Introduction

Maple is a computer application that does mathematics. It is also a text processor so comments can be entered to accompany math calculations. Class demonstrations will show you how it works.

Handouts like this one will expand upon the information in class demonstrations. Please bring them to each lab session.

Lab assignments will also be distributed in a collection of separate handouts. All handouts will be produced and printed using Maple, in Document Mode.

Section 1. Document Mode and Worksheet Mode

Maple can be used in one of two modes, Document Mode and Worksheet Mode. Document Mode is the default. It is characterized by a blank work sheet in which the user can enter text (like what you see above) or mathematics (like what you see below).

<table>
<thead>
<tr>
<th>A derivative (with respect to x)</th>
<th>A 2-dimensional plot</th>
</tr>
</thead>
<tbody>
<tr>
<td>( (x \tan(x))' = \tan(x) + x(1 + \tan(x)^2) )</td>
<td>( \text{plot}(x \tan(x), x=-0.5 \ldots 0.5, -0.1 \ldots 0.3) )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A 2-dimensional trajectory (cycloid)</th>
<th>An integral (definite)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{plot}\left([t - \sin(t), 1 - \cos(t), t=0 \ldots 5 \pi/2]\right) )</td>
<td>( \int_{0}^{1} \sqrt{x^2 + 1} \ dx )</td>
</tr>
</tbody>
</table>

\[
\int_{0}^{1} \sqrt{x^2 + 1} \ dx = \frac{1}{2} \sqrt{2} - \frac{1}{2} \ln\left(\sqrt{2} - 1\right)
\]

As you can see, mathematics entries appear as they would in a textbook. Special math symbols like integrals can be entered in templates chosen from a pop-up menu. For example, to enter an integral, one types the word int and then presses the escape key. This brings up a menu containing several integral templates. The template is entered into the document by selecting it (use the arrow keys) and pressing the return key (or, using the mouse, click on the template).

Section 2. Maple in Document Mode

Basic Rules for Document Mode

1. To enter text press the key combination Command-T. The input cursor will then be vertical indicating that a text entry can be made. Press the [return] key to move to a new paragraph. Press [shift]-[return] to move to a new line in the same paragraph. Text paragraphs can be styled by selecting the desired style from the pull-down menu.

2. To enter mathematics for processing press the key combination Command-R. The input cursor will then be slanted indicating that a math entry can be made. Press the [return] key to send the entry to the Maple kernel for processing. The output will appear below, with a label. More than one
command or procedure can be entered for processing. Type a semi-colon or a colon to terminate one procedure and begin another in the same math entry. Press [shift]-[return] to move the input cursor to a new line in the math entry. If a procedure or a command is terminated with a semi-colon, then the corresponding output is shown below. If the terminator is a colon, then the output is suppressed. If there are several outputs for a single math entry, then only the last one gets a label for future reference.

Examples involving simple arithmetic calculations are shown below.

**In-line Evaluation**

Each of the following math entries was processed by pressing **Command-equals**. When this is done the entry is processed and the output appears on the same line after an equals sign. This is referred to as *in-line evaluation*.

**Arithmetic**

Addition, subtraction, multiplication and division are indicated with $+$, $-$, $\cdot$, and $/$, respectively. The dot for multiplication is entered by pressing the asterisk key, [shift]-8.

\[
\frac{2 \cdot 334 + 456 \cdot 23}{24} = \frac{2789}{6}
\]

Output to an arithmetic evaluation is in exact form, unless the expression to be evaluated contains a decimal number. In this case the output is also a decimal, defaulting to 10-digit accuracy.

\[
\frac{33}{333.3} + 455 = 455.0990099
\]

Maple simplifies an exact entry as much as it can.

\[
\frac{1}{1 + \frac{1}{1 + \frac{1}{2}}} = \frac{3}{5}
\]

A complicated expression like the one above can be copied and then pasted into another math entry, then edited.

\[
\frac{1}{1 - \frac{1}{1 - \frac{1}{2}}} = -1
\]

**Regarding Division**

When the division key $/$ is pressed Maple forms a stacked fraction like this: $\frac{1}{2}$. To get an "in-line" fraction like this: $1/2$, press the backslash key, \\, and then the division key, $/$.

