AP Physics 1: Algebra-Based
Summer Assignment - Document 1

Welcome to the advanced placement course - ***AP Physics 1***!

This course enables willing and academically prepared students to pursue college with the opportunity to earn college credit, advanced placement, or both, while still in high school. It is a college-level physics course that helps students develop a deep understanding of the foundational principles that shape **classical mechanics**.

Physics, the most fundamental physical science, is concerned with the basic principles of the Universe. It is the foundation upon which the other sciences—astronomy, biology, chemistry, and geology—are based. The beauty of physics lies in the manner in which just a small number of fundamental concepts, equations, and assumptions can alter and expand our view of the world around us.

AP physics 1 deals with classical mechanics. This is an appropriate place to introduce physics because many of the basic principles used to understand mechanical systems can later be used to describe such natural phenomena as waves and the transfer of energy by heat. Furthermore, the laws of conservation of energy and momentum introduced in mechanics retain their importance in the fundamental theories of other areas of physics. Today, classical mechanics is of vital importance to students from all disciplines.

In order to start our journey in learning physics, it is necessary for each student to complete some work before coming back to school. This summer work is an assignment that is based on your mathematical skills and it is due on the **first day** you join the school. **<u>You will be assessed on document 1 during the first week of school</u>**.

I truly look forward to working with you in the AP physics class next year. It is only through commitment to hard work and dedication that excellence can be achieved. Please don't hesitate to contact me anytime over the summer via email - issam.elbitar@student.bbs.edu.kw

Document 1, based on mathematical skills, is mostly a basic background that depends on algebra, geometry, trigonometry and graphs that you have learned. In order to have confidence while working in physics, it is very important you work independently on this document. The concepts of physics will be taught during the coming academic year, however, facing a difficulty in working out mathematical problems will drag your potential and affect your learning. So please avoid this!

Please, and before you start working on this document, make sure you have **graph papers, a scientific calculator, pencil, pen, ruler and eraser**. Also, print out the document and show your work in the spaces provided for each question, except for **Questions 2 and 5 in part 4 - Graphing and functions** where you need to show your work **on graph papers.**

Part 1 - Algebra

Question 1 - Solving for unknown

Solve each equation symbolically for the indicated variable. Show all of your work. The first one is solved for you.

1. $v = \frac{\Delta x}{\Delta t}$; solve for Δt $v = \frac{\Delta x}{\Delta t} \Rightarrow v \cdot \Delta t = \Delta x \Rightarrow \Delta t = \frac{\Delta x}{v}$	2. $F = m\,a$; solve for a
3. $P = \frac{V^2}{R}$; solve for R	4. $f = \frac{1}{T}$; solve for T
5. $K = \frac{1}{2}mv^2$; solve for v	6. $a = \frac{v^2}{r}$; solve for v
7. $F_S = T - mg$; solve for m	8. $F\Delta t = m(v - v_0)$; solve for v

9. $T = 2\pi\sqrt{\frac{l}{g}}$; solve for l	10. $y = y_0 + v_0 t + \frac{1}{2}at^2$; solve for a
11. $v^2 = v_0^2 + 2a(x - x_0)$; solve for v_0	12. $F_g = G\frac{mM}{r^2}$; solve for r

Question 2 - Substitution and evaluation

For each of the following, substitute the indicated values and evaluate. Include the units in each step of your work and write the final answer with the correct number of significant figures.

1. $t = \sqrt{\frac{2y}{a}}$ $(y = 800\,m;\ a = 4\,m/s^2)$ $t = \sqrt{\frac{2y}{a}} = \sqrt{\frac{2(800\,m)}{4\,m/s^2}} = \sqrt{\frac{1600\,m}{4\,m/s^2}}$ $t = \sqrt{\frac{400\,m\cdot s^2}{m}} = \sqrt{400\,s^2} = 20\,s$ *Note: m canceled out and s^2 was taken up to the numerator	2. $K = \frac{1}{2}mv^2$ $(m = 4 \times 10^3\,kg;\ v = 2 \times 10^5\,m/s)$
3. $T = 2\pi\sqrt{\frac{l}{g}}$ $(l = 2.0\,m;\ g = 9.8\,m/s^2)$	4. $F = m_1(-a_1 + (\frac{F_g}{m_2} + a_2)4)$ $(m_1 = 4.0\,kg;\ m_2 = 5.0\,kg;\ a_1 = 7.6\,m/s^2;$ $a_2 = 2.5\,m/s^2;\ F_g = 7.2\,kg\,m/s^2)$

