Lesson 7: Graphing

Graphing is an essential skill for both Physics 20 and 30. You MUST be able to follow all of the rules of properly drawing a graph, and also be able to do basic interpretation of graphs.

When you are presented with a chart of numbers that you are going to graph, you should start by identifying which variable is the manipulated variable and which is the dependent variable.

- In a lab, you are usually watching to see one thing change on its own, while letting something just plod along in an expected way.
- The one that you're watching for changes in is called the **dependent** or **responding** variable, drawn on the **y-axis**.
- The one that is changing in a regular expected pattern is the **independent** or **manipulated** variable, drawn on the **x-axis**.
- As a rule of thumb, time almost always goes on the x-axis.

Graphing Rules

Graphs you draw must have the following **five** basic characteristics. If you miss any part you will lose marks.

Title

- Your title should be short, but still clearly tell what you have graphed.
- The most common and recommended way to name your graph is to say what your y-axis and x-axis are.
  - One way to say it is "**Y-Axis versus X-Axis**"
  - The other common way is to say "**Y-Axis as a function of X-Axis**"

Labeled Axis

- Make sure to write out the ***full name*** of what you have graphed on each axis, along with the ***units*** you used.
- If you are using any sort of scientific notation for the numbers, make sure you show it here also.

A Well Chosen Scale

- The information you plot should always cover at least 75% of the area on your graph.
  - Start by looking at the maximum values you have for both the x and y axis.
  - Then check out how many major "ticks" you have on each axis of the actual graph.
  - Divide your maximums by the ticks to find out roughly what to label each tick as.

Data Plotted Correctly

- It's too bad when a person does all this work, and then does a sloppy job of plotting their information.
- Make sure you are as careful as possible when marking your points on your graph, otherwise everything else is a waste of time.
- You should always put **little circles** around each dot, since they might be hard to see on the graph paper. It also shows that each data point is a bit "iffy."

Best Fit Line

This step is sometimes optional, since your data might not give you a graph that has a straight line linear relationship.

- If your graphed data looks like a curved exponential relationship, draw a smooth curved line through your data points instead.

When drawing a best fit line do **not** "connect the dots."

- Instead, you should try to draw a completely straight line that pases through as many of your data points as possible.
- Try to get as many points above the line as below.

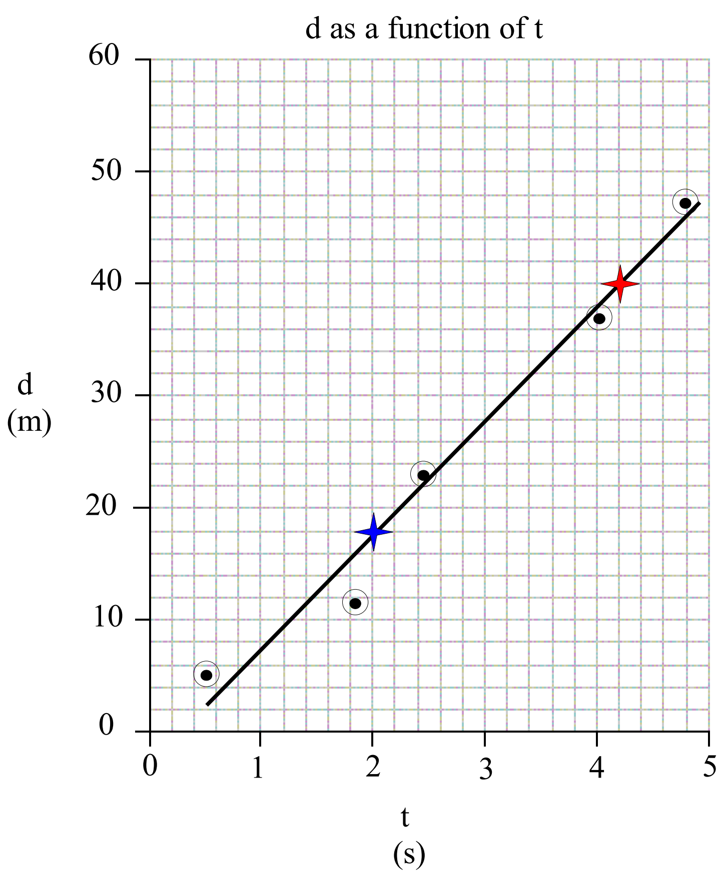
This is the line that you **must** calculate your slope from.

