

This packet contains the following:

- Notes on reviewing some math skills and graphing practice
- HW 1
- HW 1 answers
- Lab 1

Please go through the notes as slowly as you need to. If you've had other science classes, much of it may be review, in which case you'll just want to skim through to be sure you don't miss anything. You may turn in your work as you finish it or all at once. Every week, all the work will be due on the Sunday that follows the week. Work must be turned in by midnight. Be sure to send it at the latest by early in the evening, though. You cannot assume emails will go through immediately. Some take a surprisingly long time to come through. You don't want your work marked late due to high email traffic.

Week 1 work that must be turned in by midnight, Sunday, June 14, 2020:

- HW 1
- HW 2
- Lab 1

I. The Metric System and SI

The worldwide scientific community and most countries currently use an adaptation of the metric system to make measurements. The SI system or international system of units is regulated in both France and the US to keep the standards of length, time, and mass against which our metersticks, clocks, and balances are calibrated. Because other quantities can be described using combinations of these three units, length, time and mass are base units. The table below lists the seven base units, which are the foundation of SI.

Fundamental Quantities	SI Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	Ampere	A
Temperature	Kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

A wide variety of other units, called derived units are combinations of the base units. Common derived units are in the table below.

Quantity (derived units)	Name	Symbol	Expression
Frequency	Hertz	Hz	1/s
Force	Newton	N	kg m/s ²
Pressure, stress	Pascal	Pa	N/m ²
Energy, work	Joule	J	N m
Power	Watt	W	J/s
Electric charge	Coulomb	C	A s
Voltage, electric potential	Volt	V	W/A
Capacitance	Farad	F	C/V
Electrical resistance	Ohm	Ω	V/A
Magnetic field	Tesla	T	N/A m

II. Scientific Notation

To work with very large or very small numbers, it is convenient to use scientific notation. To write numbers in scientific notation, move the decimal point until only one nonzero digit remains on the left of the decimal. Then count the number of places you moved the decimal point and use that number as the exponent of 10.

A scientific calculator can automatically change any number into scientific notation if the correct mode is selected, or it can change any number from scientific notation into normal notation. If you are not able to figure this out on your calculator, I would enter the brand of calculator into YouTube and try to find a video that will explain it. There are many videos on using scientific calculators. Another option is using the manual that goes with your calculator. If the manual isn't handy, you can look it up on the internet. It shouldn't be hard to find out to do this and it will be well worth it if you can figure it out. If you still cannot figure this out, email me and I will do my best to help.

Example 12,000 may be written 1.2×10^4

0.00125 may be written 1.25×10^{-3}

Below are problems to practice. The answers are at the end of the packet.

*****Practice Problem 1**

Convert the following numbers into scientific notation.

- a. 923
- b. 0.00425
- c. 4,524,000
- d. 6750
- e. 92.03

*****Practice Problem 2**

Convert the following numbers into standard notation.

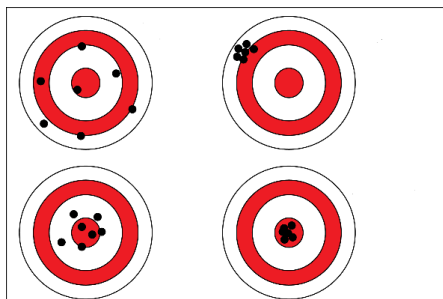
- a. 3.924×10^5
- b. 9.2×10^6
- c. 8.66×10^{-4}
- d. 1.22×10^{-8}
- e. 1.58×10^3

III. Measurement Uncertainties

Scientists only believe the results of an experiment if other people have repeatedly obtained the same result. A scientific result must be reproducible. But no scientific result is perfectly exact. Every measurement, whether it is made by a student or a professional scientist, is subject to uncertainty.

Accuracy describes how well the results of an experiment agree with the standard value. **Precision** describes the degree of exactness of a measurement. Precision depends on the instrument used to make the measurement. Generally, the instrument that has the finest division on its scale produces the most precise measurement. Precision is often described as the repeatability of a measurement. A measurement may be precise without being accurate, both accurate and precise or neither accurate nor precise.

For example, look at the targets below. The target on the top left does not show precision or accuracy. The target on the top right shows precision, but not accuracy. The targets on the bottom both show precision, but the target on the bottom right shows better precision and accuracy.



*****Practice Problem 3**

A measurement was taken three times. The correct measurement was 68.1 mL. Circle whether the set of measurements is accurate, precise, both, or neither.

- | | | | | |
|------------------------------|----------|---------|------|---------|
| a. 78.1 mL, 43.9 mL, 2 mL | accurate | precise | both | neither |
| b. 68.1 mL, 68.2 mL, 68.0 mL | accurate | precise | both | neither |
| c. 98.0 mL, 98.2 mL, 97.9 mL | accurate | precise | both | neither |

IV. Significant Figures

Significant figures are the valid digits in a measurement. There is a system of rules used for rounding numbers in a measurement. The following rules are below.

A. Rules for Counting Significant Figures

- All non-zero digits and any zeros contained between non-zero digits count.
Example $3042 = 4$ significant figures
- Leading zeros don't count
Example: $0.0035 =$ two significant figures
- Trailing zeros count if there is a decimal point
Example: $0.00240000 =$ six significant figures
- Trailing zeros do not count if there is no decimal point.
Example: $100 =$ one significant figure
- If a whole number has a decimal but no trailing numbers, all numbers before the decimal are significant.
Example: $100. =$ three significant figure

B. Working with Significant Figures

Multiplication and Division Rule: Your answer must show the same number of significant figures as the measurement in the calculation with the least number of significant figures.

Example: $12 \times 3.650 = 43.8$. Since 12 has only two significant figures, and 3.650 has four significant figures, we have to round our answer to two significant figures, which would be 44.

Another example: $1.2 \times 10^6 \times 3.20 \times 10^{-2} = 3.84 \times 10^4$. 1.2×10^6 has two significant figures and 3.84×10^4 has three significant figures. We need to round our answer to 3.8×10^4

Addition and Subtraction Rule: Your answer must show the same number of decimal places as the number in the calculation with the least number of decimal places. (We are not concerned with counting significant figures, only decimal places)

Example: $3.05 + 4.2 = 7.25$. We round this number to one decimal place, giving us 7.3

Another example: $14 - 5.5 = 8.5$. Since 14 doesn't have any decimal places we need to round the answer to 9

If you need more help understanding significant figures, the following video may help.

<https://youtu.be/7b60RZqut0U>

***Practice Problem 4

Indicate how many significant figures there are in each of the following measured values.

- | | | | |
|------------|-------------|------------|------------|
| a. 246.63 | d. 0.678 | g. 14.600 | j. 350.670 |
| b. 107.854 | e. 1.008 | h. 0.0001 | k. 1.0000 |
| c. 100.3 | f. 0.003450 | i. 700,000 | l. 321,001 |

***Practice Problem 5

Calculate the following and round the answers to the appropriate number of significant figures.

- | | |
|------------------------------|----------------------------|
| a. $32.567 + 135.0 + 1.4567$ | b. $246.32 + 238.0 + 98.1$ |
|------------------------------|----------------------------|

***Practice Problem 6

Calculate the following and round the answers to the appropriate number of significant figures.

- | | | | |
|----------|---------------|----------|----------------------|
| a. _____ | 23.7 x 3.9 | d. _____ | $\frac{1.678}{0.42}$ |
| b. _____ | 45.76 x 0.25 | e. _____ | $\frac{725}{1.006}$ |
| c. _____ | 81.04 x 0.010 | | |

*** Practice Problem 7

- | | | |
|-------------------------|------------------------|-------------------------|
| 1. Round to 4 sig figs: | 2. Round to 1 sig fig: | 3. Round to 2 sig figs: |
| a. 3.682417 | a. 41.87 | a. 22.494 |
| b. 21.860051 | b. 2.473 | b. 79.2588 |
| c. 375.6523 | c. 5.687524 | c. 0.03062 |
| d. 112.511 | d. 125.3 | d. 41.86632 |

V. Dealing with Units in a Problem

When working problems in science, units are included because we are dealing with measurements, not just numbers. When all the units in a problem are canceled correctly, the units left must equal the units for the measurement in the answer to the problem. If they do not, something is wrong with the way the problem is set up. This is very valuable information.

If the same unit appears in the numerator or the denominator, the units will multiply together. For instance, meters x meters = m² or seconds x seconds x seconds = s³. If the same unit appears in both the numerator *and* the denominator, they will cancel. For instance,

$$\frac{\cancel{\text{m}} \times \text{m}}{\cancel{\text{m}}} = \text{m}$$

$$\frac{\text{g cm}^3 \text{ s}}{\text{s}^2 \text{ cm}} = \frac{\text{g cm}^2}{\text{s}}$$

***Practice Problem 8

Determine the final units in the following problems.