5. $P = \frac{V^2}{R_1 + R_2}$

$(V = 200\,V;\ R_1 = 80\,\Omega; R_2 = 20\,\Omega)$

6. $\mu = \frac{m_1 a}{(m_1 + m_2) g}$

$(m_1 = 7.21\,kg;\ m_2 = 3.28\,kg;$

$a = 3.07\,m/s^2;\ g = 9.81\,m/s^2)$

7. $y = y_0 + v_0 t + \frac{1}{2} a t^2$

$(y_0 = -4m; v_0 = -5\,m/s;\ a = 6\,m/s^2; t = 4s)$

8. $a = \frac{m_1 g}{m_2} - \frac{m_2 g}{m_1}$

$(m_1 = 2.5\,kg;\ m_2 = 0.45\,kg;\ g = 9.8\,m/s^2)$

9. $T = mg - ma - \mu mg$ $(m = 5\,kg;\ g = 10\,m/s^2;\ a = -4 m/s^2;$ $\mu = 0.4)$	10. $W = F \times d - mgsin\theta \times d$ $(F = 14\,N;\ d = 3.5\,m;\ m = 2.0\,kg;$ $g = 9.81\,N/kg;\ \theta = 30.0°)$

Question 3 - algebraic equations used in physics

Solve the following. Show every step for every problem, including writing the original equation, all algebraic manipulations, and substitution! <u>You should practice doing all algebra before substituting numbers in for variables.</u> The first one is done for you.

For problems 1-5, use the three equations below:

$$v_f = v_0 + at \qquad x_f = x_0 + v_0 t + \frac{1}{2}at^2 \qquad v_f^2 = v_0^2 + 2a(x_f - x_0)$$

1. Use the first equation to solve for t given that $v_0 = 5\,m/s$, $v_f = 25\,m/s$, and $a = 10\,m/s^2$. $v_f = v_0 + at \Rightarrow v_f - v_0 = at \Rightarrow t = \frac{v_f - v_0}{a} = \frac{25\,m/s - 5\,m/s}{10\,m/s^2} = \frac{20\,m/s}{10\,m/s/s} = 2\,s$ (m/s canceled out)
2. Use the second equation to solve for t given that $x_0 = -2\,m$, $x_f = 28\,m$, $v_0 = 2\,m/s$, and $a = 0.5\,m/s^2$.

3. Use the first equation to solve for $t/2$ given that $v_f = -v_0$, and $a = 2\ m/s^2$.

4. Use the third equation to solve for a given that $x_0 = 0\ m$, $x_f = 120\ m$, $v_0 = 2\ m/s$, and $v_f = 14\ m/s$.

5. How does each equation simplify when $a = 0\ m/s^2$ and $x_0 = 0\ m$?

For problems 6 – 8, use the four equations below. <u>Remember to solve for the unknown before substituting numbers in for variables</u>

$\Sigma F = ma$ $\qquad$ $f_k = \mu_k N$ $\qquad$ $f_s \leq \mu_s N$

6. Use the first equation to find m given that $\Sigma F = 10\ N$ and $a = 2\ m/s^2$.

7. Use the first and the second equations to find a given that $\Sigma F = -f_k$, $m = 250\ kg$, $\mu_k = 0.2$, and $N = 10m$

8. Use the first equation to find m in terms of T given that $\Sigma F = T - 10m$ and $a = 0\ m/s^2$.

For problems 9 – 11, use the two equations below.

$a = \frac{v^2}{r}$ $\tau = rFsin\theta$

9. Given that $a = 2.5\ m/s^2$ and $r = 4.3\ m$, find v.
10. Originally, $a = 12\ m/s^2$ and v stays the same. If r is doubled, then find the new value for a
11. Find θ when $\tau = 4\ Nm$, $r = 2\ m$, and $F = 10\ N$.

For problems 12 - 17, use the following equations:

$K = \frac{1}{2}mv^2$ $\Delta U_g = mgh$ $U_s = \frac{1}{2}kx^2$ $W = F(\Delta x)cos\theta$ $P = \frac{W}{t}$ $P = Fv_{avg}cos\theta$

12. Use the first equation to solve for m if $K = 12\ J$ and $v = 2.4\ m/s$
13. If $\Delta U_g = 10\ J$, $m = 10\ kg$, and $g = 9.8\ m/s^2$, find h using the second equation
14. Use the first and the second equations to find v if $K = \Delta U_g$, $g = 9.8\ m/s^2$, and $h = 10\ m$

15. Given $U_s = 12\, J$ and $x = 0.5\, m$, find k using the third equation.

16. Use the fourth equation to find F given that $W = 12\, J$, $\Delta x = 2.5\, m$, and $\theta = 30°$

17. Use the last two equations to find v_{avg} given that $W = 56\, J$, $t = 5.5\, s$, $F = 12\, N$, and $\theta = 0°$

For problems 18 - 20, use the following equations:

$p = mv$ $\qquad$ $F\Delta t = \Delta p$ $\qquad$ $\Delta p = m\Delta v$

18. Given $p = 12\, kg\, m/s$ and $m = 25\, kg$, find v using the first equation.

19. Find v_f using the third equation if $p_f = 50\, kg\, m/s$, $m = 12\, kg$, and v_i and p_i are both zeros.

20. Use the second and third equation together to find v_i if $v_f = 0\, m/s$, $m = 95\, kg$, $F = 6000\, N$, and $\Delta t = 0.2\, s$.

