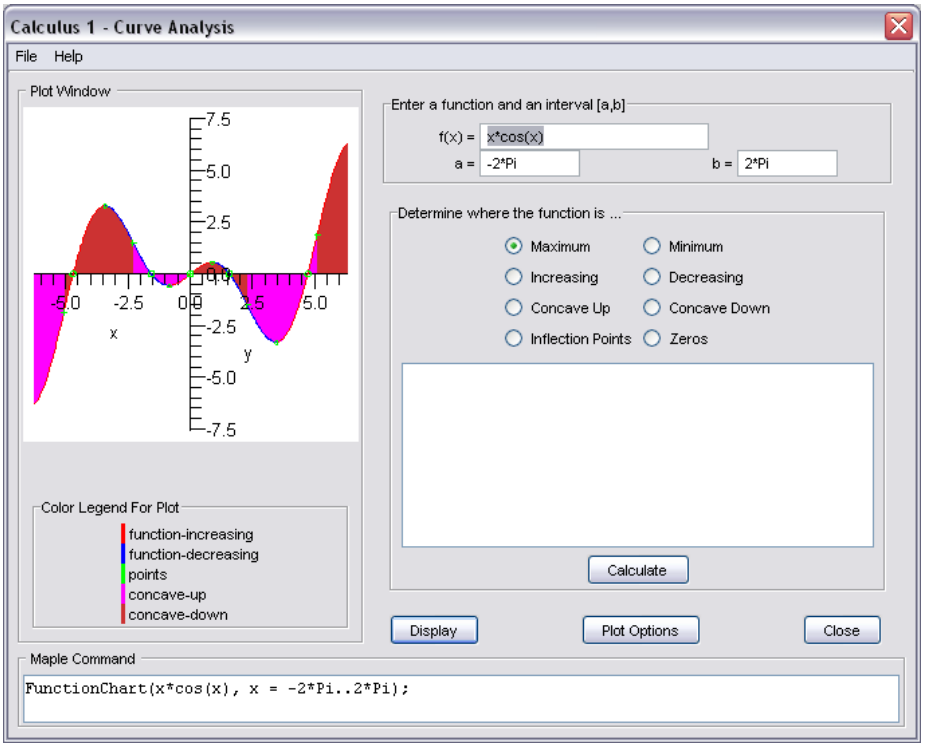


Figure 2.6: Tutor Example: Calculus 1 - Curve Analysis

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

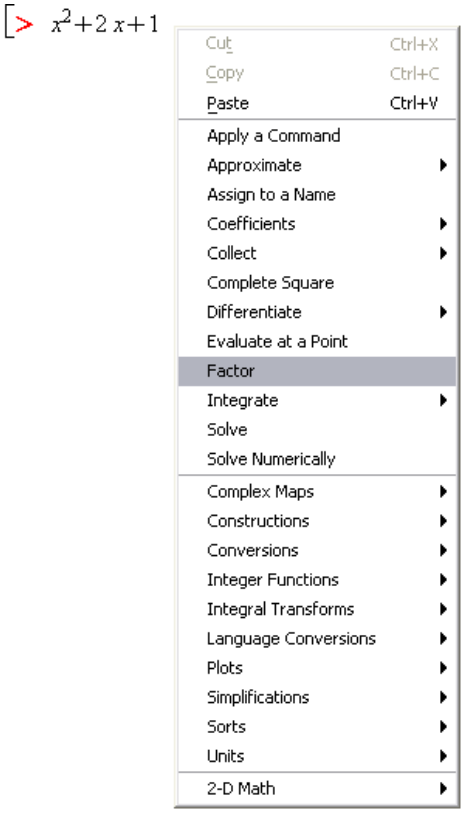


Figure 2.7: Right-click (Control-click) Expressions

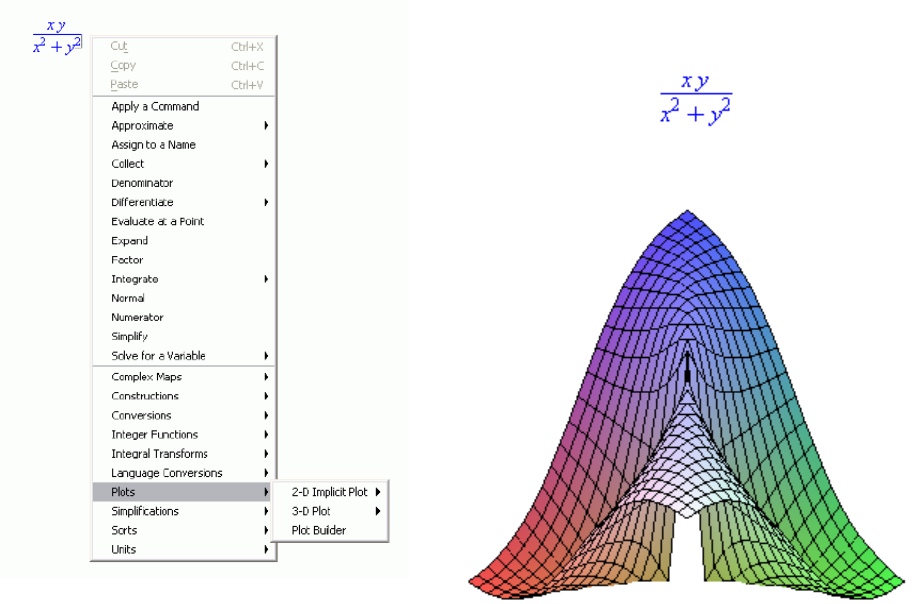


Figure 2.8: Right-click (Control-click) Expressions to Graph Results

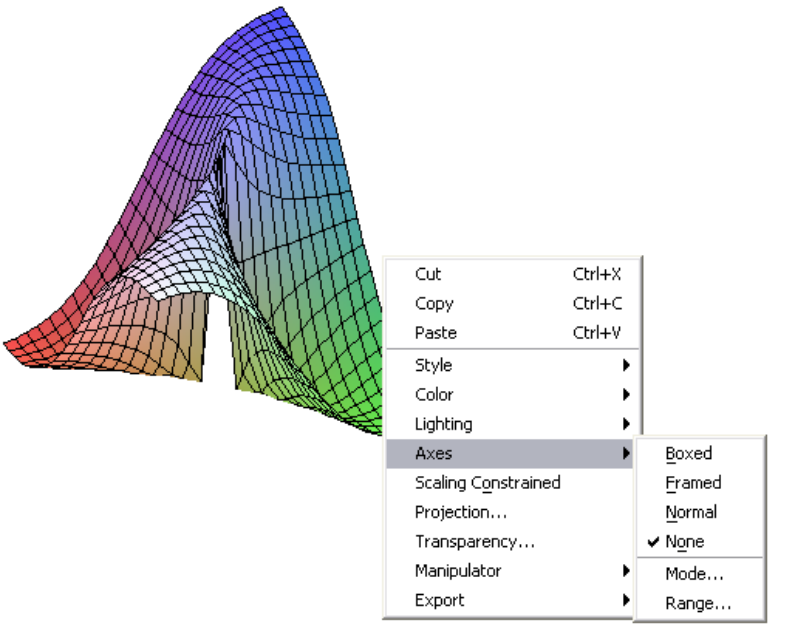


Figure 2.9: Right-click (Control-click) Plots to Change Display Options

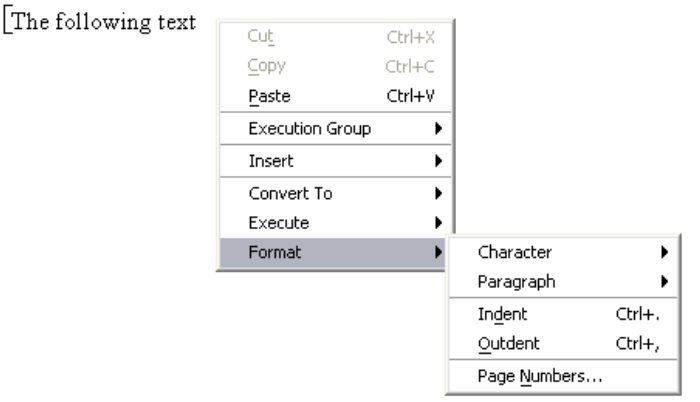


Figure 2.10: Right-click (Control-click) Text

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.

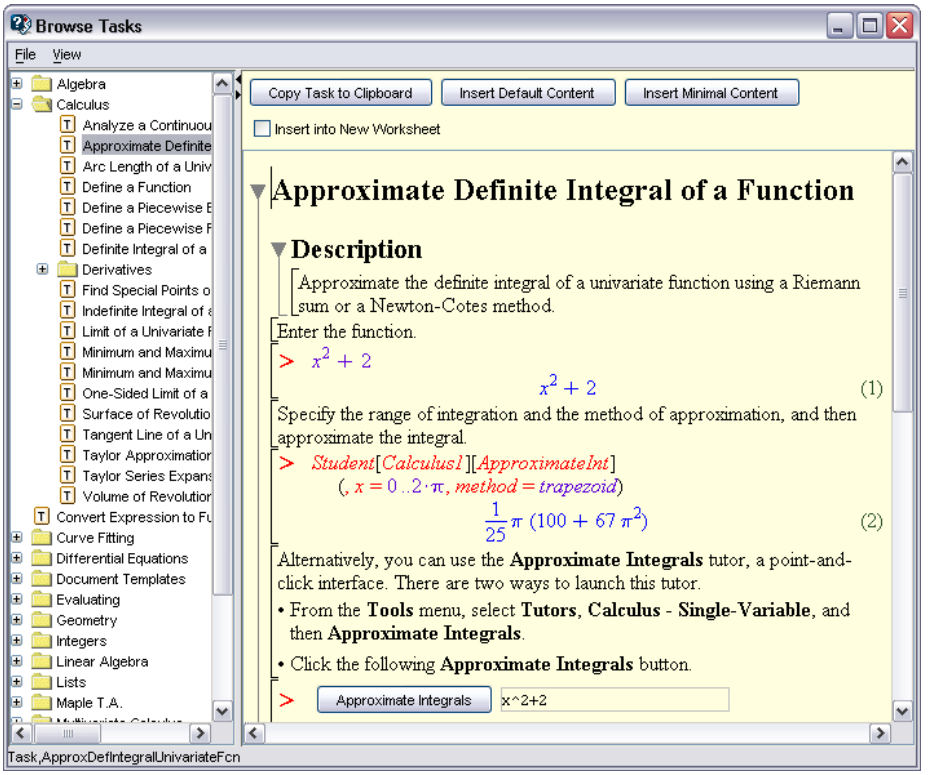


Figure 2.11 Browse Tasks Dialog

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.

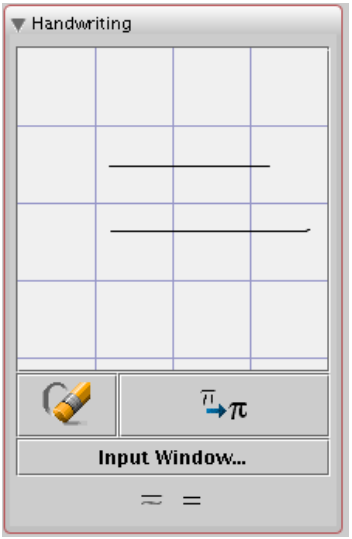


Figure 2.12: Handwriting Palette

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.

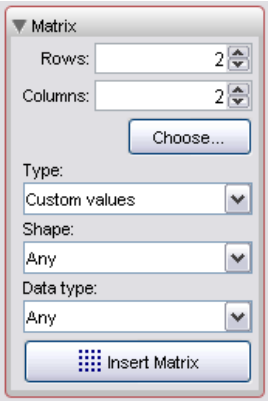


Figure 2.13: Matrix Palette

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.