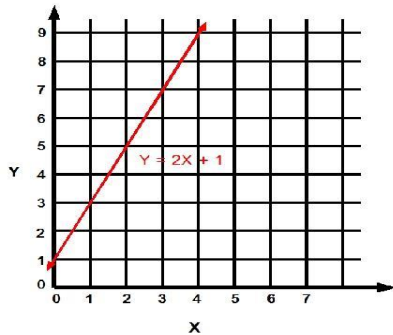
- | | |
|---|--|
| a. _____ cm x cm | d. _____ $\frac{\text{kg m}^2}{\text{s}^2 \text{ m}}$ |
| b. _____ m x m x m | e. _____ $\frac{\text{kg m}^2 \text{ s}}{\text{s}^2}$ |
| c. _____ $\frac{\text{cm x cm}}{\text{cm}}$ | f. _____ $\frac{\text{m}^3 \text{ s}}{\text{m}^2 \text{ s}^2}$ |

VI. Graphing Data

There are three relationships that are important in physics. One is a linear relationship, the second is a parabolic relationship, and the third is an inverse relationship.

The independent variable is always plotted on the x-axis and the dependent variable is always plotted on the y-axis.

1. Linear relationship

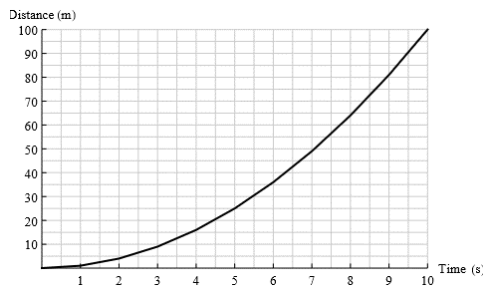


- the curve is a straight line
- the equation for the curve is $y = mx + b$ where

$$m = \text{slope} = \frac{\Delta y}{\Delta x}$$

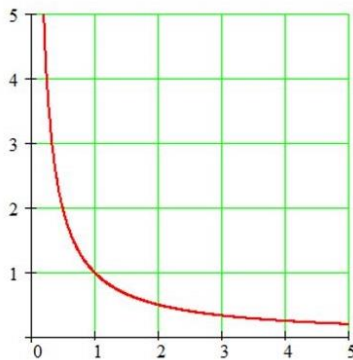
$$b = y - \text{intercept}$$

2. Parabolic (quadratic) relationship



- the curve is a parabola
- the equation for the curve is $y = kx^2$
- if the data plotted on the x-axis is squared, the curve will become linear.

3. Inverse relationship (also quadratic)



- the curve is a hyperbola
- the equation for the curve is $k = xy$ where k is a constant

VII Preparing Scatter Graphs on Excel.

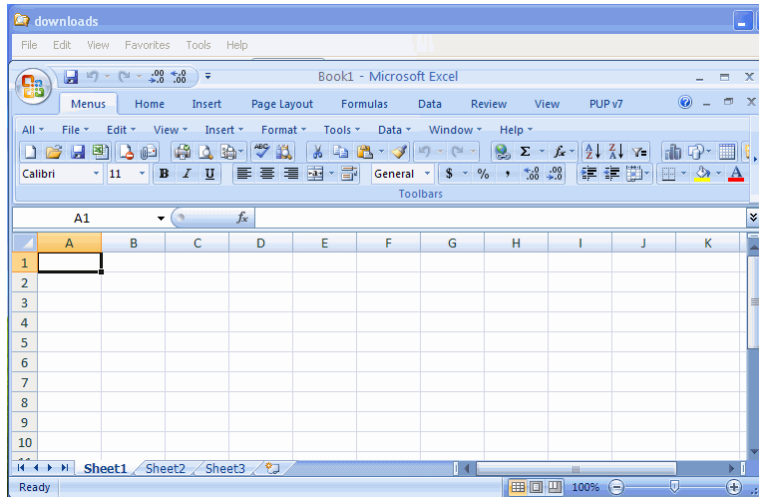
Be sure you have downloaded Microsoft Office from the Clark State website. It is free if you are a student. If you use a different version of Excel, that's fine, but realize that the directions below are for the Clark State version of Excel. Below are three different ways to learn how to prepare a graph on Excel. First, simple directions, second, directions with visuals, and third a YouTube video. Use whichever method helps you learn.

A. Simple Directions

1. Enter your data set in columns A and B. (the x-axis is A and the y-axis is B)
2. Highlight your data set and choose **Insert** and then **Charts**. Select the first scatter choice.
3. Click on **Chart Title** and enter the name for your graph.