For problems 21 - 23, use the following equations:

$T_{pendulum} = 2\pi\sqrt{\frac{l}{g}}$ $T_{spring} = 2\pi\sqrt{\frac{m}{k}}$ $T = \frac{1}{f}$

21. Use the first equation to solve for l given that $T_p = 1\, s$ and $g = 9.8\, m/s^2$
22. Use the second equation to solve for k given that $m = 8\, kg$ and $T_s = 0.75\, s$
23. Use the first and the last equations to find f given that $T_p = T$, $g = 9.8\, m/s^2$, and $l = 2\, m$

For problems 24 - 27, use the following equations:

$F_g = G\frac{mM}{r^2}$ $U_g = -G\frac{mM}{r}$ $K = \frac{1}{2}mv^2$

24. Find F_g if $G = 6.67 \times 10^{-11}\, m^3/kg\, s^2$, $M = 2.6 \times 10^{23}\, kg$, $m = 1200\, kg$, and $r = 2000\, m$.
25. What is r if $U_g = -7200\, J$, $G = 6.67 \times 10^{-11}\, m^3/kg\, s^2$, $M = 2.6 \times 10^{23}\, kg$, and $m = 1200\, kg$

26. Use the second and the third equations to find v in terms of r given that $K = -U_g$, $G = 6.67 \times 10^{-11}\ m^3/kg\ s^2$, and $M = 3.2 \times 10^{23}\ kg$

27. Using the first equation above, describe how F_g changes if r doubles.

Question 4 - Power and prefixes

(a) Fill in the power and the symbol for the following unit prefixes. Kilo- has been completed as an example.

Prefix	**Power**	**Symbol**
Giga-		
Mega-		
kilo-	10^3	k
centi-		
milli-		
micro-		
nano-		
pico-		

Not only is it important to know what the prefixes mean but also it is vital that you can convert between metric units. If there is no prefix in front of a unit, it is the base unit which has 10^0 for its power, or just simply “1”. Remember if there is an exponent on the unit, the conversion should be raised to the same exponent as well.

(b) Convert the following numbers into the specified unit. Use scientific notation when appropriate.

1. 24 g = _______________ kg	2. 94.1 MHz = _______________ Hz
3. 6 GB = _______________ kB	4. 640 nm = _______________ m
5. 3.2 m^2 = _______________ cm^2	6. 40 mm^3 = _______________ m^3
7. 1 g/cm^3 = _______________ kg/m^3	8. 20 m/s = _______________ km/hr

Question 5 - Scientific notation

Perform the following calculations. Write the final answer in scientific notation. Make sure you follow the rules of significant figures.

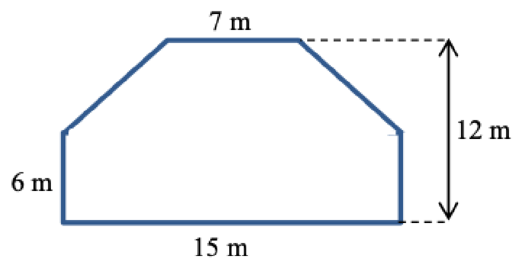
1. $(3.67 x 10^{3})(8.91 x 10^{-6})$ =
2. $(5.32 x 10^{-2})(4.87 x 10^{-4})$ =
3. $(9.2 x 10^{6}) / (3.6 x 10^{12})$ =
4. $(6.12 x 10^{-3})^{3}$ =

Part 2 - Geometry

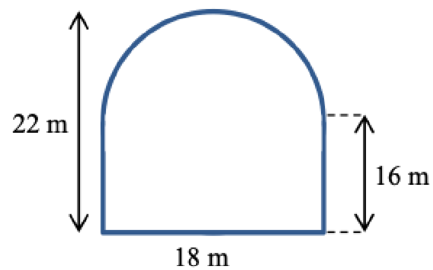
Question 1 - Area

Calculate the area of the following shapes. It may be necessary to break up the figure into common shapes.

1.



2.



Area _______________

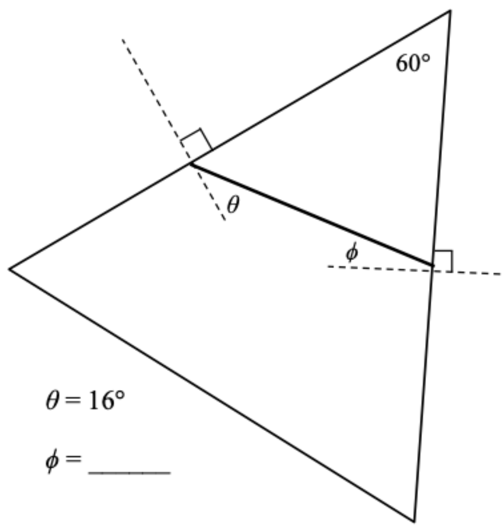
Area _______________

Show your work

Question 2 - Finding angles in geometric figures

Calculate the unknown angle values for the following.

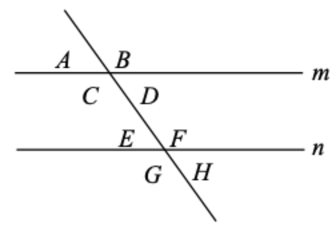
3.



$\theta = 16°$

$\phi =$ ______

4.

