Learn to use Mathematica for calculations that require a computer. You will **need it** for some homework problems.

(1) Mathematica is available in the MSU microlabs, such as Room 106 Farrell Hall and 1210 Anthony Hall. So, go to one of the microlabs (take a flash drive with you), log onto a computer and start running Mathematica. If you don't know how to start Mathematica, then go to the microlab with someone else in the class and work on this together.

The Mathematica interface is called a "Notebook". When you start Mathematica you can either open an existing Notebook (which you created and saved earlier) or open a new Notebook. If this is your first use of Mathematica, select New Document.

A Notebook contains several kinds of Input Cells (e.g., titles, texts, commands, and multiple lines of commands) and Output Cells (e.g., results of calculations and graphs).

(2) Open a Notebook and start typing into an input cell. Type

```
Plot[Sin[x],{x,0,Pi},
        AxesLabel->{"x","sin(x)"}]
```

To execute the command, type **SHIFT-ENTER** . (Hold the 2 keys down together.)

Mathematica will open an Output Cell and display the graph.

(3) Now save the notebook to your flash drive. Click on File and Save As ; you will be prompted for a directory (where to save the file) and a filename. Save the notebook to a file on your flash drive.

(4) You will want to print out the programs and plots that you make with Mathematica. I don't know how to print from the computers in the microlabs, so I recommend a different method.   Click on <u>File</u> and <u>Print.</u> A dialog box will open. Expand the scroll bar labeled <u>Name</u>; select <u>Print to File (PDF).</u> Then type into the input box called <u>Output file</u> the directory and name that you want for the printout of the Notebook. By default the filename is "print.pdf" but you should give it a better name. Also, if you click on the button marked "..." you will open a window to your directories, including those on the flash drive.

Now you have a printout of the Notebook, in PDF format, stored on your flash drive. You should know a place where you can print PDF files, perhaps in a computer room in your dorm.

(5) The next few pages provide some example calculations for you to try out. You can type all the commands into one Input Cell, and then execute them all by typing **SHIFT-ENTER**.   Or, you can type one command at a time, executing them one-by-one. (But it is easier to group several commands together into a single Input Cell.)

(6) If you need information about a command, there is extensive on-line help within Mathematica. For example, suppose you want to know about the **Solve** command. In an empty Input Cell type **?Solve** and **SHIFT-ENTER**.

Exercise 1.

Plot the function tan(x) for x from −5 to 5, using reasonable plot ranges on the axes.

    Plot[Tan[x],{x,-5,5},
        PlotRange->{{-5,5},{-10,10}}]

Make a sketch of the graph in the box:

Exercise 2.

Find the two solutions of the equation $2x^2 + 3x - 7 = 0$.

Denote the two solutions by r_1 and r_2.

Determine their digital values to 10-place accuracy.

Calculate $r_1 + r_2$ and $r_1 r_2$.

```
roots=Solve[2*x^2+3*x-7==0,x]
r1=x /. roots[[1]]
r2=x /. roots[[2]]
SetPrecision[r1,10]
Simplify[r1+r2]
```

Record your answers in the box:

$r_1 =$ _____

$r_2 =$ _____

$r_1 \times r_2 =$ _____

Exercise 3.

A mortar fires a shell from ground level on a horizontal plane. The initial speed is 37 m/s and the initial direction is 60 degrees above the horizontal. Plot the trajectory. Calculate the maximum height , final horizontal distance (where the shell lands) and final time of flight of the shell. Neglect air resistance.

```
Remove["Global`*"]
{g,v0} = {9.81,37}
x[t_]:=v0*Cos[Pi/3]*t
y[t_]:=v0*Sin[Pi/3]*t-0.5*g*t^2
ParametricPlot[{x[t],y[t]},{t,0,10},
      PlotRange->{{0,150},{0,75}}]
QQ = Solve[y[t]==0,t]
tfinal = t /. QQ[[2]]
distance = x[tfinal]
```
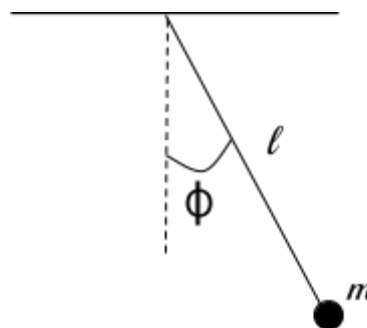
Record your answers in the box:

final time = _____

final distance = _____

max height = _____

Exercise 4.

The equation of motion of a simple pendulum is $\phi'' = -(g/l)\sin\phi$ where l is the length of the pendulum; l = 1.1 m. (Notation: Prime ' denotes d/dt.)   **Solve** the equation for these initial conditions: $\phi(0) = \pi/2$ and $\phi'(0) = 0$. **Plot** a graph of $\phi(t)$. **Determine** the period of revolution.

```
Remove["Global`*"]
{g,len}={ 9.81, 1.1 }
equations= {phi''[t]== - (g/len)*Sin[phi[t]],
      phi[0]==Pi/2,phi'[0]==0}
soln = NDSolve[equations,phi,{t,0,10},
      PrecisionGoal->10, AccuracyGoal->10]
angle = phi /. soln[1]]
Plot[angle[t],{t,0,10}]
estimate=2.66
FindRoot[angle[t]-0.5*Pi,{t,estimate}]
```

Record your answers in the box:

Sketch of the graph:

Period = _____

Exercise 5.

A particle moves in one dimension, x.

The force on the particle at x is $F(x) = -kx(1 + x^2/a^2)^{-1/2}$.

Calculate the work done if the particle moves from 0 to 3a.

What is the potential energy at x = 3a?

    F[x_]:= – k*x*Power[1+x^2/a^2, –0.5]
    Integrate[F[x],{x,0,3*a}]

Record your answers in the box:

Work = _____

P.E. = _____