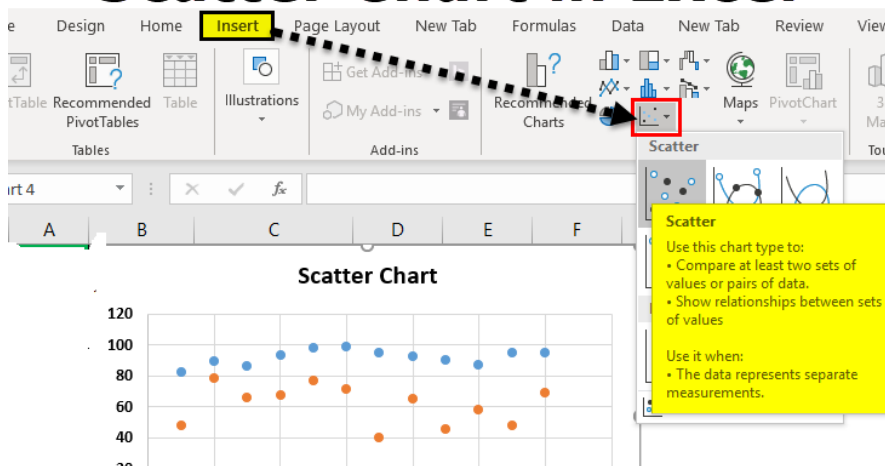
- Click on the **plus sign** at the top right corner. Click on **axis titles**. Choose the **primary horizontal axis**; Give the axis a name and include the units for the x-axis. Next choose the **primary vertical axis**; name it and include the units.
- Click on the plus sign again and choose **Trendline** found at the bottom of the list. Choose **More Options**. Click on the curve that seems to match your graph. Scroll down and find **Display Equation on the Chart** and **Display R-squared Value on Chart**. Choose both.