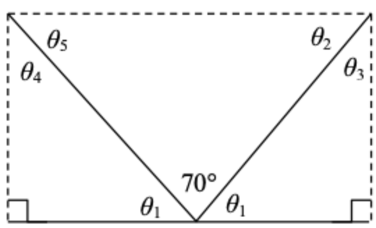


Lines m and n are parallel.

$A =$ 75° $B =$ _____ $C =$ _____ $D =$ _____

$E =$ _____ $F =$ _____ $G =$ _____ $H =$ _____

5.



$\theta_1 =$ _____

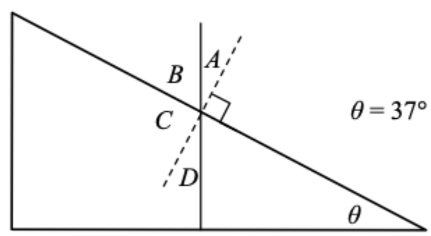
$\theta_2 =$ _____

$\theta_3 =$ _____

$\theta_4 =$ _____

$\theta_5 =$ _____

6.



$\theta = 37°$

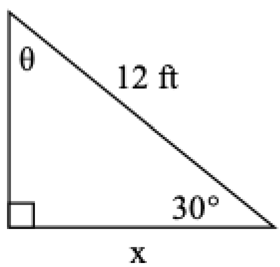
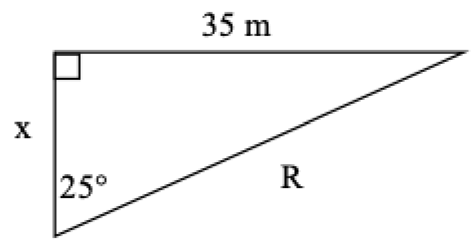
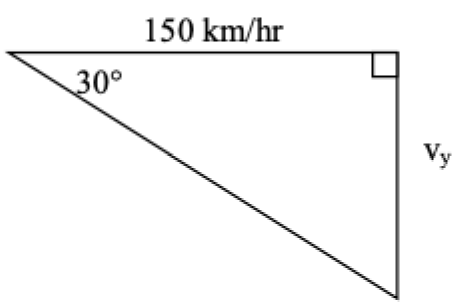
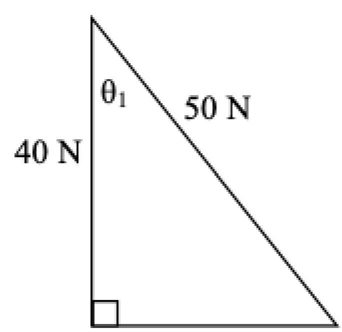
$A =$ _____ $B =$ _____

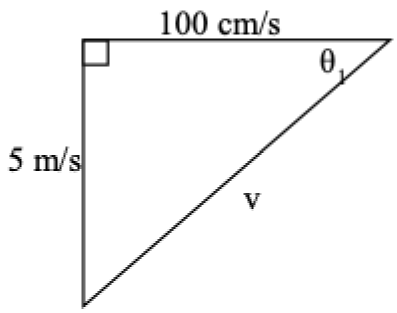
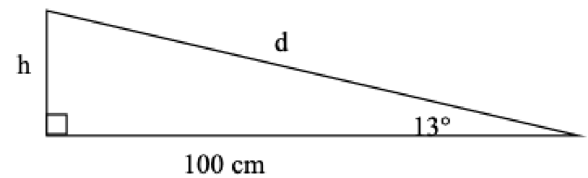
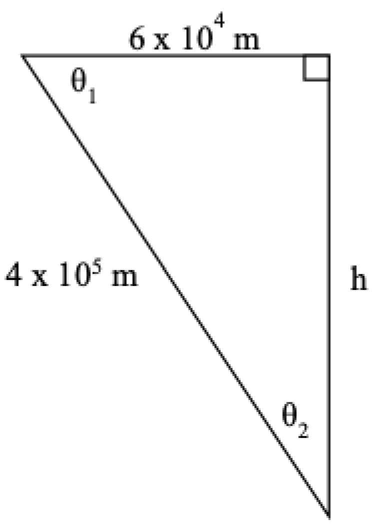
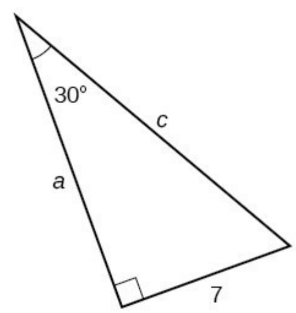
$C =$ _____ $D =$ _____

Part 3 - Trigonometry

Question 1 - Right triangle trigonometry

For each of the given right triangles, solve for every unknown. Make sure your calculator is in degree mode. Be sure to include the correct units.

1. 	2. 
3. 	4. 

5. Hint: Convert to the same unit, either cm/s to m/s or vice-versa 	6. 
7. 	8. 

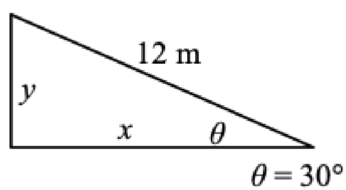
Question 2 - Trigonometric functions and Pythagorean theorem

(a) Write the formulas for each one of the following trigonometric functions. Remember SOHCAHTOA!

