AP Physics 1: Algebra-Based
Summer Assignment

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. **You will be assessed on this document during the second week of school**.

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

This document, 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. Therefore understanding the below will help you to avoid this!

Make sure, and before you start working on the questions below, to have **graph papers, a scientific calculator, pencil, pen, ruler and eraser**. Also, **print out the document** and show your work in the space provided for each question, except for **the graphing questions** where you need to show your work **on graph papers.**

Part 1 - Algebra

Question 1 - Solving for the unknown

Solve each equation for the indicated variable. Show the steps clearly. The first one is solved for you.

1. $v = \frac{\Delta x}{\Delta t}$; solve for Δt multiply both sides by Δt, $v \cdot \Delta t = \frac{\Delta x}{\Delta t} \cdot \Delta t$ Cancel out Δt on the right side of the equation, $v \cdot \Delta t = \Delta x$ Divide both sides by v, then $\Delta t = \frac{\Delta x}{v}$	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 if $y_0 = 0$ and $v_0 = 0$

11. $v^2 = v_0^2 + 2a(x - x_0)$; solve for v_0 if $x_0 = 0$ and $v = 0$	12. $F_g = G\frac{m_1 m_2}{r^2}$; solve for r

Question 2 - Substitution and evaluation

For each of the following, **substitute** the indicated values and **evaluate**. **Write** the final answer with the correct unit after you simplify the units and with the correct number of significant figures.

1. $K = \frac{1}{2}mv^2$ $(m = 4 \times 10^3\ kg;\ v = 2 \times 10^5\ m/s)$	2. $T = 2\pi\sqrt{\frac{l}{g}}\ (l = 2.0\ m;\ g = 9.8\ m/s^2)$
3. $y = y_0 + v_0 t + \frac{1}{2}at^2$ $(y_0 = 4m; v_0 = 0;\ a = -10\ m/s^2; t = 4s)$	4. $F_g = G\frac{m_1 m_2}{r^2}$ $(G = 6.67 \times 10^{-11} N \cdot m^2/kg^2;$ $m_1 = 6.78 \times 10^{24}\ kg;\ m_2 = 4.32 \times 10^5\ kg;$ $r = 2.98 \times 10^7\ m)$

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 2-4, use the three equations below. The first one is solved for you.

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

1. Find t. Given: $v_0 = 5\ m/s$, $v_f = -25\ m/s$, and $a = -10\ m/s^2$.

$v_f = v_0 + at \Rightarrow v_f - v_0 = at \Rightarrow t = \frac{v_f - v_0}{a} = \frac{-25-5}{-10} = \frac{-30}{-10} = 3\ s$

2. Find t. Given: $x_0 = 0$, $x_f = 28\ m$, $v_0 = 2\ m/s$, and $a = 0.5\ m/s^2$.

3. Find t. Given: $v_f = -v_0 = -3m/s$, and $a = -2\ m/s^2$.

4. Find a. Given: $x_0 = 0\ m$, $x_f = 120\ m$, $v_0 = 32\ m/s$, and $v_f = 0$.

For problems 5 – 6, use the equations below. <u>Remember to solve the equations algebraically first, rather than plugging in values immediately.</u>

$\Sigma F = ma$ $f_k = \mu_k F_n$ $f_s \leq \mu_s F_n$

5. Find a. Given: $\Sigma F = -f_k$, $m = 250\,kg$, $\mu_k = 0.2$, and $F_n = 2500\,N$
6. Find F_n. Given: $\mu_k = 0.4$, $\mu_s = 0.2$, $\Sigma F = F_{app} - 100$, and the object is on the verge of moving..

For problems 7 - 10, use the following equations:

$K = \frac{1}{2}mv^2$ $\Delta U_g = mgh$ $U_s = \frac{1}{2}kx^2$ $W = F\,d\,cos\theta$ $P = \frac{W}{t}$ $P = F\,v\,cos\theta$

7. Find m. Given $K = 12\,J$ and $v = 2.4\,m/s$
8. Find v. Given $K = \Delta U_g$, $g = 9.81\,m/s^2$, and $h = 12.5\,m$
9. Find k. Given $U_s = 12\,J$ and $x = 24\,cm$ (you have to convert the cm to m)
10. Find v. Given: $W = 56\,J$, $t = 5.5\,s$, $F = 12\,N$, and $\theta = 0°$

Question 4 - Scientific notation

Write the following in scientific notation.

