Summer Assignment
2020-2021 School Year

AP Physics 2
Mrs. Downing

Welcome to AP Physics 2!

I am so excited that you have chosen to continue your physics journey this year! During your time in class, we will cover a variety of topics ranging from static and current electricity, magnetism, fluid statics and dynamics, thermodynamics and conservation laws, waves and optics, and modern and nuclear physics.

There are two major skills that permeate every unit we cover in this physics course: a working knowledge and understanding of graphing methods and graphical analysis of data and the ability to design, plan, and execute a laboratory investigation. This summer assignment will take you through both of these skills and hopefully get you excited for what is to come! Please read the instructions for this assignment carefully as there are two parts that you will need to complete.

Part 1: Experimental Design

(adapted from University of Colorado Boulder's Engineering STEM Curriculum)

Your assignment is to design an experiment to answer the following question: "You have a large rock on a boat that is floating in a pond. You throw the rock overboard and it sinks to the bottom of the pond. Does the water level in the pond rise, fall, or remain the same?"

You will bring your typed lab report to school with you on the first day. This will count as your first lab grade of the year.

Background Information:

> Archimedes' principle and a density-buoyancy relationship are important in the engineering design of all sorts of floating vessels. For safety and efficiency, engineers analyze how floating vessels such as ships and oil platforms respond to added weight. This helps engineers design them so that they float correctly, without sinking or overturning.
>
> Ships are designed to have different shapes and sizes depending on their purposes. For example, barges have mostly flat bottoms and are designed to carry heavy goods through rivers and canals. Tug boats, which are very powerful for their small sizes, are designed to push or pull other large vessels in crowded channels or in open bodies of water. Container ships, which are some of the largest ships in the world, are designed to carry heavy loads of containers full of products across the world. Cruise ships are large but slow and are designed as luxurious floating hotels to accommodate guests as they travel to different ports of call.

> In order to prevent flooding, especially after storms, it is extremely important for engineers to know how much water ships displace in order to help them navigate through small channels and lock-systems. In today's activity, you will consider a floating boat with a rock in it, and the same floating boat with the rock fully submerged in the water. You are going to use what you have learned about Archimedes' principle to determine whether the water line will rise, fall or stay the same when the rock is taken out of the boat and placed in the water. It is your job as engineers to derive an equation to determine how the ship and water line respond to the weight and volume of the rock. You can give your results to your project engineer—ME! to review your engineering work and our company can later use the results to see how ships respond in different shipping channels.
>
> Before beginning the actual experimentation part of this activity, you will need to do some background research on the following topics and vocabulary terms:
>
> - Mass and weight
> - Volume
> - Mass density
> - Buoyancy
> - Archimedes' principle
>
> Take notes on the information you find. You will need to include it in the report you write for this part of the assignment.

Problem:

> "You have a large rock on a boat that is floating in a pond. You throw the rock overboard and it sinks to the bottom of the pond. Does the water level in the pond rise, fall, or remain the same?"
>
> Using items that you have at home, design an experiment to determine the answer to the above question. Take pictures of your experimental set-up and materials and make sure to follow the guidelines for good data collection and experimentation.
>
> Note: You do not have to use an actual pond or boat. Think about things in your home that you could use to model a rock, pond, and boat and use those! The physics principles will be the same.

Report:

Your write-up should include the following sections:

- Title & Objective: a descriptive title and the objective (purpose) of the experiment;
- Prediction: a hypothesis about what you think will happen to the water level in the pond
- Background: research and information on mass, weight, volume, mass density, buoyancy, and Archimedes' Principle
- Procedure: a detailed description of how you carried out your experiment including a diagram of your experimental set-up and/or pictures taken and what data you will measure and observe
- Data & Observations: qualitative and quantitative data measured and observed during your procedure
- Analysis and Conclusions: Answer the following questions in this section of your report
    - How does Archimedes' Principle apply to the rock and boat?
    - What variables needed to be defined to solve this problem?
    - Derive an equation for V_b, the volume of water displaced by the rock in the boat (hint: use Archimedes' Principle to begin).
    - Derive an equation for V_s, the volume of water displaced by the rock when it is fully submerged.
    - Compare V_b to V_s to mathematically and physically explain whether the water level rises, drops, or remains the same when the rock is thrown overboard.
    - What role does the boat play in this activity? Do we need to account for the volume of water displaced by the boat? Why or why not?
    - What would change if we use… A larger boat? A larger rock? Molasses instead of water?

Part 2: Review of Graphing and Functions

A greater emphasis has been placed on conceptual questions and graphing on the AP exam. Below you will find a few example concept questions that review foundational knowledge of graphs. the end of this part is a section covering graphical analysis that you may not have seen before: linear transformation or the linearization of data. This analysis involves converting any non-linear graph into a linear graph by adjusting the axes plotted. We want a linear graph because we can easily find the slope of the line of best fit of the graph to help justify a mathematical model or equation.

Key Graphing Skills to Remember:

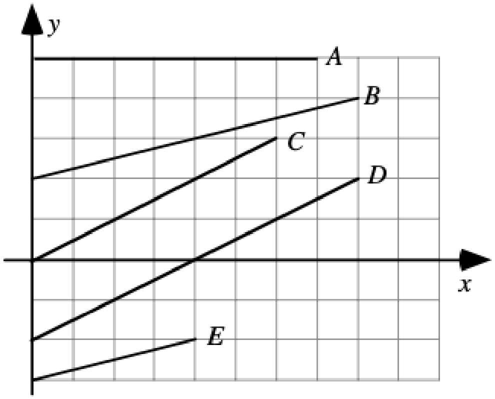
1. Always label your axes with appropriate units.
2. Sketching a graph calls for an estimated line or curve while plotting a graph requires individual data points AND a line or curve of best fit.
3. Provide a clear legend if multiple data sets are used to make your graph understandable.
4. Never include the origin as a data point unless it is provided as a data point.
5. Never connect the data points individually, but draw a single smooth line or curve of best fit.
6. When calculating the slope of the best fit line you must use points from your line. You may only use given data points if your line of best fit goes directly through them.

Print out and complete the attached review of graphing and functions. This will count as your first homework assignment.

Your first quiz will take place during the first week of school and it will cover the topics addressed in this part of the summer assignment.

Name: ___________________________________

1. Shown are several lines on a graph.

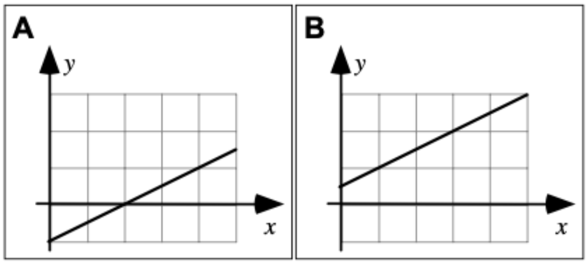


Rank the slopes of the lines in this graph from greatest to least. If any slopes are equal, indicate them as such.

Greatest _____ _____ _____ _____ _____ Least

Justify your reasoning with a written explanation.

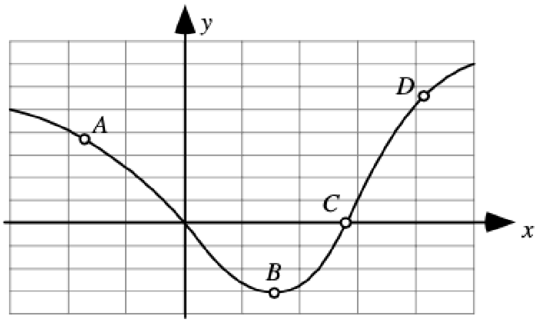
2. Shown are two graphs. Each is scaled identically.



Is the slope of the graph (i) *greater in Case A*, (ii) *greater in Case B*, or (iii) *the same in both cases*? _____

Justify your reasoning with a written explanation.