B. Directions with visuals

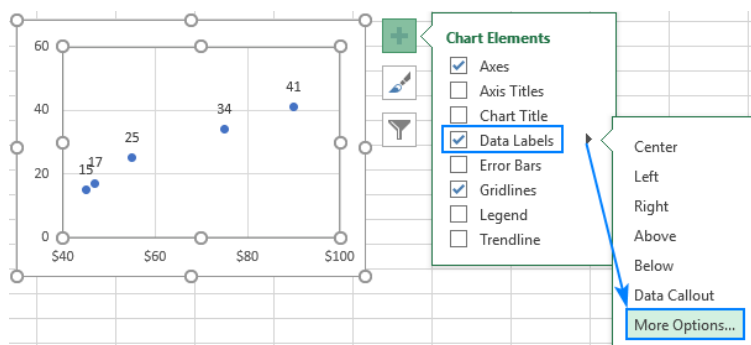


- Enter your data in Column A and Column B as shown on the left

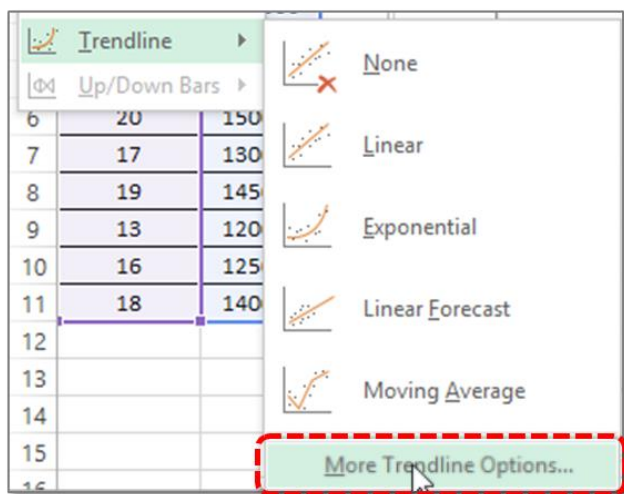
Scatter Chart in Excel



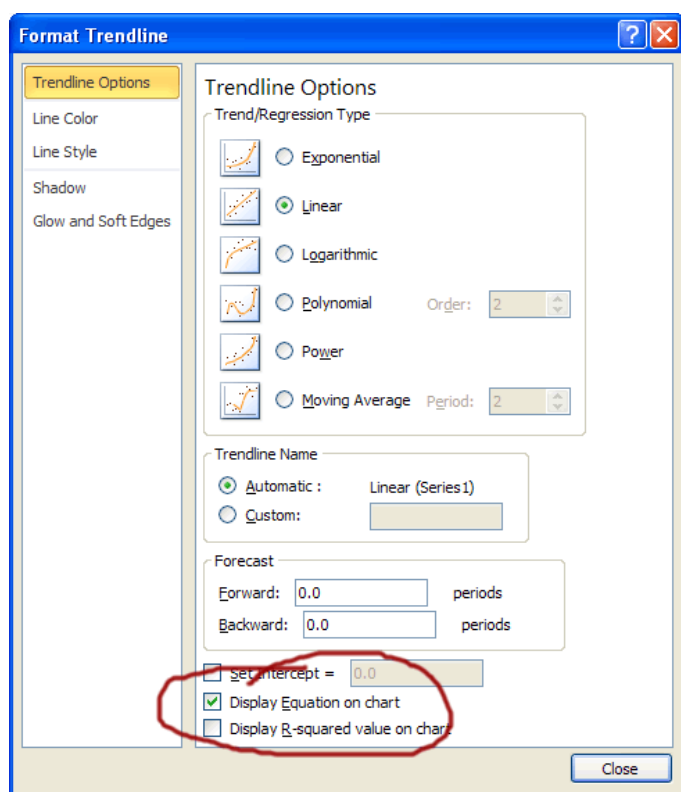
- Highlight your data set (only the numbers) and choose **Insert** and then **Charts**. Select the first scatter choice.



- Click on **Chart Title** and enter the name for your graph.
- Click on the **plus sign** at the top right corner. Click on **axis titles**. Choose the **primary horizontal axis**; Give the axis a name and include the units for the x-axis. Next choose the **primary vertical axis**; name it and include the units.



5. Click on the plus sign again and choose **Trendline** found at the bottom of the list. Choose **More Options**. Click on the graph that seems to match your graph. Scroll down and find **Display Equation on the Chart** and **Display R-squared Value on Chart**. Choose both.



6. Click on the graph that seems to match your graph. Scroll down and find **Display Equation on the Chart** and **Display R-squared Value on Chart**. Choose both.

C. Below is a link to a **YouTube video** of how to prepare a scatter plot in Excel. It is about 15 minutes long, but only the first 2 – 3 minutes apply to what we are learning. <https://youtu.be/hwqq0HYrers>

Once you have your graph completed you will usually need to include it with homework or a lab report. There are two ways to do this, depending on whether you have access to a printer.

1. If you have a printer, the graph should be included, for instance a lab or homework. Copy and paste the graph into the word document before scanning it and emailing it. Don't worry about copying and pasting the data.
2. If you do not have a printer, you will have to email your graph separately from your lab or homework. To email your graph:
 - Click on **File**, then **Save as**, then **Browse**.
 - Decide where you want to save your file, then give it a name.
 - **Go to Save as type**: scroll down to **PDF file**. Click on the PDF file.
 - When you are ready to email me your graph, open an email, then click **attachment** (the paperclip icon), and then click on **browse**. Find where you saved your file and select it. Then send the email.

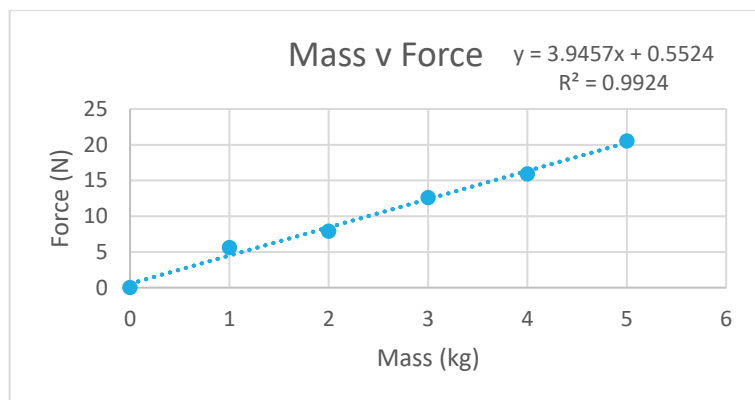
A Graphing Example

Prepare a graph of the following data in Excel and use it to answer the questions below.

Column A	Column B
Mass (kg)	Force (N)
0	0.0
2	5.6
3	7.9
4	12.6
5	15.9
6	20.5

- What is the independent variable?
- What is the dependent variable?
- What is the general equation for this kind of graph? What is the equation for this particular graph?
- What is the R^2 value? What does it indicate about the data?
- What is the slope of this graph?
- What is the relationship between force and mass?

Solution:



Notice the graph has a title and the axes are labeled with units. The curve has the trendline drawn and the equation for the line and the R^2 is showing. Although there is much more that Excel can do with data, this kind of simple graph is what you need to be able to do for PHY 1100.