Parentheses will be required for expressions like the two shown above.

\[
frac{1}{(1 + 1/(1 + 1/2))} = \frac{3}{5}
\]

\[
frac{1}{(1 - 1/(1 - 1/2))} = -1
\]

When multiplying terms that are inside parentheses use an explicit multiplication symbol.

\[(1 + 3/2) \cdot (4 - 4/5) = 8\]

Multiplication can also be *implied* by typing a space between the parentheses, as shown below.

\[(1 - 1/2 + 1/3) \cdot (1 + 1/2 - 1/3) = \frac{35}{36}\]
**Square Roots**

To apply the square root function type `sqrt`.

\[ \sqrt{144} = 12 \]

A square root symbol can be obtained by typing `sqrt`, then pressing the escape key `[esc]` to bring up a pop-up menu. Press `[return]` to choose the first entry in the menu.

\[ \sqrt{256} = 16 \]

Square roots are automatically simplified, if possible.

\[ \sqrt{240016} = 4 \sqrt{15001} \]
\[ \sqrt{12345678} = 3 \sqrt{1371742} \]

If a decimal number is entered, then the square root is approximated to 10 digits.

\[ \sqrt{2345678.0} = 3513.641701 \]

The square root of \(-1\) is denoted with a capital I.

\[ \sqrt{-4} = 2 \ i \]

Other roots can be obtained using fractional exponents. However fractional exponents are not always simplified as one might expect. See the next example where \(8^{1/3}\) does not simplify at all. However, by right-clicking on the "output" and choosing Simplify/Power from a contextual menu it simplifies to 2.

\[ 8^{1/3} = 8^{1/3} \xrightarrow{\text{simplify power}} 2 \]

### Section 3. Contextual and Pop-up Menus

Procedures can be applied to math entries, and their outputs, by right-clicking on the expression and choosing a command from a contextual menu. The menu that appears after right-clicking on \(8^{1/3}\) is displayed on the right.

This is useful for new and casual users who are not familiar with *Maple* commands. It is also handy when a decimal approximation is desired. See the following entry. The initial output is an exact simplification. The contextual menu command yielded the approximation.

\[ \sqrt{1 + 1/3} = \frac{2}{3} \sqrt{3} \atop\text{at 5 digits}} \rightarrow 1.1547 \]

Pop-up menus are used to enter math expressions and special symbols. For example, the following limit calculation was made by typing the word limit, pressing the escape key, and choosing the first template on a pop-up menu.

\[ \lim_{n \to \infty} (1 + 1/n)^n = e \]

The pop-up menu for the word "limit" is shown below. When it appears the first item is already selected. It is the template for the entry above. The user can tab from position to position in the template.
The following integral calculation was made by choosing a template from a pop-up menu that was obtained by typing the word int (and pressing the escape key). The numerical approximation was then generated by right-clicking on the exact output formula and then choosing Approximate/5 on the contextual menu.

\[
\int_0^3 \sqrt{1 + x^2} \, dx = \frac{3}{2} \sqrt{10} - \frac{1}{2} \ln \left( -3 + \sqrt{10} \right) \quad \text{at 5 digits} \rightarrow 5.6526
\]

**The evalf procedure**

Decimal approximations can also be obtained by applying a procedure named *evalf* (read this as "evaluate as a floating point number"). The next entry illustrates one way to do this.

\[
\int_0^\pi x \sin(x^2) \, dx = \frac{1}{2} - \frac{1}{2} \cos(\pi^2) \ ; \ \text{evalf}(\%)
\]

\[
0.9513426804
\]

Referring to the last math entry, the semi-colon terminating the integral calculation signals that another command, *evalf*, follows. The percent sign in *evalf* refers to the previous output, the evaluated integral. When *evalf* is applied the default accuracy of the approximation is 10 digits. To get more digits (or fewer) then insert the desired number right after the expression to be evaluated, as shown below.

\[
\text{evalf}(\pi, 40) = 3.141592653589793238462643383279502884197
\]

This is a 40 digit approximation to \(\pi\).

**The constants \(\pi\) and \(e\)**

To enter the constant \(\pi\) type pi and then press escape, return. Similarly, to enter the constant \(e\), type the letter \(e\) and press escape, return.

Rules and examples showing how to enter special constants, elementary functions, and fundamental math symbols are discussed in the next section.

### Section 4. Math Entries in Document Mode

#### The Elementary Functions of Calculus

The elementary calculus functions are entered just as they appear in most textbooks. See the following list.

- \(\sin(x)\)
- \(\cosh(x)\)
- \(\arcsin(x)\)
- \(\arcsinh(x)\)
- \(\exp(x)\) \hspace{1cm} \text{the exponential function}
- \(\cos(x)\)
- \(\cosh(x)\)
- \(\arccos(x)\)
- \(\arccosh(x)\)
- \(\ln(x)\) \hspace{1cm} \text{the natural log function}
- \(\tan(x)\)
- \(\tanh(x)\)
- \(\arctan(x)\)
- \(\arctanh(x)\)
- \(\log(x)\) \hspace{1cm} \text{the natural log function}
- \(\sec(x)\)
- \(\operatorname{sech}(x)\)
- \(\sec(x)\)
- \(\csc(x)\)
- \(\csc(x)\)
- \(\cot(x)\)
- \(\cot(x)\)
- \(\text{arccot}(x)\)
- \(\text{arsech}(x)\)
- \(\text{arccoth}(x)\)
- \(\text{arcsinh}(x)\)
- \(\text{arccosh}(x)\)
- \(\text{arctanh}(x)\)
- \(\text{arcsech}(x)\)
- \(\text{arccsch}(x)\)
- \(\text{arccoth}(x)\)