1. 0.00034 =	2. 2887.78 =
3. 0.00000633 =	4. 12233 =

Question 5 - Ratios

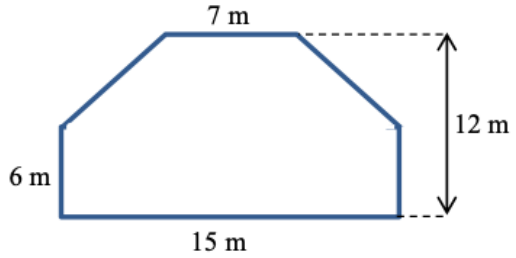
1. If A = 10x, B = 3, C = 2x , and D = 6, then find $\frac{\frac{A}{B}}{\frac{C}{D}}$	2. An object has a kinetic energy $K = \frac{1}{2}mv^2$. If its speed is doubled then what is the ratio of its new kinetic energy to its original kinetic energy?
3. Consider $F_1 = G\frac{mM}{r^2}$. If m is doubled and r is tripled, then the new force is F_2 . Find $F_2 : F_1$ (i.e. $\frac{F_2}{F_1}$)	4. Consider $T_1 = 2\pi\sqrt{\frac{l}{g}}$ and $T_2 = 2\pi\sqrt{\frac{2l}{g}}$. Find $T_2 : T_1$
5. Consider $T_{spring\ 1} = 2\pi\sqrt{\frac{m}{k}}$ and $T_{spring\ 2} = 2\pi\sqrt{\frac{4m}{9k}}$, then find $T_{spring\ 2} : T_{spring\ 1}$	6. Given the gravity of planet 1 is $g_1 = G\frac{M}{r^2}$and the gravity of planet 2 is $g_2 = G\frac{2M}{(\frac{r}{2})^2}$. Find $g_2 : g_1$

Part 2 - Geometry

Question 1 - Area and Volume

It may be necessary to break up the figure into common shapes.

1.



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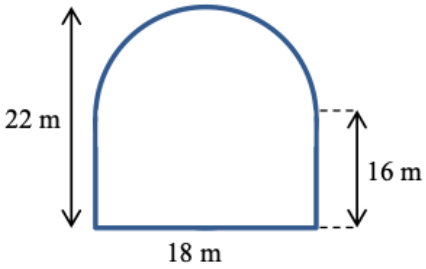
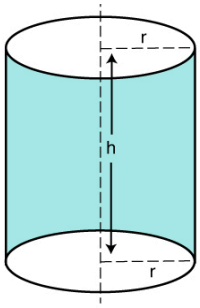


Area _____

Area _____

Show your work

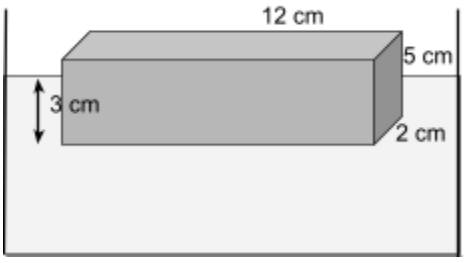
3. Cylinder with r = 43 cm and h = 10 cm



