Summer Assignment | AP Physics 1

Welcome to AP Physics! This summer work must be completed by anyone who is taking the AP Physics 1 course at Calvary Christian High School. While I will not grade everyone's packet for accuracy, there will be a quiz on this material. We will review these problems in class. The quiz will include the following topics, each of which has its own section in this packet.

- Significant figures
- Metric conversions and Scientific Notation
- Solving algebraic equations
- Right triangle trigonometry
- Proportionality and graphing

Notice how most of these are mathematics topics. Since Physics Honors is not a prerequisite for AP Physics, you are not required to know much physics in order to take this class. However, I do expect everyone to come in with a general understanding of basic kinematics, the first physics topic that we will study. More information on how to learn about basic kinematics can be found later in this packet.

Much of this packet is reference material and important reading. While it may not be as much physical "work" as other summer work, it is very important that when we begin class you understand all of this material. If you do not have the skills that are necessary to complete this, then you are expected to learn them on your own over the summer. If you lose this packet, please email me and I can send another copy to you.

My prayer is that you will begin to discover how God continually reveals himself through His creation as we attempt to understand the physical world.

If you have any questions please feel free to email me at rust.brandon@cchs.us

Have a great summer,

Mr. Fe_2O_3

Mr. Rust

AP Physics 1 Summer Assignment

Read all information carefully and complete all problems. You must show work for the problems to receive credit. Work may be shown on a separate sheet of paper if necessary.

Greek Letters

In Physics, we use variables to denote a variety of unknowns and concepts. Many of these variables are letters of the Greek alphabet. If you are not familiar with these letters, you should. While there is no practice work for this section and while you do not have to outright memorize these letters at this point, you need to have this exposure so that when class starts and you see μ on the board, you don't call it, "that funny looking m-thing".

These variables have specific names and I will be using these names. You need to do this as well.

Greek Letter	Name	Commonly used for
α	Alpha (lowercase)	Angular acceleration, radiation particle
β	Beta (lowercase)	Radiation particle
Δ	Delta (uppercase)	Showing a change in a quantity
ε	Epsilon (lowercase)	Permittivity
ϕ	Phi (lowercase)	Magnetic Flux, work function
γ	Gamma (lowercase)	Radioactivity, relativity
λ	Lambda (lowercase)	Wavelength
μ	Mu (lowercase)	coefficient of friction
π	Pi (lowercase)	Mathematical constant
θ	Theta (lowercase)	Angle name
ρ	Rho (lowercase)	Density, resistivity
Σ	Sigma (uppercase)	Showing the sum of numbers
τ	Tau (lowercase)	Torque
ω	Omega (lowercase)	Angular velocity
ξ	Xi (uppercase)	Electromotive force; induced voltage

The Metric System

Everything in physics is measured in the metric system. The only time that you will see English units is when you convert them to metric units. The metric system is also called SI (from the French, "Système International"). In the SI system fundamental quantities are measured in meters, kilograms, and seconds.

Here are the metric prefixes that we will use throughout the year:

Name of prefix	Numerical value	Abbreviation
pico-	10^{-12}	p
nano-	10^{-9}	n
micro-	10^{-6}	μ
milli-	10^{-3}	m
centi-	10^{-2}	c
kilo-	10^{3}	k
mega-	10^{6}	M
Giga	10^{9}	G

Answers and Solutions

In physics, the *solution* to a problem is usually more important than the *answer*. An *answer* is the number that you circle at the end of the process of solving a problem. The entire process is called the *solution*. On the free response portion of the AP exam, you can earn most of the credit for a problem with a good solution but the wrong answer, yet a correct *answer* alone with no *solution* will earn you nothing. Throughout the year, we will use the same process for writing a solution. If you exclude any of the steps in the process, you will lose credit. The steps to writing a *solution* are as follows:

1) Draw a diagram if needed
2) List given variables on far left, include unknown variable
3) Write the full relevant equation
4) Plug in values **including units**
5) Solve for an answer (**including units**) and circle/box answer

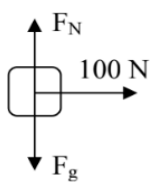
(Note: it is not necessary to show all of the mathematical steps involved in solving an equation)

Example of a full solution:

Ex) A 50 kg mass is subject to a horizontal force of 100 N on a frictionless surface. Determine the acceleration of the mass.