- The independent variable is always on the x-axis. In this case, the independent variable is mass.
- The dependent variable is always on the y-axis. In this case, the dependent variable is force.
- The general equation for graph is $y = mx + b$ because it is linear. This particular graph has the equation $y = 3.95x + 0.55$
- R^2 value = 0.99 which shows strong correlation among the data, because 1.00 is perfect correlation.
- The slope is 3.95.
- The relationship between force and mass is linear. As mass increases, force increases.

*****Practice Problem 9** Graph the following data and then answer the questions below:

Column A	Column B
Time (s)	Distance (m)
0	0
1.12	4.96
2.42	23.8
3.03	38.0
4.55	85.1
5.04	104.1

Questions:

- What is the shape of the curve?
- What is the R^2 value and what does it mean?
- If the times were squared and then the data graphed again, what should be the shape of the curve?

Answers to Practice Problems

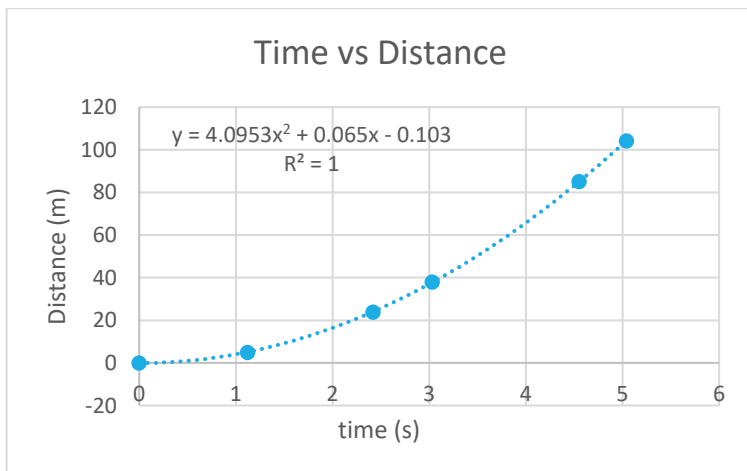
- 1.
- 9.23×10^2
 - 4.25×10^{-3}
 - 4.524×10^6
 - 6.750×10^3
 - 9.203×10^1
- 2.
- 392,400
 - 9,200,000
 - 0.000866
 - 0.0000000122
 - 1580

- 3.
- neither
 - both
 - precise but not accurate

- 4.
- | | | | |
|------|------|------|------|
| a. 5 | d. 3 | g. 5 | j. 6 |
| b. 6 | e. 4 | h. 1 | k. 5 |
| c. 4 | f. 4 | i. 1 | l. 6 |

- 5.
- 169.0
 - 582.4
- 6.
- 92
 - 11
 - 0.81
 - 4.0
 - 721

- 7.
- | | | | | | |
|----|----------|----|--------|----|----------|
| 1. | a. 3.682 | 2. | a. 40 | 3. | a. 22 |
| | b. 21.86 | | b. 2 | | b. 79 |
| | c. 375.7 | | c. 6 | | c. 0.031 |
| | d. 112.5 | | d. 100 | | d. 42 |
- 8.
- | | | |
|------------------|-----------------------------|-----------------|
| a. cm^2 | c. cm | f. m/s |
| b. m^3 | d. kg m/s^2 | |
| | e. $\text{kg m}^2/\text{s}$ | |
- 9.



- A parabola
- The $R^2 = 1$ which indicates perfect correlation in the data
- The curve would become linear

Name _____

Physics 1100 HW 1

Due June 14, 2020

1. For each data set below, determine the mathematical expression. To do this, first graph the original data on Excel. Assume the 1st column in each set of values to be the independent variable (x-axis) and the 2nd column the dependent variable (y-axis). Draw a graph of the data set and use the trendline options to find the best fit for the graph. Show the equation for the graph and the R^2 value on the graph. Give the graph a title and label the axis (including the units). Print the graphs and attach them to your homework or copy and paste them in the area below the data. To print small graphs, highlight the area behind the graph and go to **File** and then **Print**.