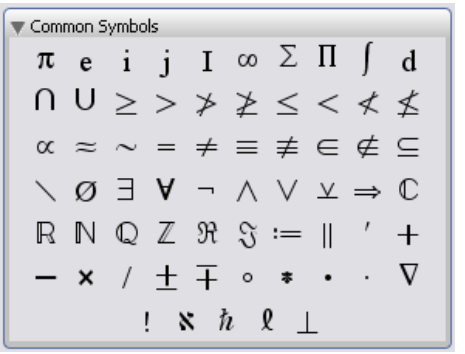


Figure 2.14: Common Symbols Palette

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 *Commands (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

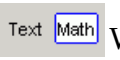
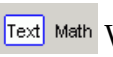
Commands are contained in the Maple library, which is divided into two groups: the *main library* and *packages.*

- 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)	• 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	• 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;	The **restart** command causes Maple to clear its internal memory. Alternatively, in the toolbar, click the restart icon.  For specific details, refer to the *Maple User Manual.*

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

2-D Math

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

```
> restart
```

```
> factor(x^2 + 2 x + 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(α)^2 + sin(α)^2
```

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

```
> a ∫ e^(sqrt(2) x) dx
```

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

```
> lim[x → ∞] f(x)
```

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

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

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

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.

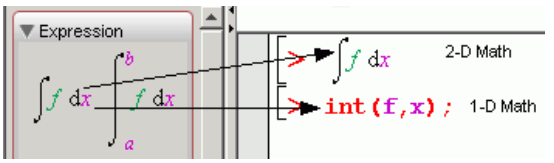
4. The first placeholder is highlighted. Enter your expression, and if necessary, use the **Tab** key to move to the next placeholder.

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.



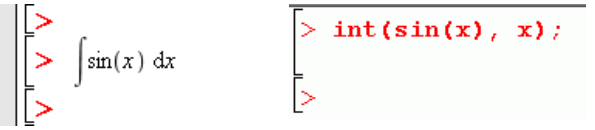
You can control the appearance of expressions in the worksheet. You can convert 2-D Math to 1-D Math.

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.