3. Four points are labeled on a graph.



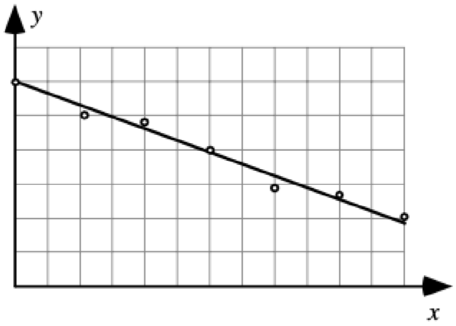
Rank the magnitudes (sizes) slopes of the graph at the labeled points. If any slopes are equal, indicate them as such.

Greatest _____ _____ _____ _____ Least

Justify your reasoning with a written explanation.

4. A student makes the following claim about some data that they and their lab partners have collected:

"Our data show that the value of y decreases as x increases. We found that y is inversely proportional to x."



What, if anything, is wrong with this statement? If something is wrong, identify and explain how to correct all errors. If this statement is correct, explain why.

5. You must understand functions to be able linearize them. First let's review what graphs of certain functions looks like. Sketch the shape of each type of function below. k is listed as a generic constant of proportionality.

Linear $y = kx$ Inverse $y = {}^{k}/_{x}$ Inverse Square $y = {}^{k}/_{x^2}$ Power $y = kx^2$

You will notice that only the linear function is a straight line. We can easily find the slope of our line by measuring the rise and dividing it by the run of the graph or calculating it using two points. The value of the slope should equal the constant k from the equation.

Finding k is a bit more challenging in the last three graphs because the slope isn't constant. This should make sense since your graphs aren't linear. So how do we calculate our constant, k? We need to transform the nonlinear graph into a linear graph in order to calculate a constant slope.

We can accomplish this by transforming one or both of the axes for the graph. The hardest part is figuring out which axes to change and how to change them. The easiest way to accomplish this task is to solve your equation for the constant. When you solve for the constant, the other side of the equation should be in fraction form. This fraction gives the rise and run of the linear graph. Whatever is in the numerator is the vertical axis and the denominator is the horizontal axis.

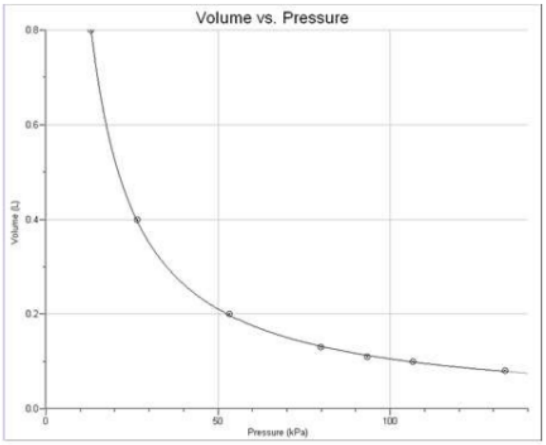
6. First let's solve each equation to figure out what we should graph.

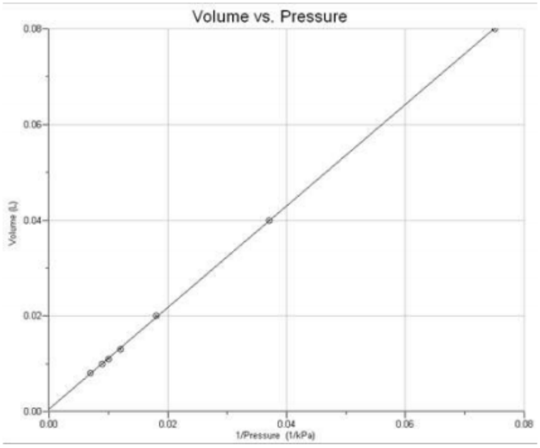
State what should be graphed in order to produce a linear graph to solve for k.

Inverse Graph Vertical Axis: ______________________ Horizontal Axis: _____________________
Inverse Square Graph Vertical Axis: ______________________ Horizontal Axis: _____________________
Power (Square) Graph Vertical Axis: ______________________ Horizontal Axis: _____________________

Take a look at this example that may be familiar from your chemistry classes.