**Entering Math Constants (Math entry mode: Command-R)**

<table>
<thead>
<tr>
<th>To enter</th>
<th>Type</th>
<th>To obtain</th>
</tr>
</thead>
<tbody>
<tr>
<td>The constant (\pi)</td>
<td>\text{pi [esc] [return]}</td>
<td>(\pi)</td>
</tr>
<tr>
<td>The constant (e)</td>
<td>\text{e [esc] [return]}</td>
<td>(e)</td>
</tr>
<tr>
<td>The exponential function in the form (e^x)</td>
<td>\text{exp [esc] [return]}</td>
<td>(e^x)</td>
</tr>
</tbody>
</table>
The following table contains examples illustrating how to enter various mathematical expressions.

### Entering Math Expressions (Math entry mode: Command-R)

<table>
<thead>
<tr>
<th>To make</th>
<th>Type this</th>
</tr>
</thead>
<tbody>
<tr>
<td>A simple fraction ( \frac{\sin(x)}{x(y + z)} )</td>
<td>( \frac{\sin(x)}{x} ) [space] ((y+z)) \</td>
</tr>
<tr>
<td></td>
<td>The space is for implied multiplication.</td>
</tr>
<tr>
<td>A complicated fraction ( \frac{x + 2y}{x^2 - y} )</td>
<td>( 1/x^2 ) [right arrow] - ( y ) [up arrow] [delete] ( x + 2y )</td>
</tr>
<tr>
<td></td>
<td>The [up arrow] is to move the input cursor to the numerator.</td>
</tr>
<tr>
<td></td>
<td>The [delete] is to delete the 1 in the numerator.</td>
</tr>
<tr>
<td>A derivative ( \frac{d}{dt}(t^2 \ln(t)) )</td>
<td>diff [esc] (ordinary derivative template) ( t ) [right arrow] ( t^2 ) [right arrow] ( \ln(t) )</td>
</tr>
<tr>
<td></td>
<td>The [right arrow] is to move the input cursor out of the denominator of the derivative to the baseline.</td>
</tr>
<tr>
<td>A partial derivative ( \frac{\partial}{\partial z} \left( \frac{\sin(xz)}{z^2 - y} \right) )</td>
<td>diff [esc] (partial derivative template) ( z ) [right arrow] ( \sin(x[z]) ) [space] ( z^2 ) [right arrow] - ( y ) [right arrow]</td>
</tr>
<tr>
<td></td>
<td>The [space] is for implied multiplication and [right arrow] moves the input cursor to the baseline.</td>
</tr>
<tr>
<td>An indefinite integral ( \int \sqrt{y - y^2} ) ( dy )</td>
<td>int [esc] (indefinite integral template) sqrt [esc] [return] ( y - y^2 ) [tab] ( y )</td>
</tr>
<tr>
<td></td>
<td>The [tab] key is pressed to move the input cursor into the differential at the end of the integral template.</td>
</tr>
<tr>
<td>A definite integral ( \int_{\pi}^{2\pi} \frac{2 + \sin^2(t)}{dt} )</td>
<td>int [esc] (definite integral template) pi [esc] [tab] ( 2 ) pi [esc] [tab] ( 2 + \sin^2 ) [right arrow] ( t ) [tab] ( t )</td>
</tr>
<tr>
<td></td>
<td>Note that ( \sin^2(t) ) can be used for ( \sin(t)^2 ).</td>
</tr>
</tbody>
</table>

In-line evaluation (Command-equals) of the derivatives and integrals in the table have the following outputs.

\[
\frac{d}{dt}(t^2 \ln(t)) = 2t \ln(t) + t
\]

and

\[
\frac{\partial}{\partial z} \left( \frac{\sin(xz)}{z^2 - y} \right) = \frac{\cos(xz)x}{z^2 - y} - \frac{2 \sin(xz)z}{(z^2 - y)^2}
\]

\[
\int \sqrt{y - y^2} \, dy = -\frac{1}{4} (1 - 2y) \sqrt{y - y^2} + \frac{1}{8} \arcsin(-1 + 2y)
\]

and

\[
\int_{\pi}^{2\pi} \frac{2 + \sin^2(t)}{dt} = \frac{5}{2} \pi
\]