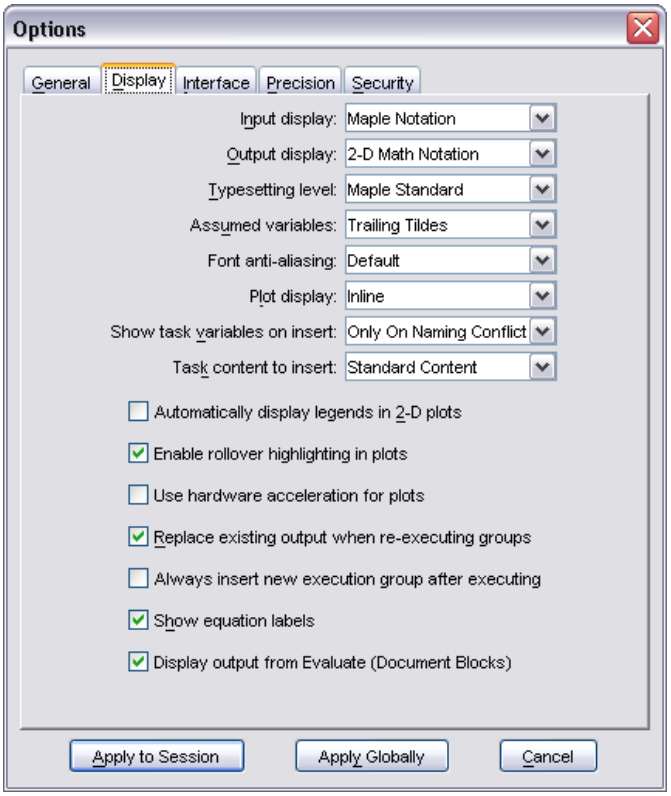


Figure 2.17: Options Dialog: Input Display

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(x^2 + 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);
```

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

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

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

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.

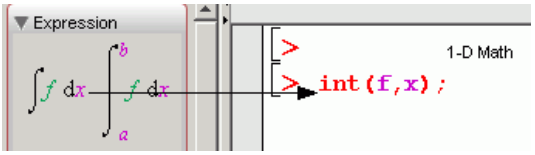
4. The first placeholder is highlighted. Enter your expression, and if necessary use the **Tab** key to move to the next placeholder.

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.

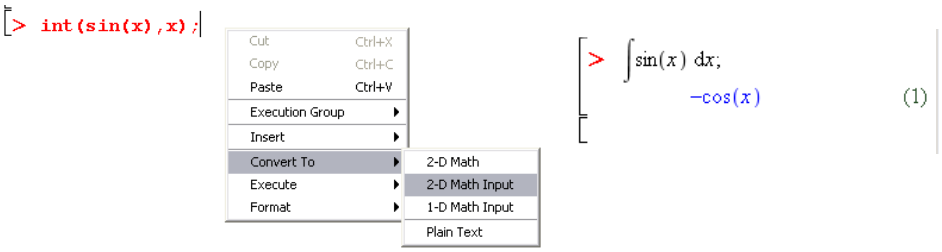


Figure 2.18: 1-D Math Input Converted to 2-D Math Input

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**.

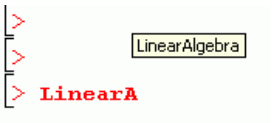
Using the with command to load the Optimization package	
