Calculus Lab 1—Introductory Maple

Reminder: Below you will find some *Exercises*. For these, copy the answers from the screen onto paper and pass in the paper with your name on it.

Objectives: In this lab, we will familiarize ourselves with some common Maple commands and learn how to factor, solve, and plot polynomials using Maple.

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1. Arithmetic with Maple:

Give Maple each of the following commands. Remember to end each command with the semi-colon character ; and to hit the ENTER key after each command:

```
7*3;
(45-15)/6;
(3+4)^2-13;
sqrt(%);
```

The percent sign `%` is short for 'the last expression,' and `sqrt(x)` takes the positive square root of x. The asterisk `*` is the multiplication symbol, division is accomplished by the slash `/` symbol, and exponents follow the hat `^` symbol. Notice the use of parentheses to group things. Now compare the output from the following three commands:

```
6/8;
evalf(%);
6./8;
```

Maple will not convert fractions to decimal numbers unless you ask it to. Maple calls decimal numbers "floating point numbers." The command `evalf(x)` means '**eval**uate x as a **f**loating point number;' or in other words, convert it to a decimal. In the third command, the decimal point after the 6 tells Maple that 6 is a floating point number, so Maple automatically treats `6./8` as a floating point number instead of as the fraction 6/8. By default, Maple displays 10 digits of accuracy for floating point numbers.

2. Algebra: the `expand()` and `factor()` commands.

Execute the following commands. Don't forget the semi-colon:

```
(x+3)*(x-2);
expand(");
factor(");
```

Exercise 1: Use Maple to factor the polynomial $x^4 - 2x^3 - 7x^2 + 8x + 12$. Report the result.

The command `expand(%)` means 'multiply out the last expression.' Its reverse is the `factor()` command. Next we will introduce the `:=` symbol, which means '*define* the quantity on the left to be the same as that on the right.'

```
y:=  x^4-2*x^3-7*x^2+8*x+12;
solve(y=0);
```

This last command solves the equation $x^4 - 2x^3 - 7x^2 + 8x + 12 = 0$ for x. Based on the factoring exercise, are the solutions what you expected them to be?

```
solve(y=-5);
```

Notice the symbol `I` appears in the answer. In Maple `I` $= \sqrt{-1}$. When the `I` symbol appears, the solutions are not real numbers, since no real number equals the square root of -1.

```
solve(x^4+x^2+x+1=0);
```

Most likely, Maple just returned an answer like

```
RootOf(_Z^4+_Z^2+_Z+1)
```

If so, it's Maple's way of saying it doesn't have the ability to find the roots exactly. It can estimate the root numerically, but we won't pursue this topic now. Instead, below we'll use a graphical method to find roots approximately.

3. Basic Plotting: We can use the quadratic formula to solve the equation

$$6x^2 + x - 35 = 0$$

But we can also use a graph. Give Maple the following command:

```
plot(6*x^2+x-35,x=-4..4);
```

Notice we specify the domain of x and that we use two dots when doing so: `x=-4..4`.

Exercise 2: Let's look for a graphical solution of a problem very similar to one we addressed above. For what values of x is the following true?

$$x^4 - 2x^3 - 7x^2 + 8x + 12 > 0 \qquad (*)$$

We will answer the question by graphing this polynomial. Try:

`plot(x^4-2*x^3-7*x^2+8*x+12,x);` Since we did not specify a domain, Maple uses the default $x \in [-10,10]$.

This gives the big picture, but we need to zero in by fixing a smaller domain.

`plot(x^4-2*x^3-7*x^2+8*x+12,x=-4..4);` Getting better.

`plot(x^4-2*x^3-7*x^2+8*x+12,x=-4..4,y=-5..25);`

Here we've specified both domain (x-values) and range (y-values). You will often find it necessary to vary the domain and range to improve your plots.

Now change the plot domain and/or range to zero in on those points where the graph crosses the x-axis. Click on the graph to select it (its border will probably change when you do this). Use the mouse to place the cursor at each of the points where the curve crosses the axis. Depress the mouse button. Maple now displays the coordinates of the cursor's position (see Figure on next page). Look for this display on the far left of the menu bar (or at top of the window, if your plot displays in its own window). This technique helps you accurately locate points. When you use it, remember to click twice—once to select the graph and then once more when you have located the point whose coordinates you wish to know. Knowing these coordinates, you should now be able to say for what values of x the inequality **(*)** above is true.

Finally, we can plot many functions on a single set of axes using `plot()`. Simply enclose all the functions in an extra set of curly braces `{}`.

`plot({x,x^2,x^3},x=-2..2,y=-5..5);` Sometimes it's best to specify the range explicitly, especially when plotting polynomials.

Exercise 3: Equations with powers of x that are greater than 4 are often impossible to solve exactly. Use Maple's plotting routine to solve $x^5 - x^3 = 2x - 1$ approximately. How many roots are there, and what are their values? How many roots would you expect? Did you miss any?

Hint: Plot the expressions $x^5 - x^3$ and $2x - 1$ on the same set of axes. Think about the significance of the point of intersection of the two resulting curves.

Figure: Displaying coordinates: