AP Physics 1 Summer Assignment

AP Physics 1 is a rigorous first-year course, requiring students to apply critical thinking skills and mathematical and trigonometric concepts to the analysis of the physical world. This assignment, completing Unit 1 of the course, is a review of many of the skills you have already acquired, along with some new skills you will find necessary throughout this course and your future endeavors.

The assignment is as follows:

- Download and print the assignment from the High School home page
- Read and complete all of the work in the packet.
  - **The readings should go in the *Notes* section of your binder**
  - **The work should go in the *Homework* section of your binder**
- Register for the course Google Classroom:
  - Course Name: **AP Physics 1 Summer 2025**
  - Course Code: **r7dyi3za**
- Watch the videos posted on the Google Classroom for instructions on how to use *Graphical Analysis* to make the graphs needed for the assignment. We will be using it extensively throughout the course for making graphs and analyzing data.

In completing the assignment, it is imperative that ***all work must be shown whenever possible.*** The work should be done on the worksheets or on separate loose-leaf paper as needed. Note that **work must be shown to get credit.**

This assignment is due ***Friday, September 5, 2025***. After a brief review of the assignment, an assessment will be given based on this assignment. These will be your first grades in AP Physics 1 You should also have a binder and filler paper to serve as a notebook and a scientific calculator (a graphing calculator is strongly recommended).

Please feel free to e-mail me at any time if you have questions. Realize, however, that I may not check my e-mail daily during the summer, so it may take some time before I reply. Please include the words “AP Physics 1 Summer Assignment” somewhere in the subject line, as I do not normally open e-mail from addresses I do not recognize. Also, please be as specific as possible with your questions. The more detail you can provide the easier it will be for me to help you. I look forward to seeing you in class in September.

Sincerely,
Mr. Guziewicz

E-mail: jguziewicz@jefftwp.org

Unit I Reading: Significant Figures

Laboratory investigations usually involve the taking of and interpretation of measurements. All physical measurements obtained by means of instruments (meter sticks, thermometers, electrical meters, clocks, etc.) are to some extent uncertain. If, for example, the mass of an object is determined by means of a Dial-O-Gram balance, the measured mass will be uncertain by at least $\pm$ 0.01 gram. If the object were now weighed on progressively more accurate scales, the uncertainty in the mass of the object would get progressively less, but regardless of the precision of the measuring device, any instrumental measurement is to some extent uncertain. The degree of uncertainty in physical measurements can be indicated by means of significant figures. Consider, for example, a measurement of the length of the object as indicated below, with three differently calibrated meter sticks.

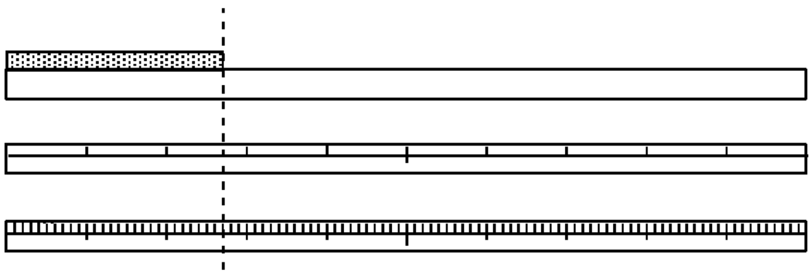


Figure 1

Observe that when measuring the length of the object with the uncalibrated meter stick (top) the actual length of the object in Figure 1 can only be estimated, and then only to the nearest tenth of a meter, or as 0.3 meter (one significant figure).

Measuring the length of the object, however, with a meter stick calibrated in tenths of a meter (center stick in Figure 1) it is obvious that the length of the object is greater than 0.2 m but less than 0.3 m. Once again, it would seem to be reasonable to estimate the length of the object to the nearest tenth of the smallest calibration or to the nearest hundredth of a meter; thus 0.27 m. It might actually be as short as 0.26 m or as long as 0.28 m, so 0.27 m (to the nearest hundredth of a meter) seems to be the most reasonable estimate of the object's length. This measurement has two significant figures indicating less uncertainty in the second measurement than in the first.

Measuring the length of the object with a meter stick calibrated in hundredths of a meter (lower stick in figure 1), the length of the object could be estimated to tenths of the smallest calibrations (centimeters) or the measured length could be estimated to the nearest millimeter; nearer to 0.270 m than to 0.269 m or 0.271 m. Note that this measurement has three significant figures indicating less uncertainty in this measurement than in either of the other two preceding measurements. Thus, the number of significant figures in a measurement indicates the precision of the measurement and not the absolute length of the object.

Once the logic of significant figures is accepted, some simple rules are useful for their implementation.

Rule 1- which digits are significant: The digits in a measurement that are considered significant are all of those digits that represent marked calibrations on the measuring device plus one additional digit to represent the estimated digit (tenths of the smallest calibration).

The zero digit is used somewhat uniquely in measurements. A zero might be used either as an indication of uncertainty or simply as a place holder. For example, the distance from the earth to the sun is commonly given as 1,500,000,000 km. The zeroes in this measurement are not intended to indicate that the distance is accurate to the nearest km, rather these zeroes are being used as place holders only and are thus not considered significant.

Rules for zeros:

1. All non-zero digits in a measurement **are** considered to be significant.
2. Zeroes **are** significant if bounded by non-zero digits; e.g., the measurement 4003 m has four significant figures.
3. If a decimal point is expressed, all zeroes following non-zero digits **are** significant; e.g., the measurement 30.00 kg has four significant figures.
4. If a decimal point is not explicitly expressed, zeroes following the last non-zero digit **are not** significant, they are **place holders only**; e.g., the measurement 160 N has two significant figures.
5. Zeroes preceding the first non-zero digit **are not** significant, they are **place holders only**; e.g., the measurement 0.00610m has three significant figures.

As an example, take the process of finding the average of the following series of measurements:

t_o = 20.78 s
t_1 = 20.32 s
t_2 = 20.44 s
t_3 = 21.02 s
t_4 = 20.81 s
t_5 = 20.63 s
t_6 = 21.12 s

$$t_{av} = (t_o + t_1 + t_2 + t_3 + t_4 + t_5 + t_6) \div 7 = 20.73 \text{ s}$$

The rule developed earlier in this discussion suggested that we should retain, as significant figures, all digits those values we were certain of plus one estimated digit. With this rule, we would retain the digit in the tens column because all of the data values in this column are the same (we are certain of these values). We would also retain the digit in the units column because, even though there are some differences in this column, the rule says we may retain one digit that is estimated (value of the digit in this column is uncertain).

The rule then suggests that we should retain only 2 digits (tens and units) for t_{av}, and after rounding, the best value would be t_{av} = 21 s.

Rules for addition and subtraction with significant figures:

1. Change the units of all measurements, if necessary, so that all measurements are expressed in the same units (kilograms, meters, degrees Celsius, etc.).
2. The sum or difference of measurements may have no more decimal places than the least number of places in any measurement.

   For example:

   11.44 m
   5.00 m
   0.11 m
   13.2 m
   29.750 m

   But since the last measurement (13.2 m) is expressed to only one decimal place, the sum may be expressed to only one decimal place. Thus 29.750 m is rounded to 29.8 m.

   Consider the quotient: 294,921 cm^2 ÷ 38 cm. What should the answer be?
   8,000 cm, or 7,800 cm, or 7,760 cm, or 7,761 cm?

   The question is what uncertainty do we wish to express in a product or quotient? To answer this question we might wish to examine the above example. Recall that the last digit in each measurement is an estimated digit so the product might be as large as 7,970.86 cm (maximum value), or as small as 7,562.05 cm (minimum value).
   Observe that while the digits in the thousands column are both the same, the values of the digits in the hundreds column vary. Therefore, the quotient would be 7,800 cm, to two significant figures. Note that the number of figures in the quotient is the same as the least number of significant digits in either the divisor or the dividend. If we were to test many examples, we would find this relationship to hold true in most cases, leading to the following rule.

Rules for multiplication and division with significant figures:

Students typically make one of two mistakes: either they keep *too few* figures by rounding off too much and lose information, or they keep *too many* figures by writing down whatever the calcualtor displays. Use of significant figure rules helps us express values with a reasonable amount degree of precision.

When multiplying or dividing, the number of significant figures retained may not exceed the **least** number of digits in either the of the factors.

Example: 0.304 cm x 73.84168 cm. The calculator displays 22.447871. A more reasonable answer is 22.4 cm^2 . This product has only three significant figures because one of the factors (0.304 cm) has only three significant figures, therefore the product can have only three.

Another example: 0.1700 g ÷ 8.50 L. The calculator display of 0.02 g/L, while numerically correct, leaves the impression that the answer is not known with much certainty. Expressing the density as 0.0200 g/L leaves the reader with the sense that very careful measurements were made.

Name___________________________________

Date__________Pd___

Unit 1 Worksheet 2 – Significant Figures

The zero rules for significant figures follow:

(1) Zeros are significant when bounded by non-zero digits.
(2) Zeros preceding the first non-zero digit are never significant.
(3) If a decimal point is explicitly expressed, all zeros after the first non-zero digit are significant.
(4) If a decimal point is not explicitly expressed, zeros following the last non-zero digit are not significant.

For problems 1 - 10, in the first blank give the number of significant digits in the measurement and in the second blank, list the number(s) of the zero rule(s) that were necessary for your decision. For example:

___3___ _____1,4____ 9070 m

Problems

1. _____ _________ 0.025 s **2.** _____ _________ 405 kg

3. _____ _________ 20.50 m **4.** _____ _________ 7 600 cm

5. _____ _________ 0.0102 kg **6.** _____ _________ 0.1020 g

7. _____ _________ 0.004 ml **8.** _____ _________ 20 010 mg

9. _____ _________ 2.0×10^2 m **10.** _____ _________ 500 ml

As a general rule, we say that when taking measurements, we are justified in estimating to tenths of the smallest marked graduation on the measuring instrument.

For each of the following problems, in the blank record the correct measurement followed by the appropriate explanation of the rule(s) utilized. For example:

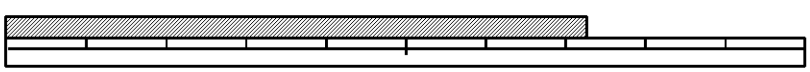


Figure 1

___0.73 m____ The meter stick is graduated in tenths of a meter so the measurement should be estimated to hundredths of a meter.

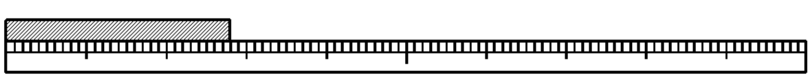
11. 

Figure 2

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12. 

Figure 3

____

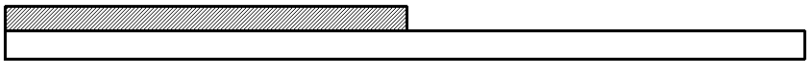
13. 

Figure 4

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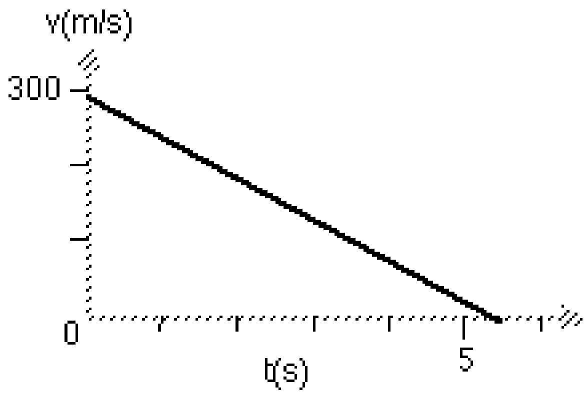


Figure 5

14. ________ Estimate the value of v when t = 0

15. ________ Estimate the value of t when v = 0

For each of the following problems**, in the left blank** record the value of the indicated calculation as given by the calculator. **In the right blank** express the answer to the appropriate number of significant figures. **Explain your reasoning.**

16. 114.21 g + 3041 g + 0.042 g + 349.5 g =

____________ ____________

17. $1.05 \text{ s} \times 10. \frac{\text{m}}{\text{s}}$ =

____________ ____________

18. Determine the volume of a block with dimensions

2.56 cm x 4.652 cm x 8.70 cm.

____________ ____________

19. $\frac{9.081 \text{ m/s}}{450 \text{ s}}$ =

____________ ____________

20. Determine the slope of the line in Figure 5 (Show your work)

____________ ____________

Name______________________________________

Date__________ **Pd**____

Scientific Methods Worksheet 2:
Proportional Reasoning

Some problems adapted from Gibbs' Qualitative Problems for Introductory Physics

1. 100 cm are equivalent to 1 m. How many cm are equivalent to 3 m? Briefly explain how you could convert any number of meters into a number of centimeters.

2. 45 cm are equivalent to how many m? Briefly explain how you could convert any number of cm into a number of m.

3. One mole of water is equivalent to 18 grams of water. A glass of water has a mass of 200 g. How many moles of water is this? Briefly explain your reasoning.

Use the metric prefixes table to answer the following questions:

4. The radius of the earth is 6378 km. What is the diameter of the earth in meters?

5. In an experiment, you find the mass of a cart to be 250 grams. What is the mass of the cart in kilograms?

Metric prefixes:

giga	= 1 000 000 000	billion
mega	= 1 000 000	million
kilo	= 1 000	thousand
centi	= 1 / 100	hundredth

6. How many megabytes of data can a 4.7 gigabyte DVD store?

7. A mile is farther than a kilometer. Consider a fixed distance, like the diameter of the moon. Would the number expressing this distance be larger in miles or in kilometers? Explain.

8. One US dollar = 0.95 Euros (as of 5/22.) Which is worth more, one dollar or one Euro? How many dollars is one Euro?

9. In April, 2022, Germans paid 1.96 Euros per liter of gasoline. At the same time, American prices were $4.25 per gallon.
   a. How much would one gallon of European gas have cost in dollars?
   b. How much would one liter of American gasoline have cost in Euros?
   (One US dollar = 0.95 Euros, 1 gallon = 3.79 liters)

10. A mile is equivalent to 1.6 km. When you are driving at 60 miles per hour, what is your speed in meters per second? Clearly show how you used proportions to arrive at a solution.

11. Let $y = a/(bx^2)$. In each case listed below, describe how y will change. Explain each response.

a. Double a, keeping b and x constant.

b. Double b, keeping a and x constant.

c. Double x, keeping a and b constant.

12. For each of the following mathematical relations, state what happens to the value of y when the value of x is halved. (k is a constant)

a. $y = kx$

b. $y = k/x$

c. $y = k/x^2$

13. When one variable is *directly proportional* to another, doubling one variable also doubles the other. If y and x are the variables and a and b are constants, circle the following relationships that are direct proportions. For those that are not direct proportions, explain what kind of proportion does exist between x and y.

a. $y = 3x$
b. $y = ax + b$
c. $y = x$
d. $y = ax^2$
e. $y = a/x$
f. $y = ax$
g. $y = 1/x$
h. $y = a/x^2$

14. When one variable is *inversely proportional* to another, doubling one variable halves the other. If y and x are the variables, and a and b are constants, circle the following relationships that are inverse proportions. For those that are not inverse proportions, explain what kind of proportion does exist between x and y.

a. $y = ax$
b. $y = a/x^2$
c. $y = b/x$
d. $y = 1/(x + b)$
e. $y = ax + b$
f. $y = 5/x$
g. $y = x^2$
h. $y = 1/x$

Experimental Design and Graphical Analysis of Data

A. Designing a controlled experiment

When scientists set up experiments they often attempt to determine how a given variable affects another variable. This requires the experiment to be designed in such a way that when the experimenter changes one variable, the effects of this change on a second variable can be measured. If any other variable that could affect the second variable is changed, the experimenter would have no way of knowing which variable was responsible for the results. For this reason, scientists always attempt to conduct **controlled experiments**. This is done by choosing only one variable to manipulate in an experiment, observing its effect on a second variable, and *holding all other variables in the experiment constant*.

Suppose you wanted to test how changing the mass of a pendulum affects the time it takes a pendulum to swing back and forth (also known as its period). You must keep all other variables constant. You must make sure the length of the pendulum string does not change. You must make sure that the distance that the pendulum is pulled back (also known as the amplitude) does not change. The length of the pendulum and the amplitude are variables that must be held constant in order to run a controlled experiment. The only thing that you would deliberately change would be the mass of the pendulum. This would then be considered the **independent variable**, because you will decide how much mass to put on the pendulum for each experimental trial. There are three possible outcomes to this experiment: 1. If the mass is increased, the period will increase. 2. If the mass is increased, the period will decrease. 3. If the mass is increased, the period will remain unchanged. Since you are testing the effect of changing the mass on the period, and since the period may depend on the value of the mass, the period is called the **dependent variable**.

In review, there are only two variables that area allowed to change in a well-designed experiment. The variable manipulated by the experimenter (mass in this example) is called the **independent variable.** The **dependent variable** (period in this case) is the one that responds to or depends on the variable that was manipulated. Any other variable which might affect the value of the dependent value must be held constant. We might call these variables **controlled variables.** When an experiment is conducted with one (and only one) independent variable and one (and only one) dependent variable while holding all other variables constant, it is a **controlled experiment**.

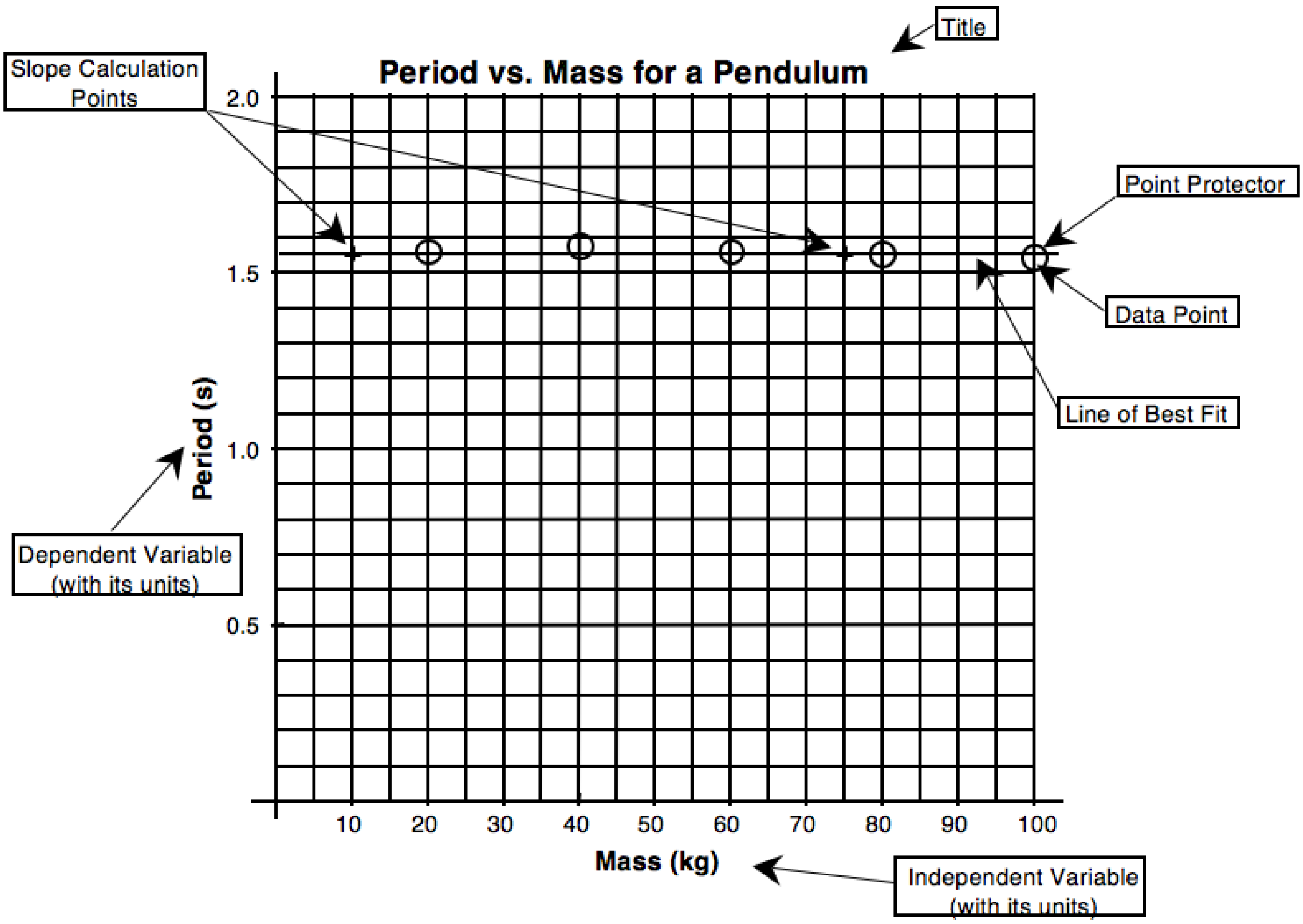
B. Characteristics of Good Data Recording

Raw data is recorded in ink. Data that you think is "bad" is not destroyed. It is noted but kept in case it is needed for future use.
The table for raw data is constructed prior to beginning data collection.
The table is laid out neatly using a straightedge.
The independent variable is recorded in the leftmost column (by convention).
The data table is given a descriptive title which makes it clear which experiment it represents.
Each column of the data table is labeled with the name of the variable it contains.
Below (or to the side of) each variable name is the name of the unit of measurement (or its symbol) in parentheses.
Data is recorded to an appropriate number of decimal places as determined by the precision of the measuring device or the measuring technique.
All columns in the table which are the result of a calculation are clearly explained and sample calculations are shown making it clear how each column in the table was determined.
The values held constant in the experiment are described and their values are recorded.

C. Graphing Data

Once the data is collected, it is necessary to determine the relationship between the two variables in the experiment. You will construct a graph (or sometimes a series of graphs) from your data in order to determine the relationship between the independent and dependent variables.

For each relationship that is being investigated in your experiment, you should prepare the appropriate graph. In general your graphs in physics are of a type known as scatter graphs. The graphs will be used to give you a conceptual understanding of the relation between the variables, and will usually also be used to help you formulate mathematical statement which describes that relationship. Graphs should include each of the elements described below:



Elements of Good Graphs

A **title** that describes the experiment. This title should be descriptive of the experiment and should indicate the relationship between the variables. It is conventional to title graphs with DEPENDENT VARIABLE vs. INDEPENDENT VARIABLE. For example, if the experiment was designed to show how changing the mass of a pendulum affects its period, the mass of the pendulum is the independent variable and the period is the dependent variable. A good title might therefore be PERIOD vs. MASS FOR A PENDULUM.

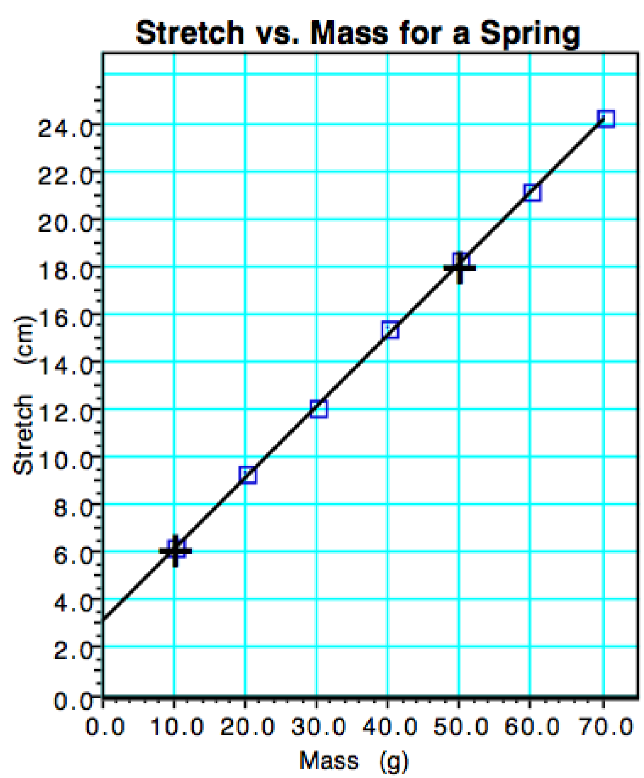
The graph should **fill the space** allotted for the graph. If you have reserved a whole sheet of graph paper for the graph then it should be as large as the paper and proper scaling techniques permit.

The graph must be properly **scaled.** The scale for each axis of the graph should always begin at zero. The scale chosen on the axis must be uniform and linear. This means that each square on a given axis must represent the same amount. Obviously each axis for a graph will be scaled independently from the other since they are representing different variables. A given axis must, however, be scaled consistently.

Each axis should be **labeled** with the **quantity** being measured and the **units** of measurement. Generally, the independent variable is plotted on the horizontal (or x) axis and the dependent variable is plotted on the vertical (or y) axis.
Each data point should be plotted in the proper position. You should plot a point as a small dot at the position of the of the data point and you should circle the data point so that it will not be obscured by your line of best fit. These circles are called **point protectors**.
A **line of best fit**. This line should show the overall tendency (or trend) of your data. If the trend is linear, you should draw a straight line which shows that trend using a straight edge. If the trend is a curve, you should sketch a curve which is your best guess as to the tendency of the data. This line (whether straight or curved) does not have to go through all of the data points and it may, in some cases, not go through any of them.
Do not, under any circumstances, connect successive data points with a series of straight lines, dot to dot. This makes it difficult to see the overall trend of the data that you are trying to represent.
If you are plotting the graph by hand, you will choose two points for all linear graphs from which to calculate the slope of the line of best fit. These points should not be data points unless a data point happens to fall perfectly on the line of best fit. Pick two points which are directly on your line of best fit and which are easy to read from the graph. Mark the points you have chosen with a +.
Do not do other work in the space of your graph such as the slope calculation or other parts of the mathematical analysis.
If your graph does not yield a straight line, you will be expected to manipulate one (or more) of the axes of your graph, replot the manipulated data, and continue doing this until a straight line results. We will address the details of linearization later in the course.

D. Graphical Analysis and Linear Mathematical Models

When the data you collect yields a linear graph, you will proceed to determine the mathematical equation that describes the relationship between the variables using the slope intercept form of the equation of a line. Consider the following experiment in which the experimenter tests the effect of adding various masses to a spring on the amount that the spring stretches. The development of the mathematical model is shown on the next page.



Begin with the equation for a line:

$y = mx + b$

Determine the slope and y-intercept from graph slope (m) = 0.30 (cm/g); y-intercept = 3.2 cm

Substitute constants <u>with units</u> from experiment $y = [0.30\ (\text{cm/g})]x + 3.2\ \text{cm}$

Substitute variables from experiment

Stretch = S; mass = m

$S = [0.30\ (\text{cm/g})]m + 3.2\ \text{cm}$

Final mathematical model: $S = [0.30\ (cm/g)]m + 3.2\ cm$

The result of this experiment, then, is a mathematical equation which models the behavior of the spring:

$$\textbf{Stretch} = \mathbf{0.30\ cm/g \cdot mass + 3.2\ cm}$$

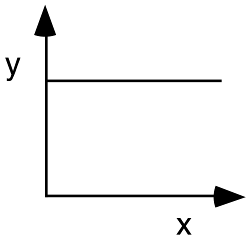
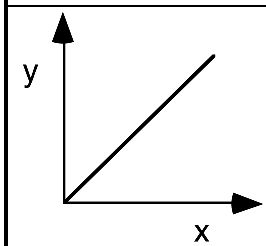
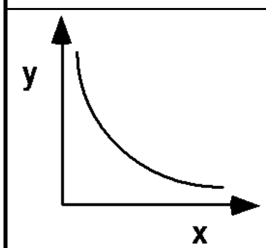
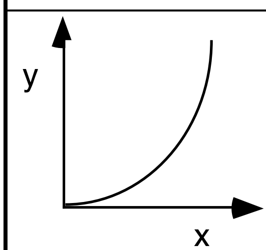
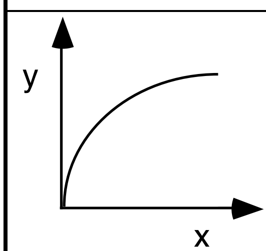
With this **mathematical model** we know many characteristics of the spring and can predict its behavior without actually further testing the spring. In models of this type, there is physical significance associated with each value in the equation. For instance, the slope of this graph, 0.30 cm/g, tells us that the spring will stretch 0.30 centimeters for each gram of mass that is added to it. We might call this slope the "wimpiness" of the spring, since if the slope is high it means that the spring stretches a lot when a relatively small mass is placed on it and a low value for the slope means that it takes a lot of mass to get a little stretch.

The y-intercept of 3.2 cm tells us that the spring was already stretched 3.2 cm when the experimenter started adding mass to the spring. With this mathematical model, we can determine the stretch of the spring for any value of mass by simply substituting the mass value into the equation. How far would the spring be stretched if 57.2 g of mass were added to the spring? Mathematical models are powerful tools in the study of science and we will use those that you develop experimentally as the basis of many of our studies in physics.

When you are evaluating real data, you will need to decide whether or not the graph should go through the origin. Given the limitations of the experimental process, real data will rarely yield a line that goes perfectly through the origin. In the example above, the computer calculated a y-intercept of 0.01 cm ± 0.09 cm. Since the uncertainty (±0.09 cm) in determining the y-intercept exceeds the value of the y-intercept (0.01 cm) it is obviously reasonable to call the y-intercept zero. Other cases may not be so clear cut. The first rule of order when trying to determine whether or not a direct linear relationship is indeed a direct proportion is to ask yourself what would happen to the dependent variable if the independent variable were zero. In many cases you can reason from the physical situation being investigated whether or not the graph should logically go through the origin. Sometimes, however, it might not be so obvious. In these cases we will assume that it has some physical significance and will go about trying to determine that significance.

Graphical Methods-Summary

A graph is one of the most effective representations of the relationship between two variables. The independent variable (one controlled by the experimenter) is usually placed on the x-axis. The dependent variable (one that responds to changes in the independent variable) is usually placed on the y-axis. It is important for you to be able interpret a graphical relationship and express it in a written statement and by means of an algebraic expression.

Graph shape	Written relationship	Modification required to linearize graph	Algebraic representation
	As x increases, y remains the same. There is no relationship between the variables.	None	$y = b$, or y is constant
	As x increases, y increases proportionally. Y is directly proportional to x.	None	$y = mx + b$
	As x increases, y decreases. Y is inversely proportional to x.	Graph y vs $\frac{1}{x}$, or y vs x^{-1}	$y = m\left(\frac{1}{x}\right) + b$
	Y is proportional to the square of x.	Graph y vs x^2	$y = mx^2 + b$
	The square of y is proportional to x.	Graph y^2 vs x	$y^2 = mx + b$

When you state the relationship, tell how y depends on x (e.g., as x increases, y …).

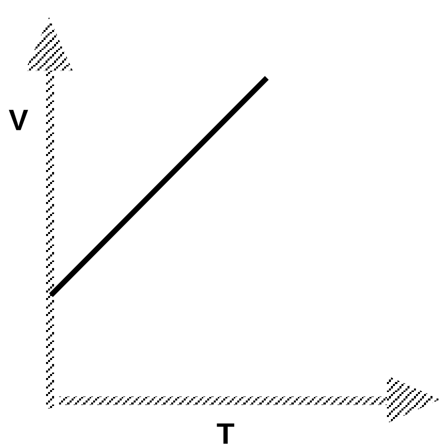
Unit I Reading – Graphical Methods

One of the most effective tools for the visual evaluation of data is a graph. The investigator is usually interested in a quantitative graph that shows the relationship between two variables in the form of a curve.

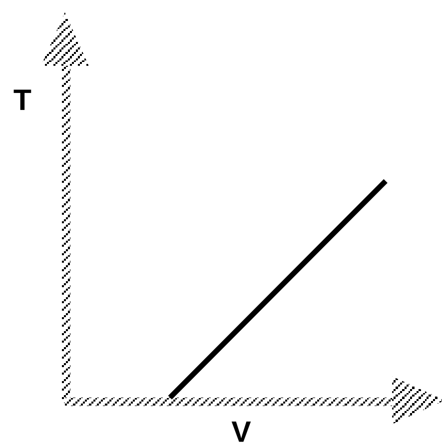
For the relationship y = f(x), **x** is the *independent variable* and **y** is the *dependent variable*. The rectangular coordinate system is convenient for graphing data, with the values of the dependent variable y being plotted along the *vertical axis* and the values of the independent variable x plotted along the *horizontal axis*.

Positive values of the dependent variable are traditionally plotted above the origin and positive values of the independent variables to the right of the origin. This convention is not always adhered to in physics, and thus the positive direction along the axes will be *indicated by the direction the arrow heads point.*

The choice of dependent and independent variables is determined by the experimental approach or the character of the data. Generally, the **independent variable** is the one over which the *experimenter has complete control*; the **dependent variable** is the one that *responds to changes* in the independent variable. An example of this choice might be as follows. In an experiment where a given amount of gas expands when heated at a constant pressure, the relationship between these variables, V and T, may be graphically represented as follows:



Correct



Incorrect

By established convention it is proper to plot V = f (T) rather than T = f (V), since the experimenter can directly control the temperature of the gas, but the volume can only be changed by changing the temperature.

Curve Fitting

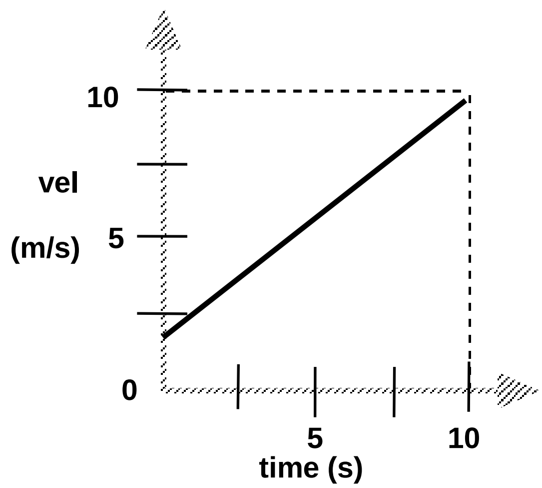
When checking a law or determining a functional relationship, there is good reason to believe that a uniform curve or straight line will result. The process of matching an equation to a curve is called **curve fitting**. The desired empirical formula, assuming good data, can usually be determined by inspection. There are other mathematical methods of curve fitting, however they are very complex and will not be considered here. Curve fitting by inspection requires an assumption that the curve represents a linear or simple power function.

If data plotted on rectangular coordinates yields a straight line, the function y = f(x) is said to be *linear* and the line on the graph could be represented algebraically by the slope-intercept form:

$$y = mx + b,$$

where **m** is the slope and **b** is y-intercept.

Consider the following graph of velocity vs. time:



The curve is a straight line, indicating that v = f(t) is a linear relationship. Therefore,

$$\mathbf{v} = m\mathbf{t} + b,$$

where slope = $m = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$

From the graph,

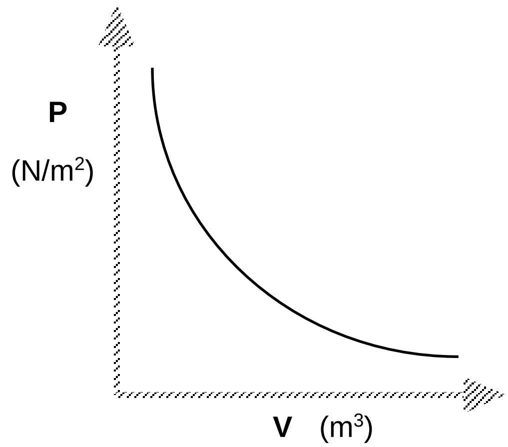
$$m = \frac{8.0 \text{ m/s}}{10.0 \text{ s}} = 0.80 \text{ m/s}^2 \quad .$$

The curve intercepts the v-axis at v = 2.0 m/s. This indicates that the velocity was 2.0 m/s when the first measurement was taken; that is, when t = 0. Thus, $b = v_0 = 2.0$ m/s.

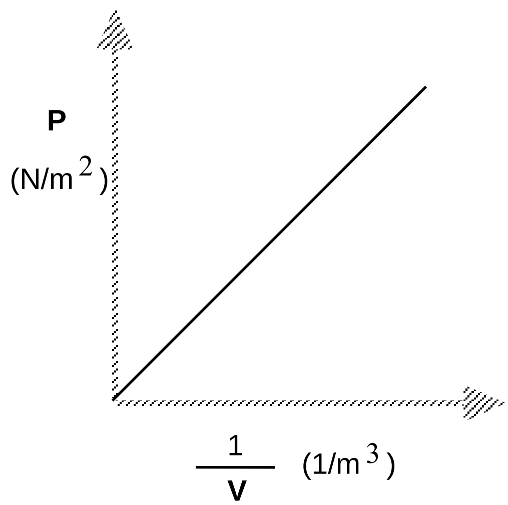
The general equation, **v** = m**t** + b, can then be rewritten as

$$\mathbf{v} = (0.80 \text{ m/s}^2)\mathbf{t} + 2.0 \text{ m/s}.$$

Consider the following graph of pressure vs. volume:



The curve appears to be a hyperbola (inverse function). Hyperbolic or inverse functions suggest a test plot be made of P vs $\frac{1}{V}$. The resulting graph is shown below:

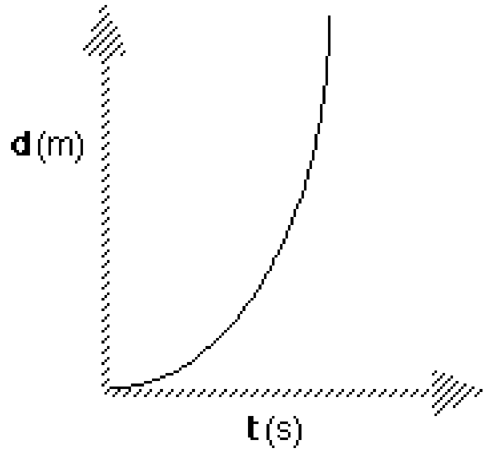


The equation for this straight line is:

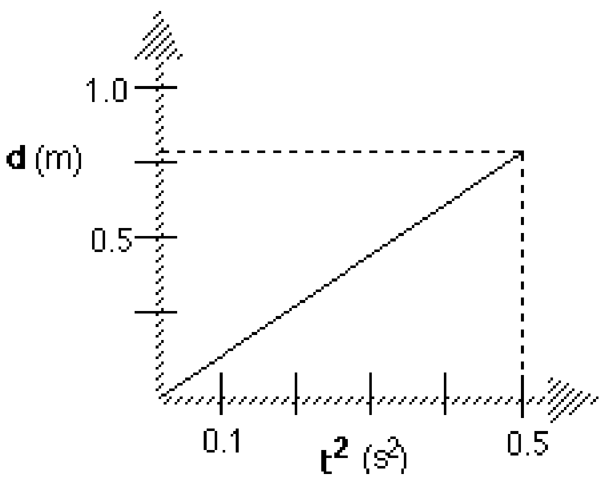
$$P = m\left(\frac{1}{V}\right) + b,$$

where b = 0. Therefore; $P = \frac{m}{V}$; when rearranged, this yields PV = constant, which is known as Boyle's law.

Consider the following graph of distance vs. time:



The curve appears to be a top-opening parabola. This function suggests that a test plot be made of d vs. t^2. The resulting graph is shown below:



Since the plot of d vs. t^2 is linear,

$$\mathbf{d} = m\mathbf{t^2} + b.$$

The slope, m, is calculated by

$$m = \frac{\Delta d}{\Delta t^2}$$

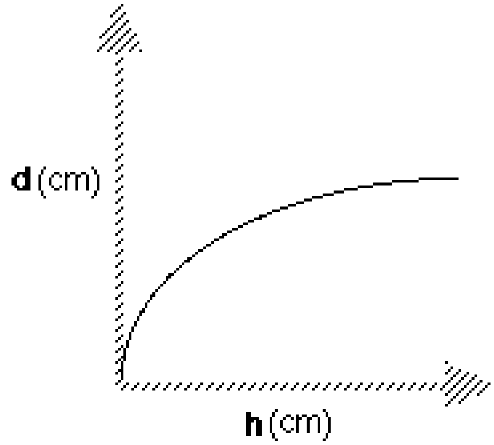
$$= \frac{.80\text{m}}{.50\text{s}^2}$$

$$= 1.6 \text{ m/s}^2$$

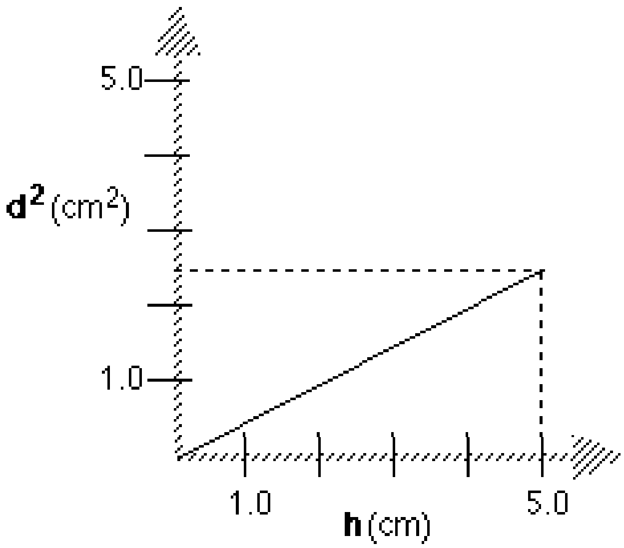
Since the curve passes through the origin, b = 0. The mathematical expression that describes the motion of the object is

$$\mathbf{d} = (1.6 \text{ m/s}^2)\mathbf{t^2} \quad .$$

Consider the following graph of distance vs. height:



The curve appears to be a side-opening parabola. This function suggests that a test plot be made of d^2 vs. h. The resulting graph is shown on the following page.



Since the graph of d^2 vs. h is linear the expression is

$$\mathbf{d}^2 = m\mathbf{h} + b.$$

The slope, m, is calculated by

$$m = \frac{\Delta d^2}{\Delta h}$$

$$= \frac{2.5\text{cm}^2}{5.0 \text{ cm}}$$

$$= 0.50 \text{ cm}.$$

Since the curve passes through the origin, b = 0. The mathematical expression is then

$$\mathbf{d}^2 = (0.50 \text{ cm})\mathbf{h}.$$

Name____

Date__________ Pd____

Scientific Methods Worksheet 1:

Graphing Practice

For each data set below, determine the mathematical expression. To do this, first graph the original data. Assume the 1st column in each set of values to be the **independent** variable and the 2nd column the **dependent** variable. Taking clues from the shape of the first graph, modify the data so that the modified data will plot as a straight line. Using the slope and y-intercept of the straight-line graph, write an appropriate mathematical expression for the relationship between the variables. Be sure to include units!

Data set 1		Data set 2	
Volume (m^3)	**Pressure (Pascals)**	**time (s)**	**position (m)**
0.1	40	0.1	0.03
0.5	8	0.2	0.12
1	2	1	3
4	1	2	12
5	.8	3	27
8	.5	4	48
10	.4	5	75
Sketch of original graph:		Sketch of original graph:	
Sketch of test plot: (Print your graph and test plot, too.)		Sketch of test plot: (Print your graph and test plot, too.)	
Mathematical expression #1:		Mathematical expression #2:	

Data set 3		Data set 4	
mass (kg)	**velocity (m/s)**	**time (s)**	**velocity (m/s)**
1	1.1	0.0	0.0
2	4.6	2.0	10.5
3	7.7	4.0	14
4	10.4	6.0	18
5	13.3	8.0	21
6	16.5	10.0	23.5
7	19.6	12.0	26
8	22.4	14.0	28
Sketch of original graph:		Sketch of original graph:	
Sketch of test plot: (Print your graph and test plot, too.)		Sketch of test plot: (Print your graph and test plot, too.)	
Mathematical expression #3:		Mathematical expression #4:	