Total Surface Area _____

Show your work

4. Rectangular slab of L = 12 cm, H = 5 cm
W = 2 cm is submerged in water.



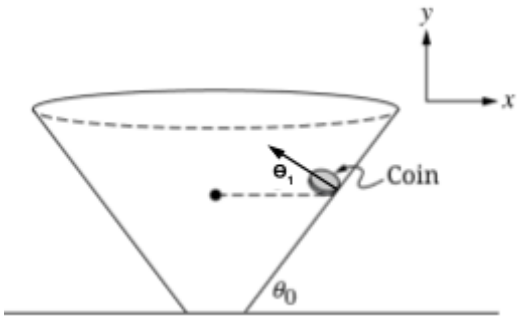
Volume of the submerged part only _____

5. If a sphere of radius R has a volume 45 cm^3 then find R.

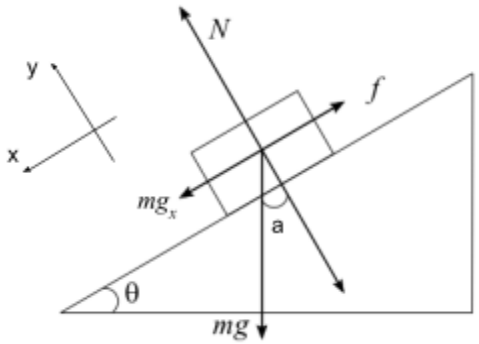
Question 2 - Finding angles in geometric figures

Calculate the unknown angle values for the following.

1. If Θ_0 is 30º in the adjacent figure then what is the value of Θ_1, the angle between the vector and the horizontal line?



2. (i) If Θ is 30º in the adjacent figure then what is the value of a, the angle between the negative y-axis and the vector mg?

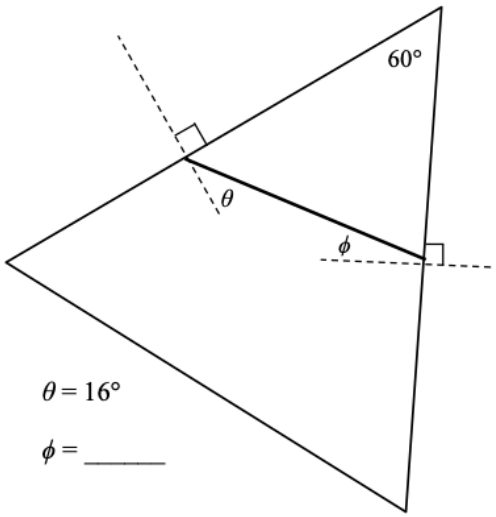


(ii) What angle does the vector f make with the positive x-axis?

(iii) What angle does the vector N make with the positive x-axis?

(iv) What angle does the vector mg_x make with the positive x-axis?

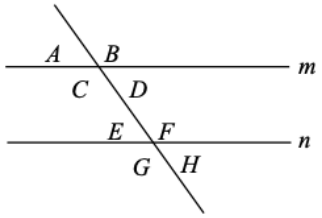
3.



$\theta = 16°$

$\phi =$ _____

4.

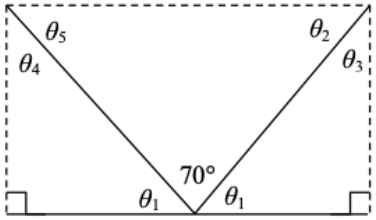


Lines m and n are parallel.

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

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

5.



$\theta_1 =$ _____

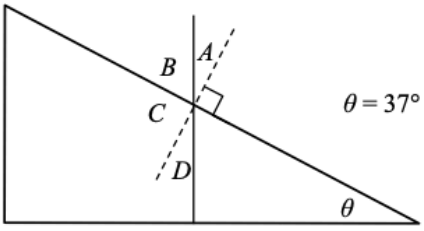
$\theta_2 =$ _____

$\theta_3 =$ _____

$\theta_4 =$ _____

$\theta_5 =$ _____

6.



$A =$ _____ $B =$ _____

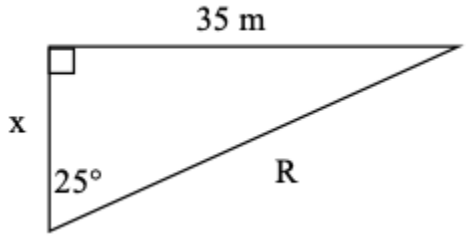
$C =$ _____ $D =$ _____

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.



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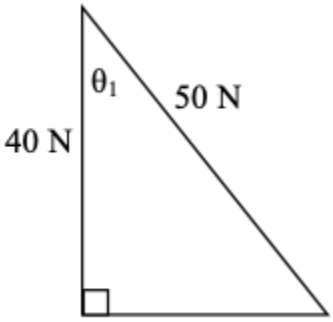
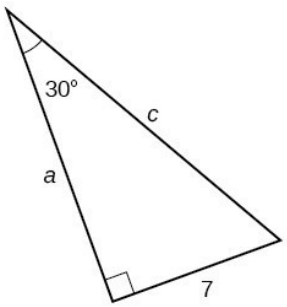


3.



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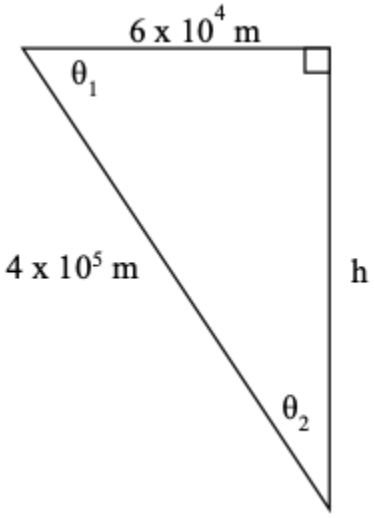


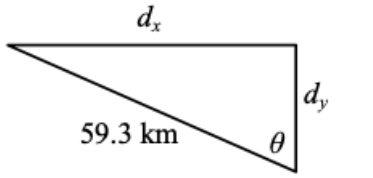
Question 2 - Trigonometric functions and Pythagorean theorem

(a) Write the formulas for each one of the following trigonometric functions. Remember SOH-CAH-TOA!

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

(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!)

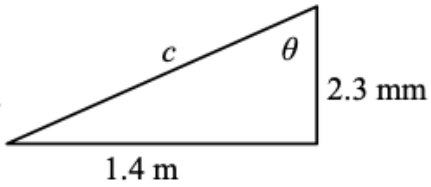
1.



$d_x =$ _____

$d_y =$ _____

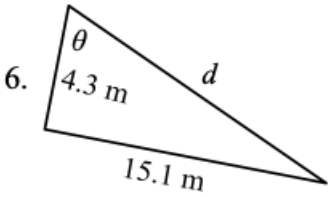
2.



$c =$ _____

$\theta =$ _____

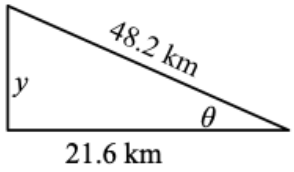
3.



$d =$ _____

$\theta =$ _____

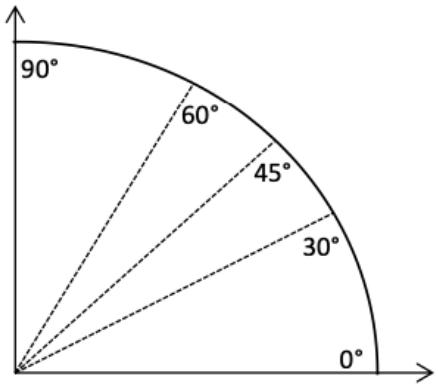
4.



$y =$ _____

$\theta =$ _____

(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:

1. At what angle is sine at a maximum? _____ at a minimum?_____

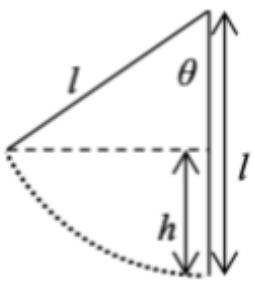
2. At what angle is cosine at a maximum? _____ at a minimum?_____

3. At what angle are the sine and cosine equivalent? _____

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

5. 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



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

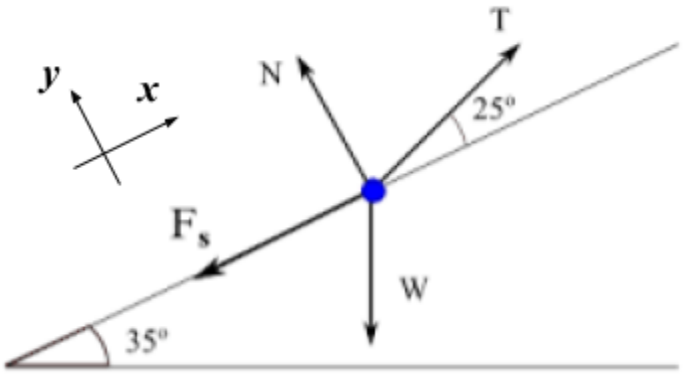
_____

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

Part 4 - Vectors

Question 1

An object is being pulled up along an inclined plane as shown below



What are the x-component and the y-component of

(i) vector T?

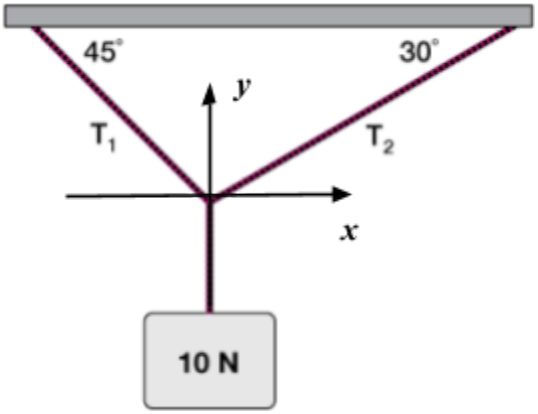
(ii) vector N?

(iii) vector F_s?

(iv) vector w?

Question 2

A block is hung in equilibrium as shown in the adjacent figure.



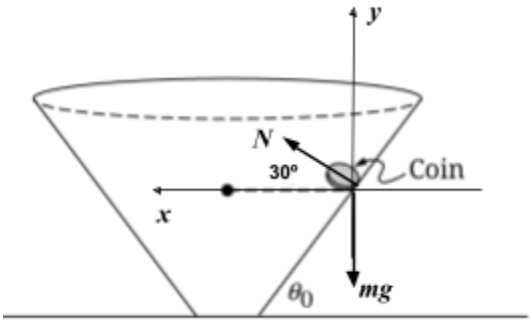
What are the x-component and the y-component of

(i) vector T_1?

(ii) vector T_2?

Question 3

A coin rolls in a circular path along the inside surface of a cone, as shown below.



What are the x-component and the y-component of

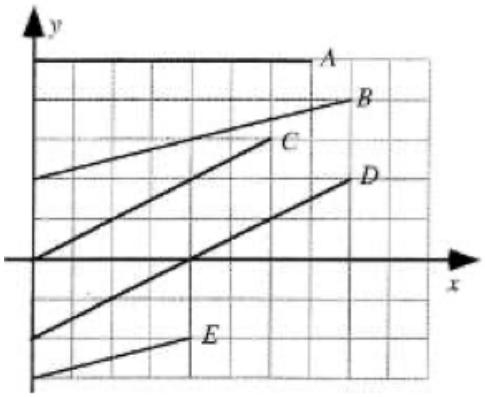
(i) vector N?

(ii) vector mg?

Part 5 - Graphing and functions

Question 1 - Finding the slope

(a) Shown are several lines on a graph

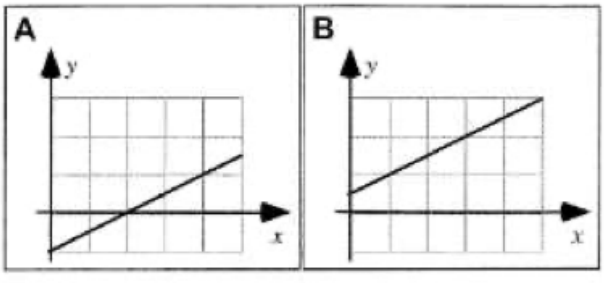


Rank the slopes of the lines in this graph.