$sin\theta =$ $cos\theta =$ $tan\theta =$

(b) Calculate the following unknowns using trigonometry. Use a calculator, but show all of your work. Please include appropriate units with all answers. (Watch the unit prefixes!)

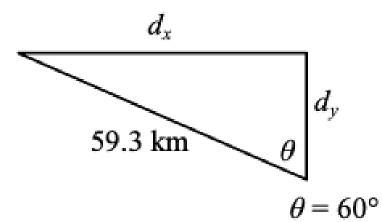
1.



$y =$ ________

$x =$ ________

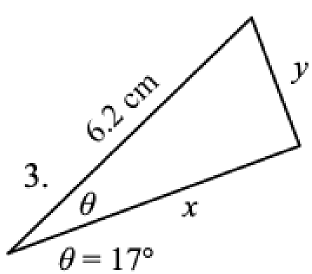
2.



$d_x =$ ______

$d_y =$ ______

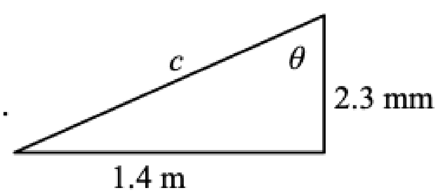
3.



$x =$ _____

$y =$ _____

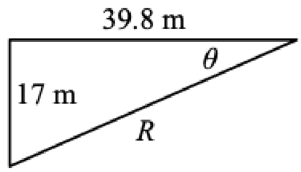
4.



$c =$ ______

$\theta =$ ______

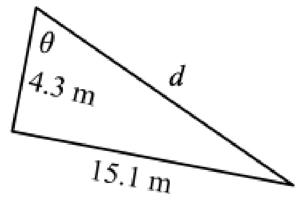
5.



$R =$ ______

$\theta =$ ______

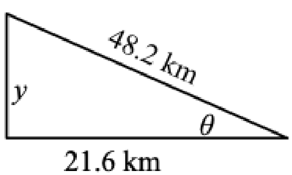
6.



$d =$ ______

$\theta =$ ______

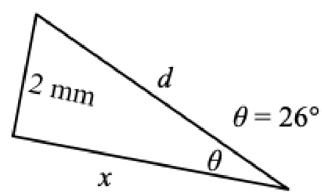
7.



$y =$ ______

$\theta =$ ______

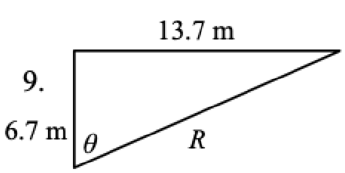
8.



$x =$ ______

$d =$ ______

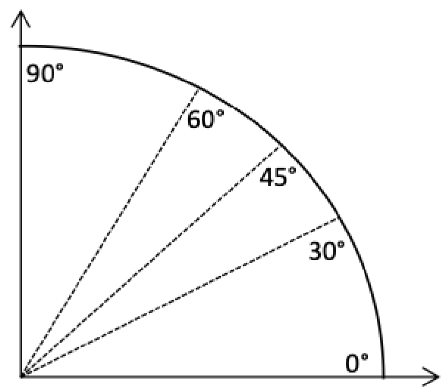
9.



$R =$ ______

$\theta =$ ______

(c) You will need to be familiar with trigonometric values for a few common angles. Memorizing this unit circle diagram in degrees (unit circle means the radius is equal to 1 unit) and the table below will be very beneficial for next year in both physics and pre-calculus. How the diagram works is **the cosine of the angle is the x-coordinate** and **the sine of the angle is the y-coordinate** for the ordered pair (x, y). Write the ordered pair, in fraction form, for each of the angles shown in the table below.



First quadrant of a unit circle diagram in degrees

θ	$\cos\theta$	$\sin\theta$
0°		
30°		
45°		
60°		
90°		

Refer to your completed table to answer the following questions.

10. At what angle is sine at a maximum? ___________ at a minimum?___________

11. At what angle is cosine at a maximum? ___________ at a minimum?___________

12. At what angle are the sine and cosine equivalent? ___________

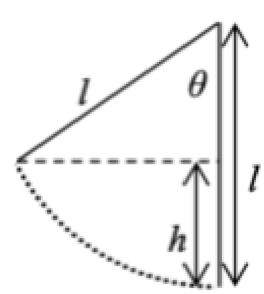
13. As the angle increases in the first quadrant, what happens to the sine of the angle?