`> with(Optimization);` `[ImportMPS, Interactive, LPSolve, LSSolve, Maximize, Minimize, NLPSolve, QPSolve]`	A list of all commands in the package is displayed. To suppress the display of all command names, end the **with(Optimization)** command 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.



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:

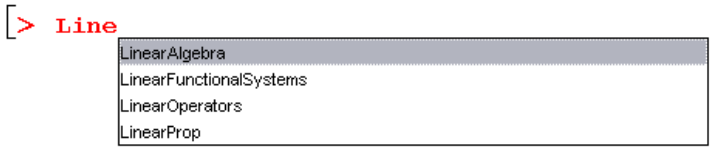
1. Begin entering a command in the worksheet.

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

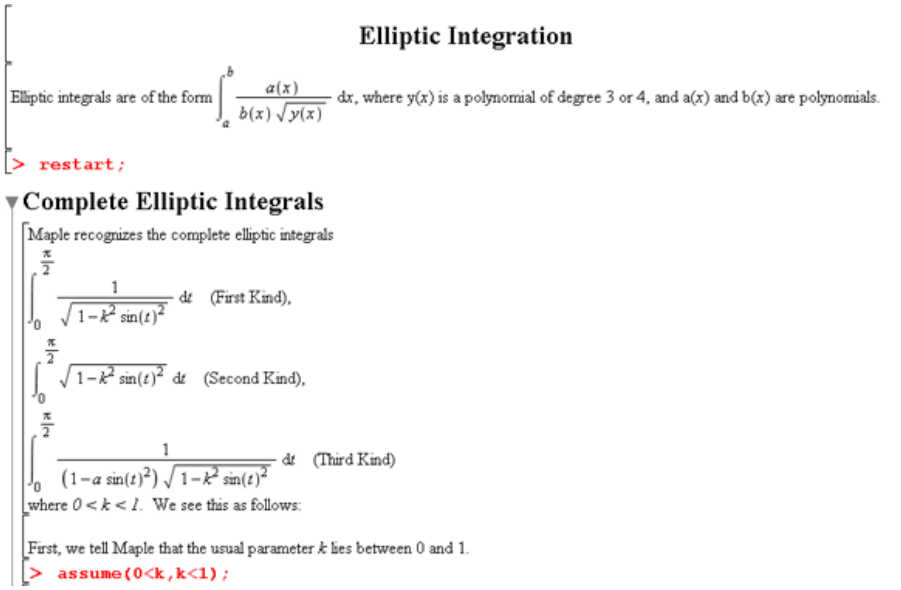


Figure 2.19: Example Worksheet

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.

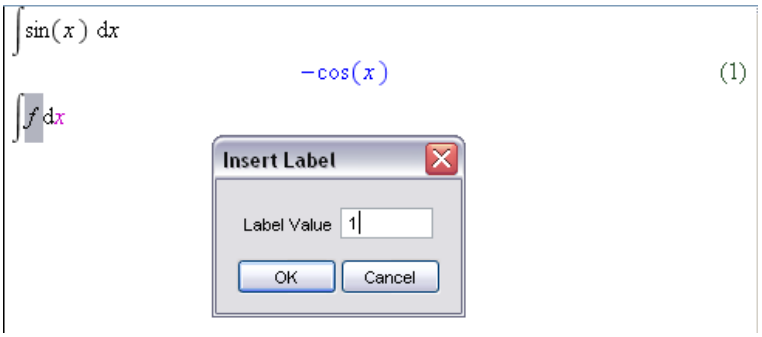


Figure 2.20 Inserting an Equation Label

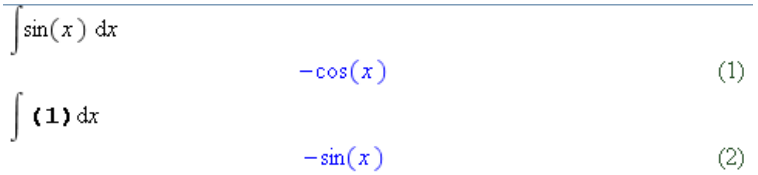


Figure 2.21: Equation Label

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.

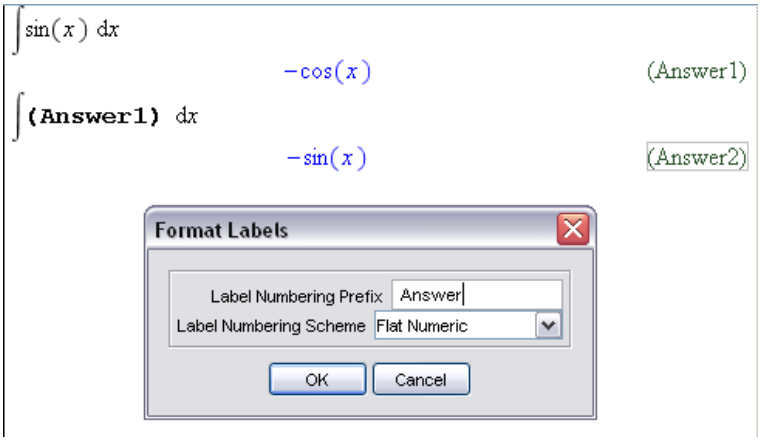


Figure 2.22 Format Labels Dialog: Adding a Prefix

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

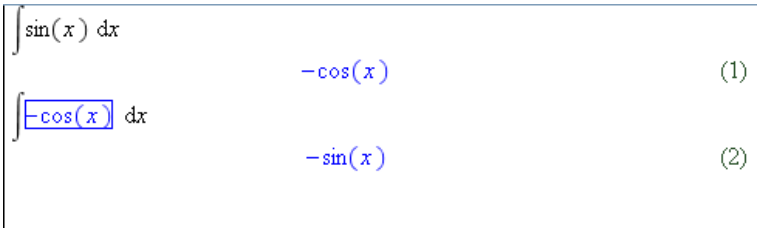


Figure 2.23: Label Reference

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.

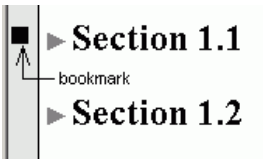


