

Your lab grade will be based on the following:

Item	Grade based on	Points
Feedback	Thoroughness	/1
In-class	Thoroughness, sense-making	/5
Problems	Accuracy, thoroughness, sense-making	/2
Summary	Whether conclusion is appropriate Whether evidence supports conclusion Whether example is reasonable	/2
TOTAL		/10

Summary: look at your lab notes while doing this!

1. Write down one major conclusion you can draw from this week's laboratory. For example, describe the interactions between positive, negative and neutral objects. Please explain *in detail*.

2. Describe the experimental evidence that supports your conclusion. Please explain *in detail*.

3. Give one example of applications/situations for the finding(s) you described above in your everyday life outside of physics lab. Describe *in detail*.

Mathematica Exercise

■ To run your code in Mathematica press "[shift]+[enter]".

■ Notation matters! If your code doesn't work check your brackets, commas, and capitalization. They all matter.

■ The help page and google are your friends. Mathematica has been around for many, many years so if you run into a problem, chances are other people have run into the same problem and solved it. Google the phrase, 'how to "fill in the blank" in Mathematica', and you will almost always find the answer.

You can save your code + graphs to a pdf, or you can print them out.

Define Variables:

First you need to define some variables. This tells the worksheet what x and y are.

Type

$x = 3$

This will replace the variable x with a 3 every time it is encountered by Mathematica.

$x=y$

Will replace "x" with "y" every time it is encountered.

These direct assignments will be stored in Mathematica for the entirety of your session. In order to clear variables assigned in this manner is to use the Clear function, or quit the kernel. The latter will completely reset the session and any functions, or assignments, you have made will also be reset.

You can set variables to a constant.

$x=3$

$y=3$

And you can do logical queries by using a '=='. Type

$x==y$

Now hit the 'shift' and 'enter.'. It should return

True

Because 3 does equal 3.

Indefinite Integrals:

Try evaluating the following:

$\text{Integrate}[x, x]$

If you want to include a coefficient you can define it as a variable to be set later. Run

`Integrate[A*x, x]`

Note that you have to use `*` to denote multiplication. Try these integrals next.

$$\int \sin(x) dx$$

$$\int e^x dx$$

$$\int \log(x) dx$$

$$\int \sqrt{y} dy$$

$$\int \frac{x^y}{x} dx$$

Here are a few more complicated ones.

$$\int \frac{x(x+y)y^x}{e^x} dx$$

$$\int \frac{x(x+y)y^x}{e^x} dy$$

Definite Integrals:

This code says to integrate x from 0 to 10.

`Integrate[x, {x, 0, 10}]`

Try it out!

Run these integrals.

$$\int_0^{\pi/2} \cos(x) dx$$

$$\int_1^{10000} \frac{1}{z} dz$$

$$\int_1^{\infty} \frac{-1}{x^2} dx$$

$$\int_0^1 e^x dx$$

Numerical Integration:

Mathematica is unable to analytically evaluate some integrals. Try this one and see what you get.

```
Integrate[Sin[Sin[x]], x]
```

Even with limits it will not work, try this.

```
Integrate[Sin[Sin[x]], {x, 0, Pi}]
```

So we will try numerical integration. This is not an exact solution but it can be very precise. This is how you write a numerical integration

```
NIntegrate[Sin[Sin[x]], {0, Pi}]
```

Try numerically integrating $\frac{e^x}{x^2}$ from 10 to 20.

Differentiation:

You can also use Mathematica to calculate derivatives. Start with this one.

```
D[x, x]
```

Try to find the derivatives of these functions.

$$e^x$$

$$e^{2x}$$

$$\log(x)$$

You can take higher order derivatives like this

D[Log[x], {x, 5}]

Find the 1st through 5th derivative of

$$\sin(x)^3$$

Plotting:

Making graphs is one of the most useful things Mathematica can do. Start by plotting a sine wave.

Plot[Sin[x], {x, 0, 6*Pi}]

There are several options that you can include.

Plot[Sin[x], {x, 0, 6 π }, PlotStyle -> Red]

Try graphing these functions.

$$y = 3x - 2$$

$$y = e^x$$

$$y = \sin\left(\frac{1}{x}\right)$$

And you can plot more than one function on the same graph.

Plot[{Sin[x], Sin[2*x], Sin[3*x]}, {x, 0, 2 Pi}, PlotLegends -> "Expressions"]

Plot all four of these functions on the same graph so it is easy to tell them apart.

$$y = x, y = x^2, y = x^3, y = x^4$$

Root Finding:

If you never want to use the quadratic formula again, you can use Mathematica to find the roots of a formula.

FindRoot[y = -3 x + 5, {x, 0}] (Don't forget to declare x as a variable)

Find the root of Tan(x).

To find the intersection of 2 functions run a command like this.

Solve[{y == -x + 1, y == x - 1}, {x, y}]

Find the intersection of

$$y = x^2 - 1, y = x + 1$$

Challenge Problem

3D Plotting:

Every once in a while, it is nice to have a 3D plot.

The electric field from a positive point charge, of charge Q , is given by $E = (1/4\pi\epsilon_0) Q/r^2$. In cartesian coordinates, the vector form can be written as follows $(Q/4\pi\epsilon_0)(x/x^2+y^2+z^2, y/x^2+y^2+z^2, z/x^2+y^2+z^2)$. Using the `VectorPlot3D` function, plot the electric field given above with appropriate axes labels. Does the plot look like what you expect it should? Describe its key features.

Phys 232 Mathematica introduction post lab.

1. One of the last things you did in the worksheet is to find the intersection of these two equations $y = x^2 - 1$, $y = x + 1$. Please write down the lines of code you used to find the intersection and the answer you got when you ran your code.
2. Now, plot these two lines and visually show that the answer you got in part 1 is correct.

CODE:

NUMERICAL SOLUTION:

PLOT:

Feedback: Please tell us what you liked about this lab, what you disliked and why. If there was any part/s that helped you or any part/s that were particularly unhelpful please let us know.