____

14. As the angle increases in the first quadrant, what happens to the cosine of the angle?

____

Use the adjacent figure to answer problems 15 and 16



15. Find an expression for h in terms of l and θ.

____

16. What is the value of h if $l = 6\ m$ and $\theta = 40°$?

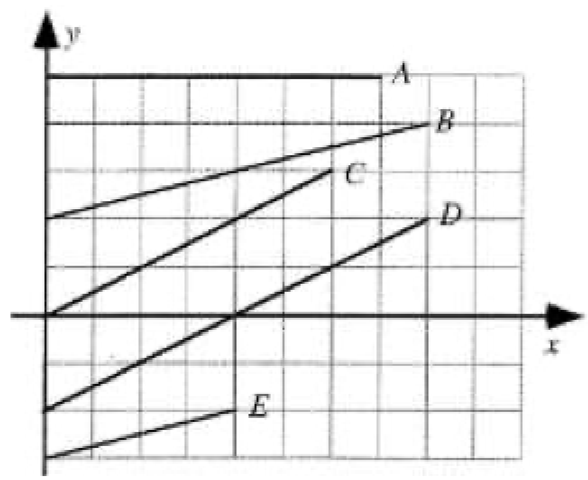
Part 4 - Graphing and functions

Key Graphing Skills to remember:

1. Use **ONLY** a pencil and a ruler to draw each graph
2. Choose a reasonable scale (***Each graph has to fill at least half of the graph paper***)
3. Always label your axes with appropriate units.
4. 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.
5. Provide a clear legend if multiple data sets are used to make your graph understandable.
6. Never include the origin as a data point unless it is provided as a data point.
7. Never connect the data points individually, but draw a single smooth line or curve of best fit
8. 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.

Question 1 - Finding the slope

(a) Shown are several lines on a graph

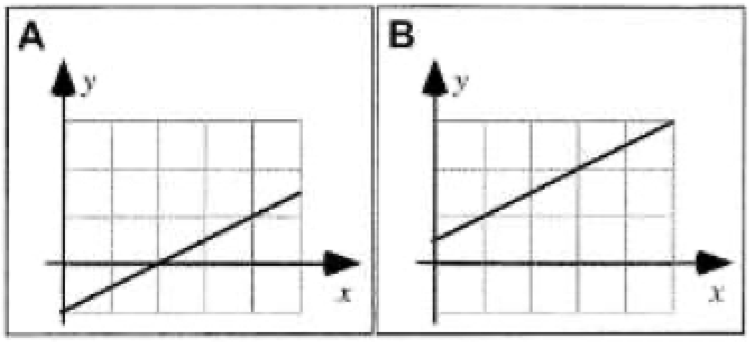


Rank the slopes of the lines in this graph.

					OR			
1 Greatest	2	3	4	5 Least		All the same	All zero	Cannot determine

Explain your reasoning.

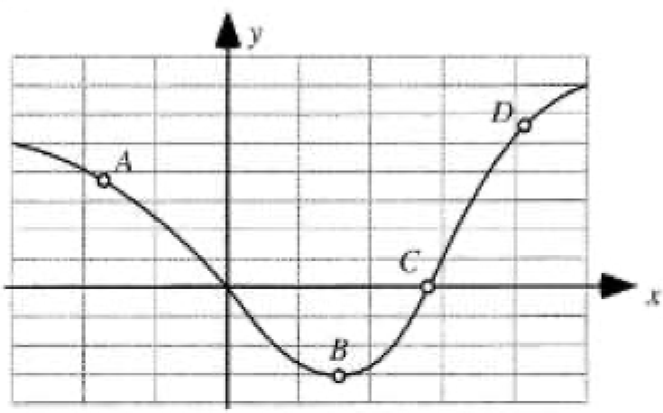
(b) Shown are two graphs



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

Explain your reasoning.

(c) Four points are labeled on the graph below.



Rank the slopes of the graph at the labeled points.

				OR			
1 Greatest	2	3	4 Least		All the same	All zero	Cannot determine

Explain your reasoning.

Question 2 - Graphing

Graph each of the following sets of data _on a seperate graph paper_. Make sure to follow the eight steps listed at the beginning of part 4 and find the slope of each graph.

Data 1

$t(s)$	$x(m)$
0	- 7.0
2	- 3.2
4	0.9
6	5.1
8	8.8
10	12.7
12	17.2

Data 2

$a(m/s^2)$	$F(N)$
1.2	103
1.4	118
1.6	124
1.8	135
2.0	147
2.2	154
2.4	166

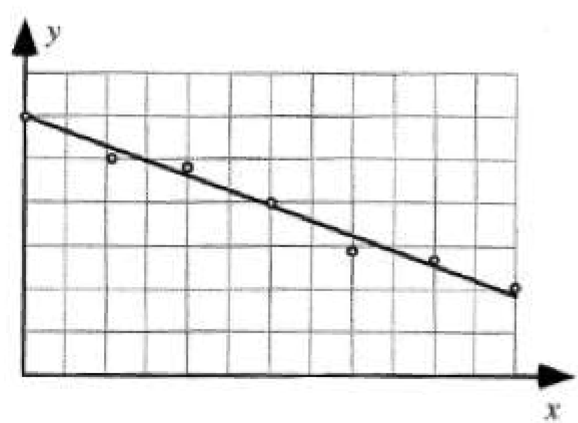
Data 3

$I(A)$	$\Delta V(V)$
0.04	8
0.08	10
0.12	12
0.16	14
0.20	16
0.24	18
0.28	20

Question 3 - Line data graph; Interpretation

A student makes the following claim about some data that he and his 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.