A. A student places various masses on a table and measure the force needed to drag them across the table.

Mass (kg)	Force (N)
0.0	0.0
1.0	5.6
2.0	7.9
3.0	12.6
4.0	15.9
5.0	20.5

Copy graph here (or attach to HW)

B. As time goes on, the height of a pile of sand in an hourglass is measured.

Time (s)	Height (cm)
0.0	0.0
28.7	4.9
40.1	9.8
49.9	15.3
57.5	20.0
64.4	24.9

Copy graph here (or attach to HW)

2. Express these numbers in scientific notation.

- a. _____ 0.123
b. _____ 11,200
c. _____ 450,000

3. Express these numbers in decimal notation.

- a. _____ 1.5×10^{-5}
b. _____ 9.2×10^9
c. _____ 5.2×10^{-6}

4. Use your calculator to solve the following. Be sure to express your answer in scientific notation.

- a. _____ $(1.2 \times 10^4)(8.4 \times 10^{-9})$
b. _____ $(9.3 \times 10^{-15})(1.2 \times 10^9)$
c. _____ $(3.7 \times 10^8)(5.7 \times 10^{-13})$

- d. _____ $\frac{(7.2 \times 10^{12})(6.5 \times 10^{-2})}{7.5 \times 10^{-11}}$
e. _____ $\frac{(6.6 \times 10^{12})(1.5 \times 10^8)}{(2.1 \times 10^{-3})(7.8 \times 10^{-25})}$

5. Indicate how many significant figures there are in each of the following measured values.

- a. _____ 46.43
b. _____ 107.850
c. _____ 100.30
d. _____ 0.6780
e. _____ 1.0008

6. Calculate the answers to the appropriate number of significant figures.

- a. _____ $26.20 + 28.28 + 9$
b. _____ $658.0 - 23.547$

7. Calculate the answers to the appropriate number of significant figures.

- a. _____ 43.7×2.8
b. _____ 65.76×0.29
c. _____ $\frac{1.677}{0.42}$
d. _____ $\frac{28.367}{3.84}$
e. _____ $\frac{1278}{1.008}$
f. _____ $\frac{(2.3 \times 10^9)(4.7 \times 10^{-11})}{(8.2 \times 10^{-4})(1.7 \times 10^{12})}$

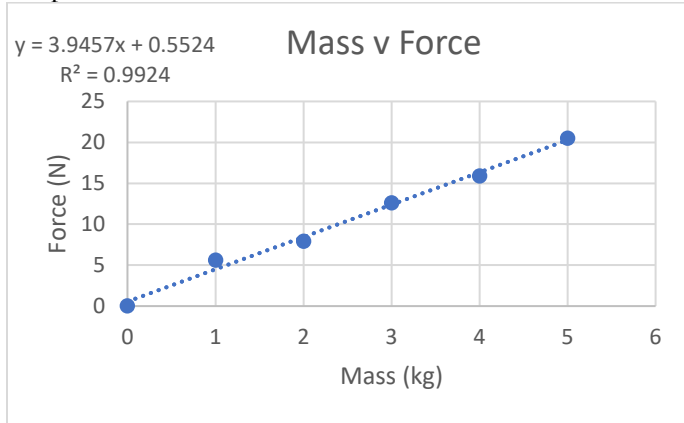
8. Determine the final units in the following problems.

- a. _____ $\text{km} \times \text{km}$
b. _____ $\text{m} \times \text{m} \times \text{m}$
c. _____ $\frac{\text{m} \times \text{m}}{\text{m}}$
d. _____ $\frac{\text{kg m}^2}{\text{m}}$
e. _____ $\frac{\text{kg m}^3 \text{ s}}{\text{m s}^2}$
f. _____ $\frac{\text{m}^3}{\text{m s}^2}$

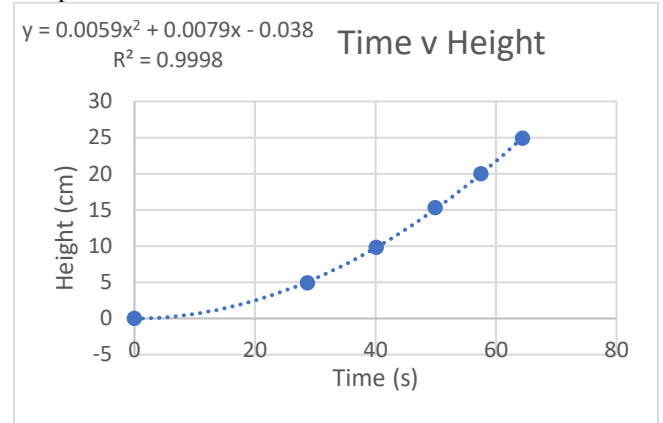
HW 1 Answers

1.

Graph A



Graph B



2.

- 1.23×10^{-1}
- 1.12×10^4
- 4.5×10^5

3.

- 0.000015
- 9,200,000,000
- 0.0000052

4.

- 1.0×10^{-4}
- 1.1×10^{-5}
- 2.1×10^{-4}
- 6.2×10^{21}
- 6.0×10^{47}

5.

- 4
- 6
- 5
- 4
- 5

6.