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

Explain your reasoning.

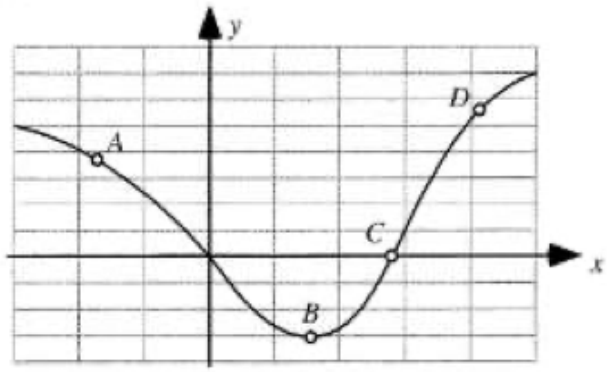
(b) Shown are two graphs



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

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.

Key Graphing Skills to remember - VERY IMPORTANT
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 two points from your line. The two points must be far from each other on the line. You may only use given data points IF your line of best fit goes directly through them.

Question 2 - Graphing

Graph each of the following sets of data *on a seperate graph paper*. Make sure you go over the points listed on the previous page.

Remember the first column goes along the x-axis and the second column goes along the y-axis.

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

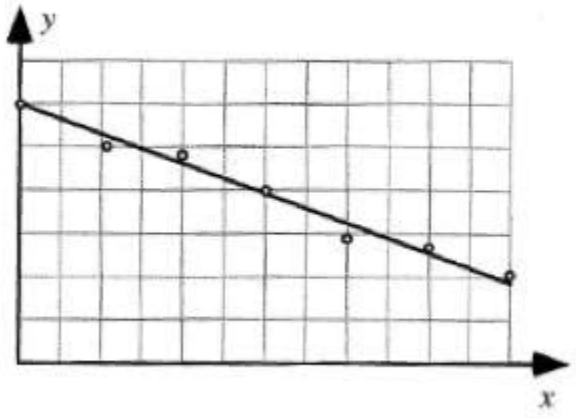
Data 3

$I(A)$	$\Delta V(V)$
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 group of students make the following claim about some collected data:

"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.

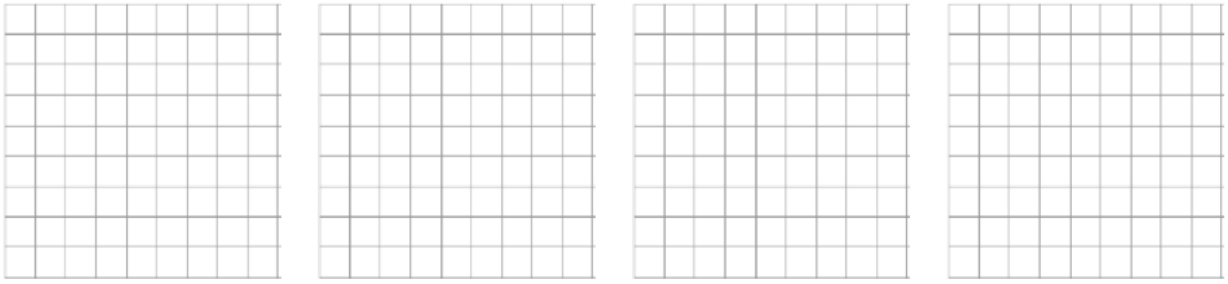
A greater emphasis has been placed on conceptual questions and graphing on the AP exam. Below you will find a few example concept questions that review foundational knowledge of graphs. You may need to review some math to complete these tasks. At the end of this part is a section covering graphical analysis 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 $y = k \cdot x^2$