- Use the formula...

$$slope = \frac{rise}{run} = \frac{(y_2 - y_1)}{(x_2 - x_1)}$$

- You must know this formula and know how to use it!
- You are ***not*** allowed to use the data points you plotted! You ***must*** read two points from the best fit line.

Example 1: **Determine** the slope of the following best fit line.



Notice that on the graph I have marked off two points on the best fit line...

$(x_2, y_2) = (4.2, 40)$

$(x_1, y_1) = (2, 18)$

I use these to calculate the slope.

$$slope = \frac{rise}{run} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$slope = \frac{40 - 18}{4.2 - 2}$$

$$slope = 11\, m/s$$

I am careful to give my final answer

- as a single value (not a fraction)
- showing units based on the axis (rise over run is metres over seconds)

Line Straightening

A special skill involving graphs is a technique called **line straightening**, sometimes called an **averaging technique**.

- Essentially, you will sometimes have data to graph that would give you a curved line.
  - Analyzing this line is very difficult... calculating a single slope or area under the line is impossible.
- What we need to do is come up with a way to manipulate the info you have so that, when plotted, it will give you a **straight line** of best fit (a linear relationship).

Warning!
Do not make the mistake of calculating some sort of average based on the numbers given if you are asked to use an "averaging technique" for a graphing problem.

You'll need to do some thinking to get these done.

1. Identify the main formula/concept that has something to do with the data you're looking at.
2. Get rid of the variables in the formula that are not part of the data you're looking at... this will leave you with a relationship, instead of a formula.
3. Look at what is being done mathematically to the variables. Most often one of them will either be squared or square rooted. Create a new column of values where you do this to the values.
4. Plot your new data as a straight line graph.

Quite often, the resulting graph will have a slope or an area under the line that has some sort of meaning.

Example 2: A student performs an experiment to measure the how centripetal force changes as the velocity is altered. He collects the data shown on the table below. Using a suitable averaging technique, **determine** a new set of values that, if graphed, would give a linear graph. **Identify** the meaning of the slope of this graph, and **determine** the mass of the object if the radius of the circle is 1.15 m.

F_c (N)	v (m/s)	
20.0	1.0	
80.0	2.0	
180	3.0	
320	4.0	
500	5.0	

First we need to identify the main formula (which we haven't studied yet!).

- Don't worry, questions you'll do will be based on formulas you've seen before.

$$\vec{F}_c = \frac{m\vec{v}^2}{r}$$

Next get rid of the unneeded parts of the formula.

- The only variables we are concerned about according to the chart of values given are F_c and v.

$$\vec{F}_c \,\alpha\, \vec{v}^2$$

Now evaluate what this relationship is telling us.

- Nothing has been done to F_c , but v is being squared.

- Come up with a new column of values with v squared. No, really, just square v. Be sure to make the units squared as well.

F_c (N)	v (m/s)	v^2 (m^2/s^2)
20.0	1.0	1.0
80.0	2.0	4.0
180	3.0	9.0
320	4.0	16
500	5.0	25

- The graph would be F_c vs v^2.
    - Try graphing it yourself and then calculate the slope... you should get about 20 $N/m^2/s^2$
- To figure out what the slope actually means in this case, you would look at your graph this way...

$$slope=\frac{rise}{run}=\frac{F_c}{v^2}$$ and from the original formula $$F_c=\frac{mv^2}{r} \rightarrow \frac{F_c}{v^2}=\frac{m}{r}$$

$$slope=\frac{F_c}{v^2}=\frac{m}{r}$$
$$slope=\frac{m}{r}$$

- So if we want to determine the mass of the object...

$$slope=\frac{m}{r}$$
$$m=slope(r)$$
$$m=20\,x\,1.15\,m=23\,kg$$