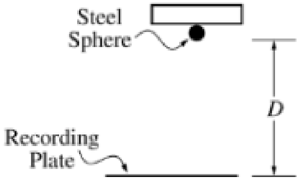
According to Boyle's the law, an ideal gas obeys the following equation $P_1V_1 = P_2V_2 = k$. This states that pressure and volume are inversely related, and the graph on the left shows an inverse shape. Although the equation is equal to a constant, the variables are not in fraction form. One of the variables, pressure in this case, is inverted. This means every pressure data point is divided into one to get the inverse. The graph on the left shows the linear relationship between volume V and the inverse of pressure 1/P. We could now calculate the slope of this linear graph.



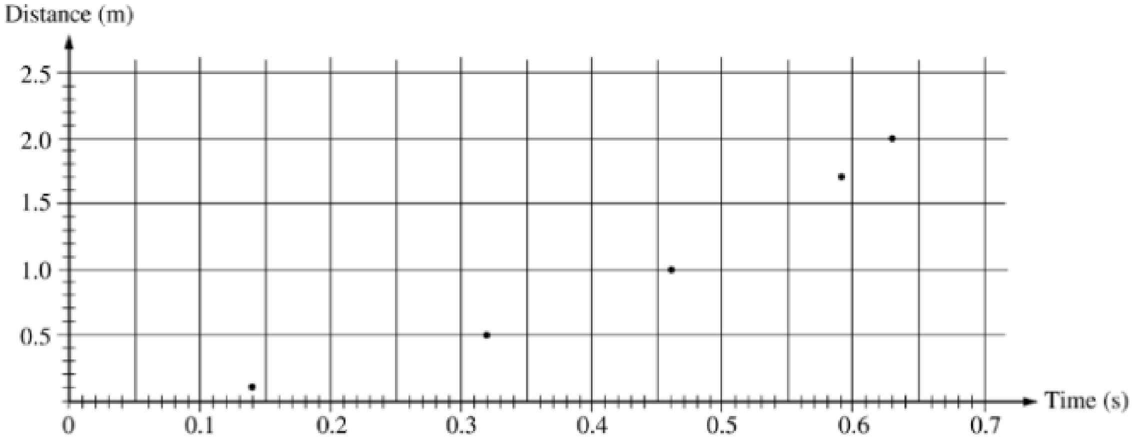


7. Complete this sample graphing exercise.

A steel sphere is dropped from rest and the distance of the fall is given by the equation $D = \frac{1}{2}gt^2$. D is the distance fallen and t is the time of the fall. The acceleration due to gravity is the constant known as g. Below is a table showing information on the first two meters of the sphere's descent.



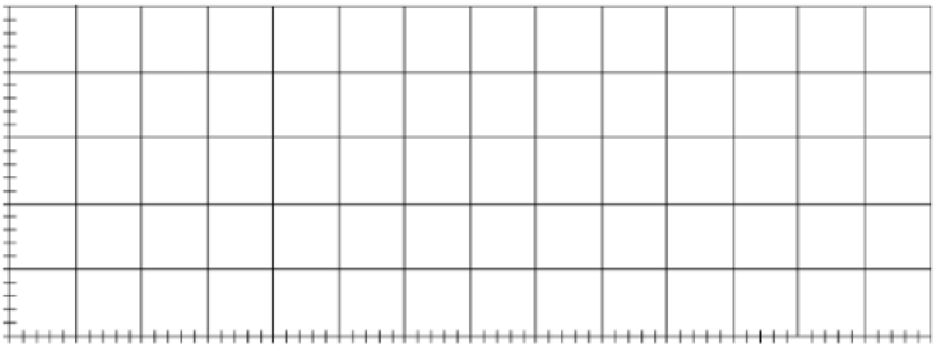
Distance of Fall (m)	0.10	0.50	1.00	1.70	2.00
Time of Fall (s)	0.14	0.32	0.46	0.59	0.63



a. Draw a line of best fit for the distance vs. time graph above.

b. If only the variables D and t are used, what quantities should the student graph in order to produce a linear relationship between the two quantities?

c. On the grid below, plot the data points for the quantities you have identified in part (b), and sketch the straight-line fit to the points. Label your axes and show the scale that you have chosen for the graph.



d. Using the slope of your graph in part (c), calculate the acceleration *g* due to gravity in this experiment.