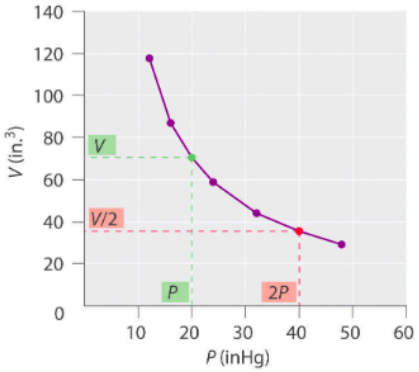
You can notice that ***only the linear function is a straight line***. Finding k is a bit more challenging in the last three graphs because the slope isn't constant. This should make sense since your graphs aren't linear. So how do we calculate k? *We need to transform the nonlinear graph into a linear graph in order to calculate a constant slope.* In order to understand it study the examples below

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 $PV = k$, where k is constant. This states that pressure and volume are inversely related, and the graph of V vs. P shows an inverse relation. Note that the PV is equal to a constant (≈ 1410).

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



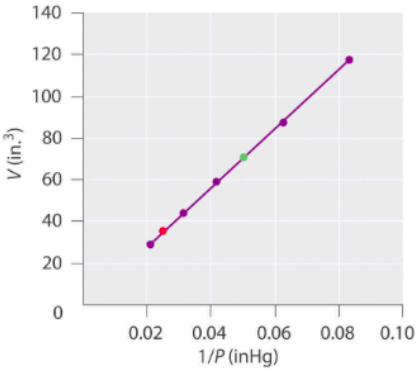
(b) Volume vs. pressure

https://chem.libretexts.org/Courses/Valley_City_State_University/Chem_115/Chapter_7%3A_States_of_Matter/7.3%3A_The_Gas_Laws

To linearize the graph, rearrange $PV = k$ in order to look like $y = k \cdot x$.

Divide both sides by P, then $V = \frac{k}{P} = k \cdot \frac{1}{P}$. Hence, take the inverse of every single data of the pressure present in the table and plot V vs. $\frac{1}{P}$.

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.

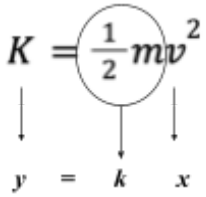


(c) Volume vs. 1/pressure

Another example: Students collected data on kinetic energy K and speed v

Using $K = \frac{1}{2}mv^2$ and 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, take the square of every single data of v and plot K on the y axis and v^2 on the x axis



The slope of K vs. v^2 graph will be equal to $\frac{1}{2}m$

The analysis above can be applied to any equation in physics.

(b) State what should be graphed. **VERY IMPORTANT QUESTION**

(i) Collected data: U_g and h. What should be graphed in order to get a linear graph to find m?

Equation: $U_g = mgh$

Vertical Axis:_____ Horizontal Axis: _____ Slope: _____

(ii) Collected data: x and v ($v_0 = 0, x_0 = 0$). What should be graphed in order to get a linear graph to find acceleration? **Equation:** $v^2 = v_0^2 + 2a(x - x_0)$

Vertical Axis:_____ Horizontal Axis: _____ Slope: _____

(iii) Collected data: U_s and x. What should be graphed in order to get a linear graph to find k?

Equation: $U_s = \frac{1}{2}kx^2$

Vertical Axis:_____ Horizontal Axis: _____ Slope: _____

(iv) Collected data: F_g and r. What should be graphed in order to get a linear graph to find m_1?

Equation: $F_g = G\frac{m_1 m_2}{r^2}$

Vertical Axis:_____ Horizontal Axis: _____ Slope: _____

(v) Collected data: T and l. What should be graphed in order to get a linear graph to find g?

Equation: $T = 2\pi\sqrt{\frac{l}{g}}$

Vertical Axis:_____ Horizontal Axis: _____ Slope: _____

(vi) Collected data: P and h. What should be graphed in order to get a linear graph to find ρ?

Equation: $P = P_{atm} + \rho gh$

Vertical Axis:_____ Horizontal Axis: _____ Slope: _____

(vii) Collected data: v and r. What should be graphed in order to get a linear graph to find μ?

Equation: $\mu g = \frac{v^2}{r}$

Vertical Axis:_____ Horizontal Axis: _____ Slope: _____

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.