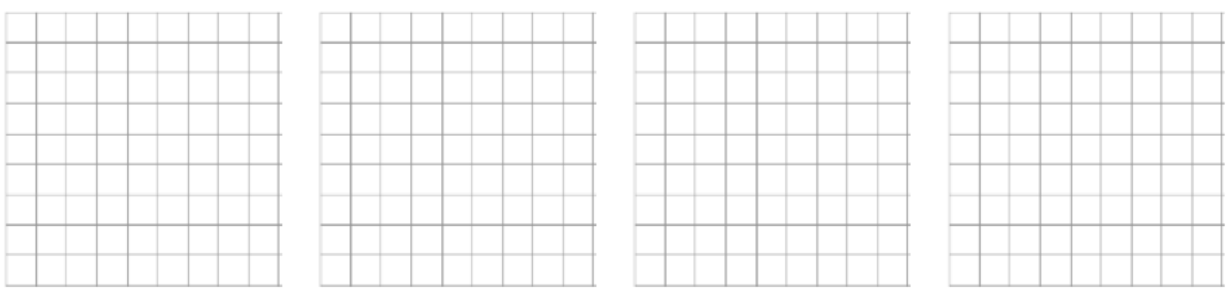
A greater emphasis has been placed on conceptual questions and graphing on the AP exam. Below you will find a few example concept questions that review foundational knowledge of graphs. You may need to review some math to complete these tasks. At the end of this part is a section covering graphical analysis that you probably have not seen before: ***linear transformation***. 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.

You must understand functions to be able to linearize. First, let's review what graphs of certain functions look like.

Question 4 - Linear and nonlinear functions

(a) Sketch the shape of each type of $y\ vs.\ x$ function below. k is listed as a generic constant of proportionality.

Linear $y = k \cdot x$ Inverse $y = k/x$ Inverse Square $y = k/x^2$ Power $y = k \cdot x^2$



You can 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.

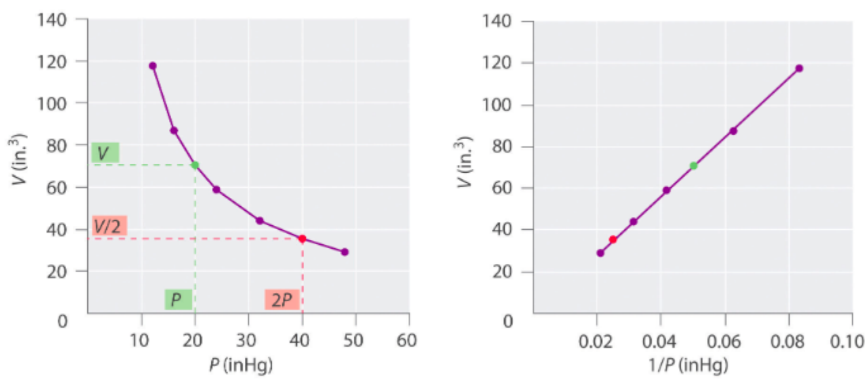
Finding k is a bit more challenging in the last three graphs because the slope isn't constant. This should make sense since your graphs aren't linear. So how do we calculate k? *We need to transform the non- linear graph into a linear graph in order to calculate a constant slope.* We can accomplish this 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*. Note in the examples from the last page there is only one constant, but this process could be done for other equations with multiple constants. Instead of solving for a single constant, **put all of the constants on one side of the equation. 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.* If the equation is not in fraction form, you will need to invert one or more of the variables to make a fraction.

Chemistry/physics Example

Let's look at an equation you should remember from chemistry. According to Boyle's law, an ideal gas obeys the following equation $PV = k$. 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 (≈ 1410), the variables are not in fraction form and the graph on the left has a non-linear form. To linearize the graph, we can take the inverse of every single data of the pressure present on the graph on the left side in order to have a fraction form $(V/(1/P) = k)$. The graph on the right shows the linear relationship between volume V and the inverse of pressure $1/P$. We could now calculate the slope of this linear graph.

P (inHg)	V (in.^{3})	PV
12.0	117.5	1410
16.0	87.2	1400
20.0	70.7	1410
24.0	58.8	1410
32.0	44.2	1410
40.0	35.3	1410
48.0	29.1	1400

(a) Data from Boyle's experiment



(b) Volume vs. pressure

(c) Volume vs. 1/pressure

[Adapted from The Gas Laws - Chemistry Libretexts]

Another example is graphing kinetic energy K vs. speed v using $K = \frac{1}{2}mv^2$. Set K as the y axis and v as the x axis will result in a power graph (a quadratic function $y = k \cdot x^2$). To linearize the graph, we can take the square of every single data of v. The slope of K vs. v^2 graph will be equal to $\frac{1}{2}m$ and the fraction will look like $K/v^2 = \frac{1}{2}m$.

Let's solve each equation to figure out what we should graph. Then complete the questions below.

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

Inverse Graph $y = k/x$ Vertical Axis:_________ Horizontal Axis: _________

Inverse Square Graph $y = k/x^2$ Vertical Axis:_________ Horizontal Axis: _________

Power (Square) Graph $y = k \cdot x^2$ Vertical Axis:_________ Horizontal Axis: _________

Question 5 - Linear transformation

Answer all the parts of question 5 on *a graph paper*.