- 63
- 634.5

7.

- 1.2×10^2 or 120
- 19
- 4.0
- 7.39
- 1268
- 7.8×10^{-11}

8.

- km^2
- m^3
- m
- kg m
- $\text{kg m}^2/\text{s}$
- m^2/s^2

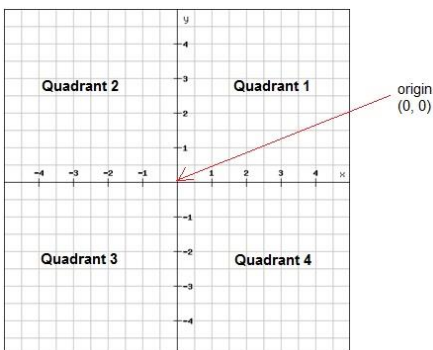
Name _____

PHY 1100 Lab 1 Curve Fitting

Due by June 14, 2020

Directions

1. Open the following hyperlink:
https://phet.colorado.edu/sims/html/curve-fitting/latest/curve-fitting_en.html
2. Note that there is a basket of brown circles. It is possible to take these circles, one at a time, and put them on the x-y coordinate system wherever you wish, to create a point. Place at least three points on the graph in quadrant I, which is the only quadrant we will use for this lab, and then click on the linear curve in the menu on the right. A menu with more options should appear.



3. After placing at least three points on the graph, see what happens when you make different selections in the menu. Become familiar with what the menu offers.
4. On the left side are two bar graphs. The x^2 and the r^2 , both statistical measurements. As the r^2 value increases, it indicates that the data are better related, that is, have more precision, but it does not indicate anything about the accuracy of the data. An r^2 value of 1.0 indicates perfect data. The x^2 value is called the chi square. A good graph will have a very low x^2 value. This program will show you a good x^2 in blue, which changes to green, then yellow and then red as the data worsens on the graph. In summary, good data has a high r^2 and a low x^2 . As one increases, the other will decrease. You can click on the information icon “i” to learn more about the x^2 if you wish.

Procedure

Part A. Turn on the values in the top right menu. Place points on the graph at the following locations and answer the questions below.

x-axis	y-axis
1.1	1.1
2.4	3.4
4.9	3.2
8.8	4.3
9.0	6.4

1. Click on linear and record the values for x^2 and r^2 below. Change the option from linear to quadratic and record the values for x^2 and r^2 below. Notice that the x^2 value enters the red zone when the quadratic choice is selected, which means that even though the r^2 values are the same, a higher x^2 means that linear is a better choice for the curve.

Linear: $x^2 =$ _____ $r^2 =$ _____

Quadratic: $x^2 =$ _____ $r^2 =$ _____

2. The equation for any straight line is $y = mx + b$, where m = slope, and b = the y-intercept. Find the equation for the line on this graph at the top of the graph and record it below. Indicate the slope of the line.

Equation = _____ slope = _____

3. Sometimes we collect data and find that a point is above or below the curve. This is called an outlier. If the point is removed, the graph should improve, but it's important to try to find a reason for the point being an outlier, since an error occurred. Remove the data point 8.8, 4.3, by returning it to the basket. Change back to linear and record the new values for x^2 and r^2 below. What happens to the r^2 and x^2 values? What does this indicate? _____

Linear: $x^2 =$ _____ $r^2 =$ _____

4. Remove the data point 2.4, 3.4. Record the. What happens to the x^2 and r^2 values? _____ What does this indicate? _____

Linear: $x^2 =$ _____ $r^2 =$ _____

5. Switch from linear to quadratic and record the new values for x^2 and r^2 below. Based on the x^2 and r^2 values, is linear still the best choice for the curve or is quadratic now a better choice? Explain. _____

Part B. Put all the points back in the basket. Place the following points on the graph and answer the questions below.

x-axis	y-axis
1.2	1.2
3.8	2.8
6.2	3.8
8.3	5.9
9.4	8.3

1. Click on linear and record the r^2 value and x^2 values, then click on quadratic and record the x^2 and r^2 values below.

Linear: $x^2 =$ _____ $r^2 =$ _____

Quadratic $x^2 =$ _____ $r^2 =$ _____

2. _____ Based on the x^2 and r^2 values which curve is a better fit for this data?

3. Find and remove the outlier (a point that is above or below the line) and record the new values for x^2 and r^2 below.

Linear: $x^2 =$ _____ $r^2 =$ _____

Quadratic $x^2 =$ _____ $r^2 =$ _____

4. Is the linear or quadratic a better fit for the graph without the outlier? Explain. _____