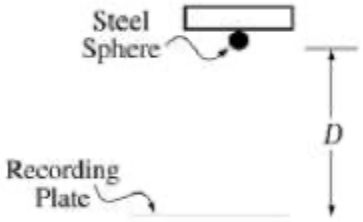
(b) Identify the relationship between the variables: direct, linear, inverse, or polynomial.

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

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

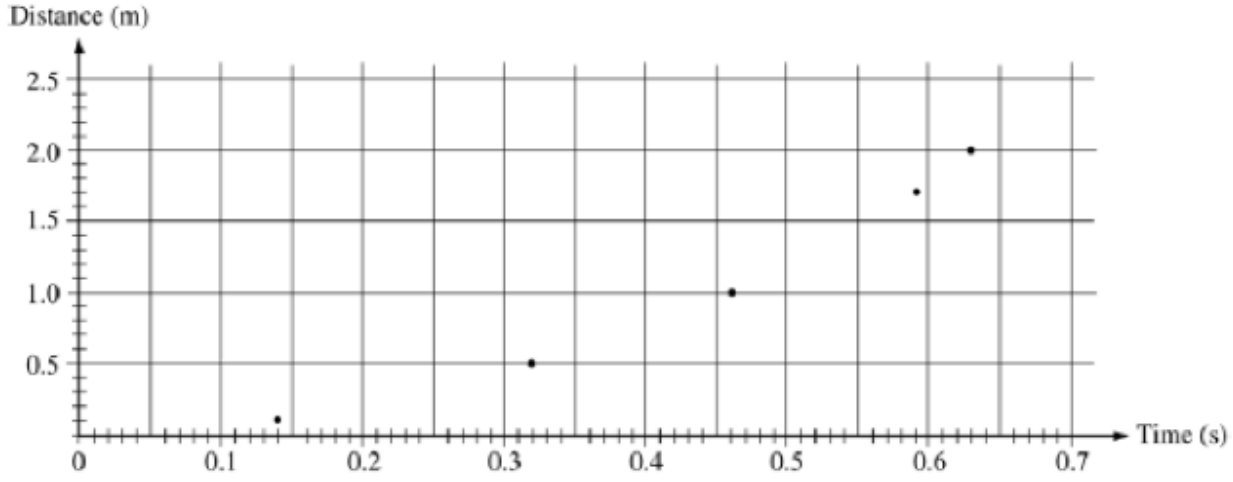
(d) Re-plot the data on a graph paper so that you get a straight line (this is called linearization of the data). Add the new values used in this part on your graph paper. Draw a best-fit-line, find the slope, and then write an equation for the line.

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.

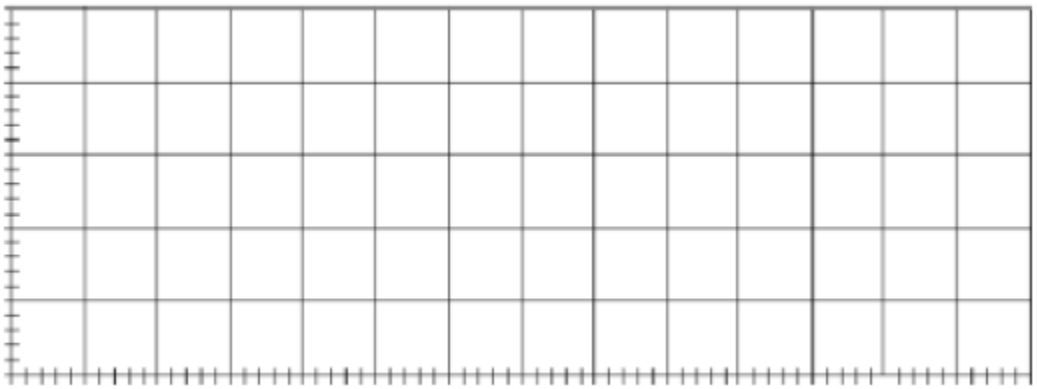
Time of fall (s)	0.14	0.32	0.46	0.59	0.63
Distance of fall (m)	0.10	0.50	1.00	1.70	2.00



(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.