Data 1

m (kg)	5	10	15	20	25
a (m/s^2)	4	2	1.4	1	0.8

Data 2

t (s)	2	4	6	8	10
x (m)	-12	12	52	108	180

Use data 1 and data 2 given above to answer the following questions:

(a) Plot each set of data given below on a seperate graph paper using a pencil, choosing a reasonable scale, labeling each axis correctly and drawing the best fit line. Please make sure you have a clear and clean graphing.

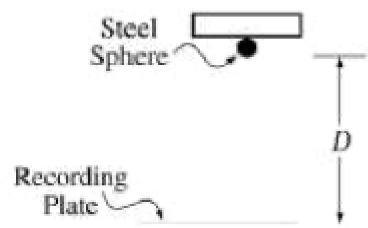
(b) Identify the relationship between the variables: direct, linear, inverse (power series), or polynomial.

(c) Write a proportionality between the two variables; i.e. either

- $y = k \cdot x$ → for the direct relation
- $y = k \cdot x + c$ → for the linear relation
- $y \cdot x = k$ OR $y = k/x$ → for the inverse relation
- $y \cdot x^2 = k$ OR $y = k/x^2$ → for the inverse square relation
- Or $y = k \cdot x^m$, where m can 2, 3, 4, etc → for the power (or polynomial)

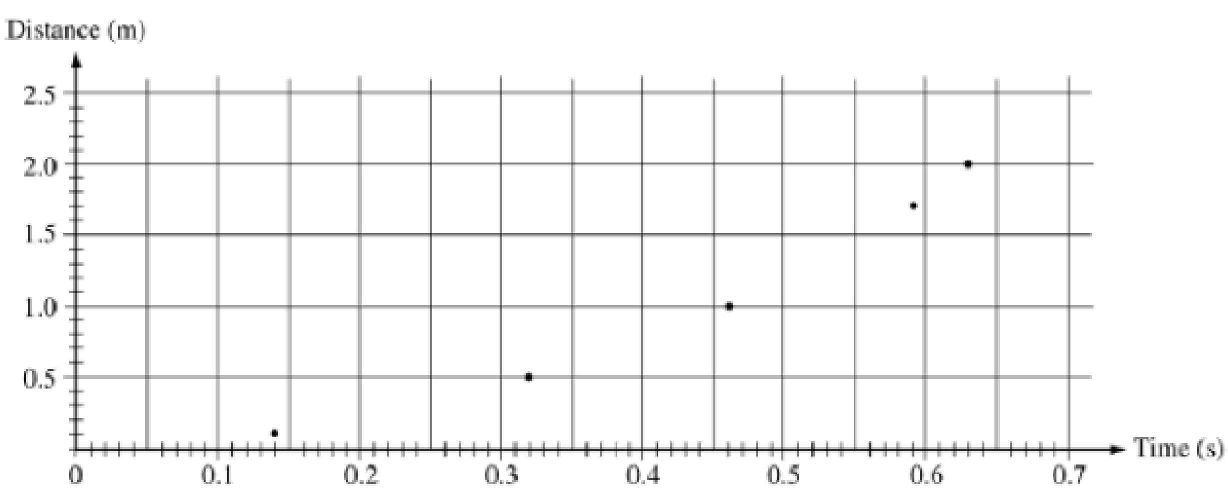
(d) Re-plot the data on a graph paper so that you get a straight line (this is called linearization of the data). Use the empty rows in the table above to calculate new values. Draw a best-fit-line, find the slope, and then write an equation for the line.

Question 6 - Sample AP 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.

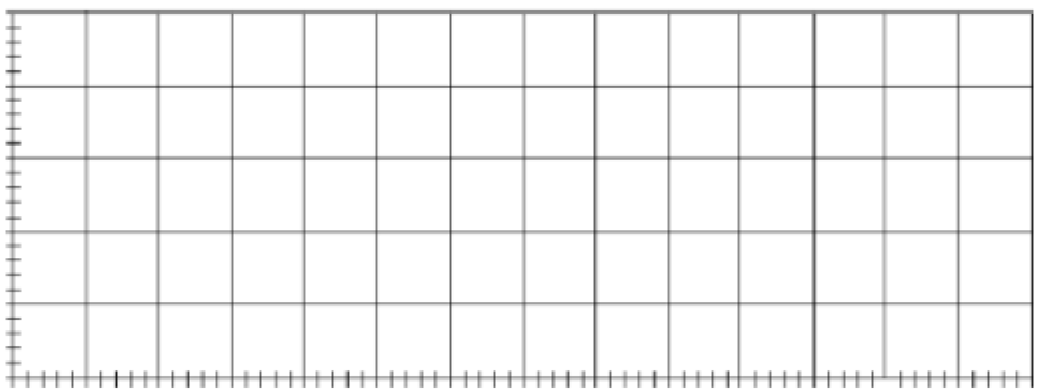
Time of fall (s)	0.14	0.32	0.46	0.59	0.63
Distance of fall (m)	0.10	0.50	1.00	1.70	2.00



(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) Calculate the value of g by using the slope of the graph.