Figure 2.24: Bookmarks

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	• **Escape**, Macintosh • **Ctrl** + **Space**, Windows • **Ctrl** + **Shift** + **Space**, UNIX	*ab* about about abreve ă abs |x| abs abs
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	*sqrt*, 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.

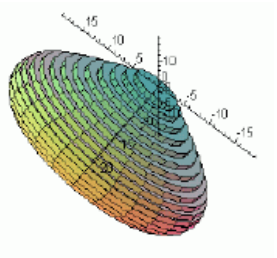
3.1 Calculus Example

Problem

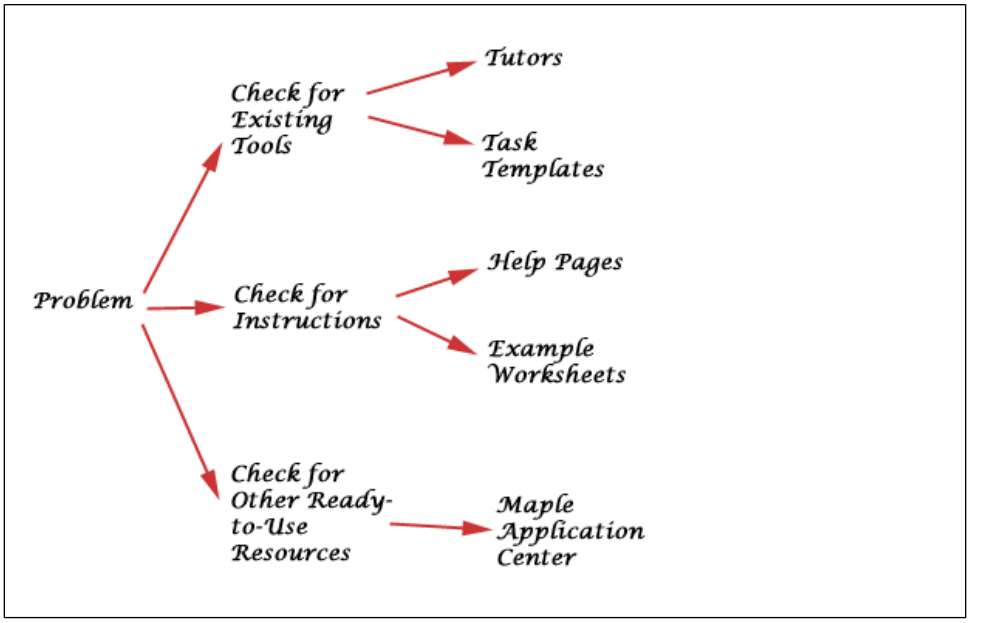
Scenario A:

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), $a \le x \le b$, 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.

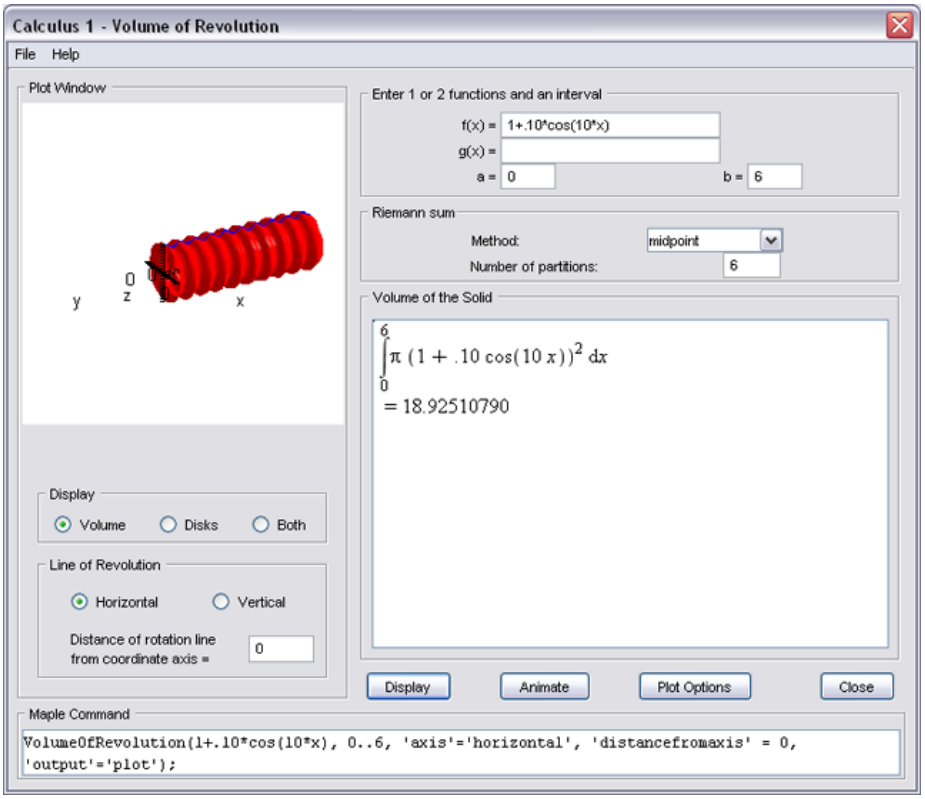


Figure 3.1: Volume of Revolution Tutor

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)

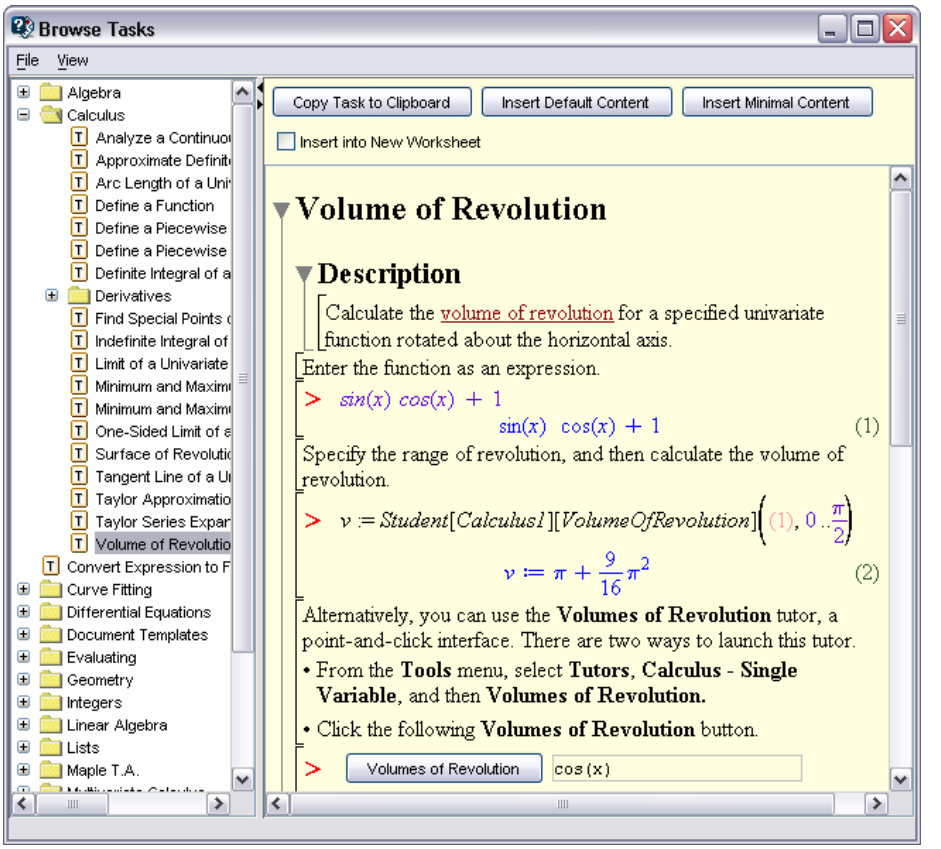
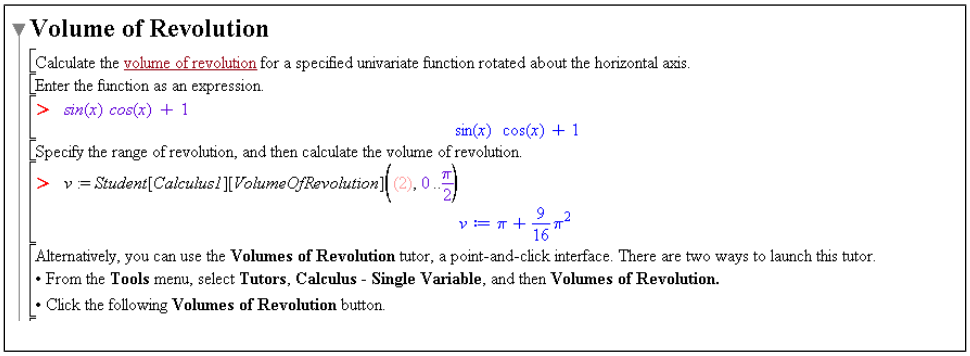


Figure 3.2: Task Template for Volume of Revolution

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.



- 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.

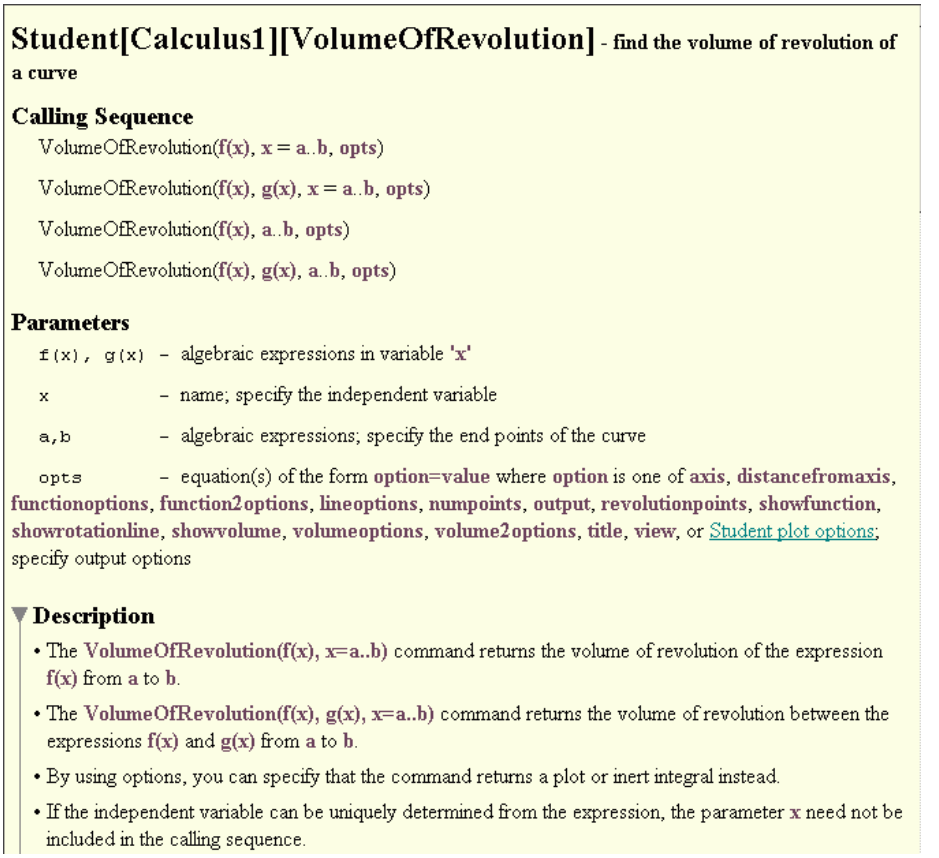
3. Review the calling sequence, parameters, and description in the **Student[Calculus1][Volume of Revolution]** help page.(See Figure 3.3)

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.

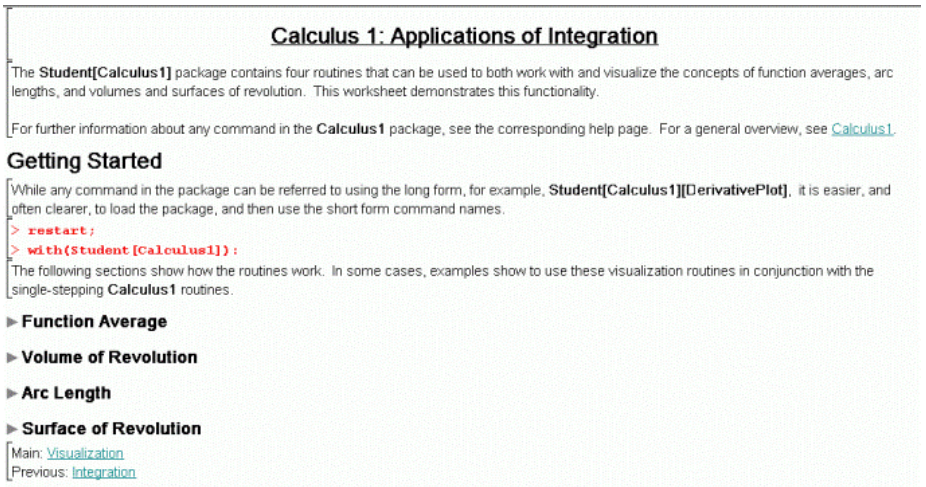


Figure 3.4: Example Worksheet

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.

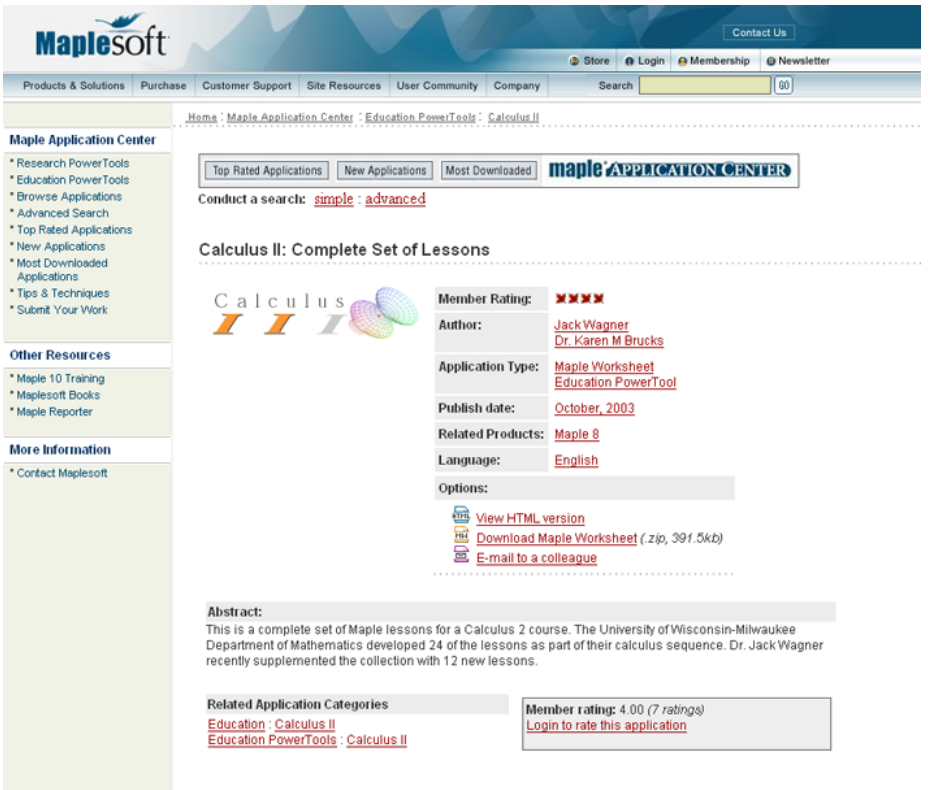


Figure 3.5: Maple Application Center: PowerTools

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.)

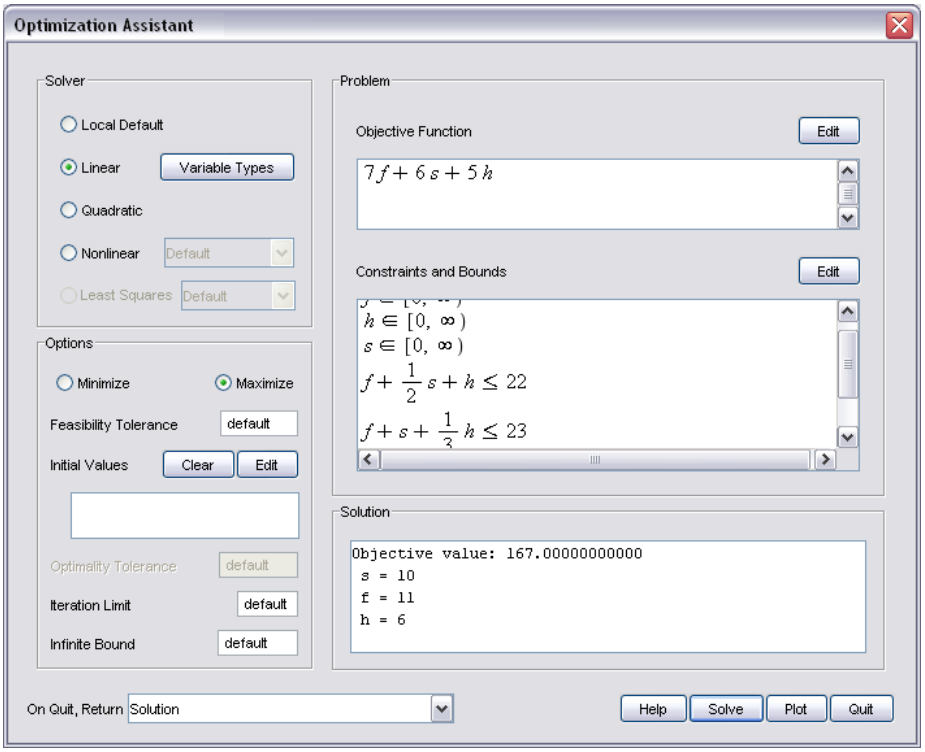


Figure 3.6: Optimization Assistant with Values Entered

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 <= 22**. Click **Add**.
- Enter **f + s + 1/3*h <= 23**. Click **Add**.
- Enter **1/4*f + s + h <= 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)

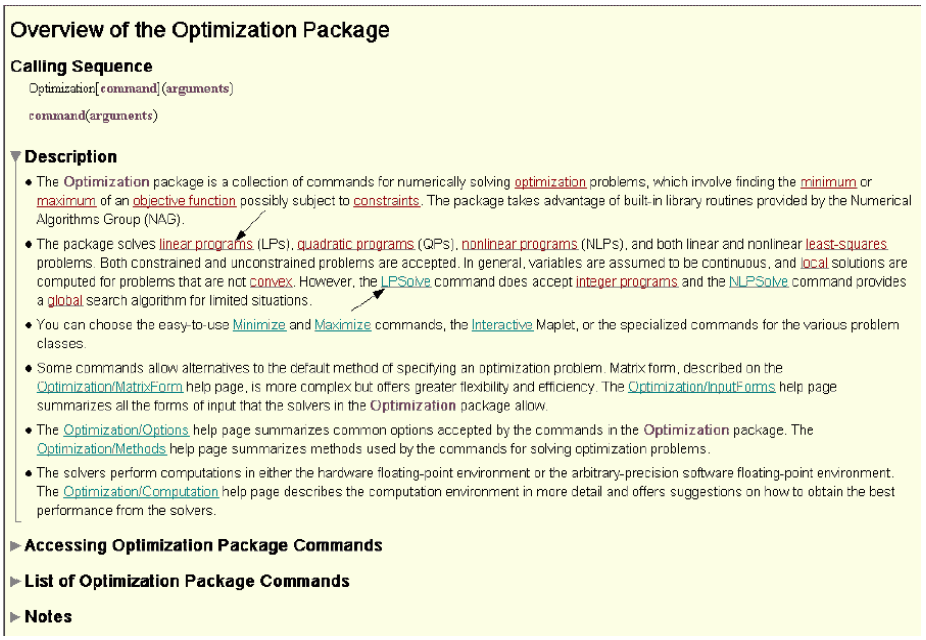


Figure 3.7: Help Page: Overview of the Optimization Package

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**.

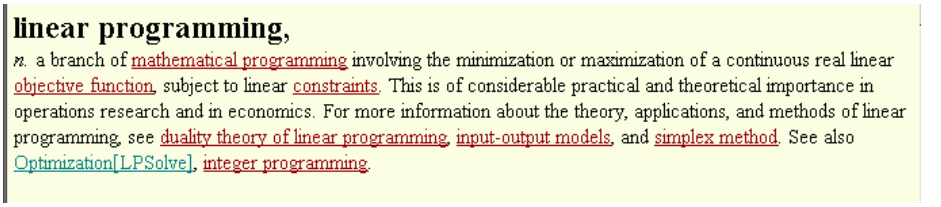
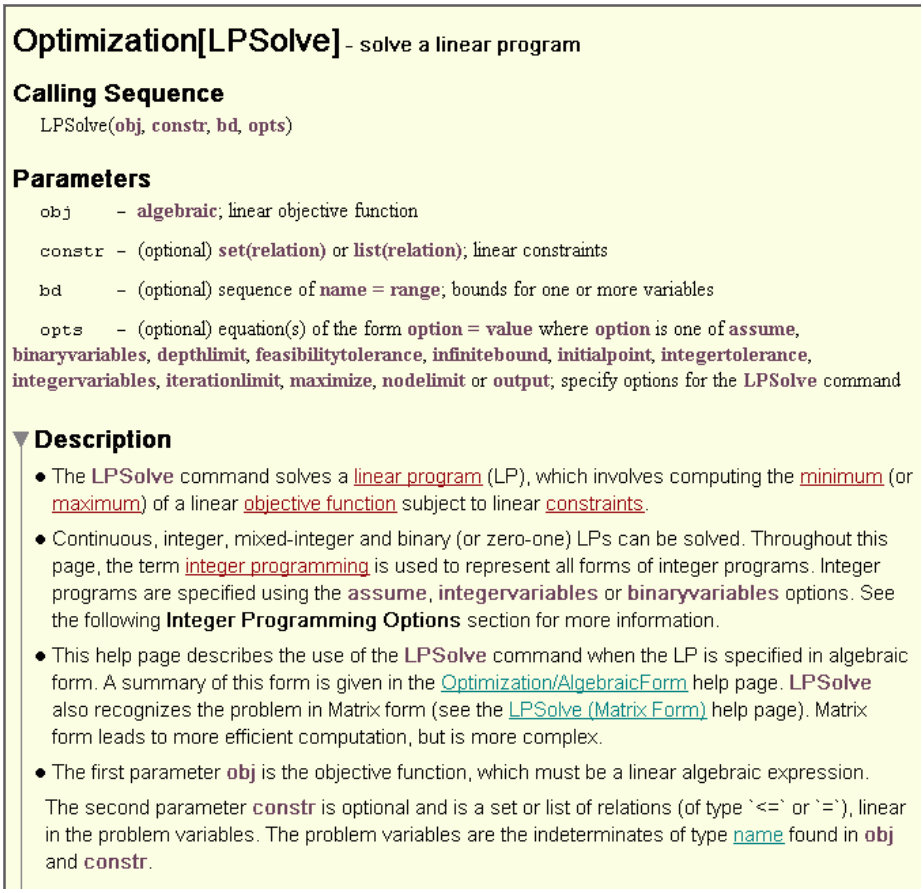


Figure 3.8: Definition of Linear Programming

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.

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

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

$$[167.00000000000, [s = 10, f = 11, h = 6]]$$

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	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. 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**.

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	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. The quantities available in the **ScientificConstants** package are divided into two distinct categories. • 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	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. The **Student** package contains the following subpackages. • **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 *types*.
series	Generalized series expansion.
map	Apply a procedure to each operand of an expression.

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