F = 100 N
m = 50 kg
a = ?

List of known and unknown variables



diagram

$\mathbf{F_{net} = ma}$ ← *Equation*

$\mathbf{100\ \mathit{N} = (50\ \mathit{kg})a}$ ← *Variables with units*

$\boxed{\mathbf{a = 2\ m/s^2}}$ ← *Boxed/circled answer with units*

Note: If you didn't remember the correct units for your variable (acceleration here), it is also acceptable to use dimensional analysis and determine equivalent units directly from the equation; for example in this question you could still receive full credit for:

a = 2 N/kg

Significant Figures

Significant figures (also known as significant digits or sig-figs) are the numbers in a value which are precisely known. Its importance can be understood with an example:

Billy is using a pair of calipers to determine the volume of a sphere ($V = 4/3\pi r^3$) for a physics lab. His calipers can only measure to the nearest millimeter. He measures the radius of the sphere to be 3.5 cm (35 mm) with his calipers. Then he calculates the volume of the sphere in a calculator, which outputs **179.59438 cm^3**. Billy shares this information with his lab group, who then use it in their calculations.

But what if the actual radius was 3.51 cm but Billy couldn't get that precision with his calipers? Using 3.51 cm, the volume would be calculated as **181.138 cm^3**. Clearly a different answer than before. For this reason, it would be incorrect to report an answer with that many digits, since most of them cannot be known precisely. He can only accurately report the volume to <u>two</u> significant figures (since he only measured 2 digits, 3.5) and so he would report that the volume is **180 cm^3**, as precise as he can get.

When you report a value based on measurements, it is understood by everyone reading it that you know that number to be precise, so you would essentially be lying if you didn't take significant figures into account.

On the AP Physics exam, you are expected to report your final answers on the free response with the correct number of significant figures. Failure to do so will lose you points. There are very specific rules for doing calculations with significant figures. Fortunately, the AP graders are not terribly strict with this and you can simply use the same number of sig figs as the given value that has the least amount. For example, if you were given the following values and asked to calculate a final velocity:

$v_0 = 3.55$ m/s → 3 sig figs   a = 2.0 m/s2 → **2 sig figs** $\Delta x = 2052$ m → 4 sig figs

Report your answer with 2 sig figs $v_f^2 = v_0^2 + 2(a)(\Delta x)$ **$v_f = 91$ m/s**

Rules for determining the number of significant figures:

Rule	**Example**	**# of sig figs**
All non-zero numbers are significant.	33,451	5
Any zeros in between non-zero numbers are significant.	7052	4
All zeros shown at the end of a number AND to the right of a decimal point are significant.	30.00	4
Zeros to the left of non-zero numbers in a number smaller than 1 are NOT significant.	0.000000000053	2
All zeroes to the left of a written decimal point are significant. If there is no decimal, they are not.	3000. 3000	4 1
Use scientific notation for clarity. If you can get rid of zeros and	0.0000034	2

write a number in scientific notation, they are NOT significant	3.4×10^{-6}	

Significant Figure Practice

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

246.3	____________	1.008	____________	70,000,000	____________
107.854	____________	0.00340	____________	350.670	____________
100.3	____________	14.600	____________	1.0000	____________
0.678	____________	0.0001	____________	320,001	____________

2. Convert the following numbers into scientific notation, and also indicate how many significant figures there are in each.

	Scientific Notation	# Sig. Figs
1) 5,690	____________________________	____________
2) 1,200,000	____________________________	____________
3) 832	____________________________	____________
4) 0.00459	____________________________	____________
5) 0.0000116	____________________________	____________
6) 3,200,000,000	____________________________	____________
7) 0.123	____________________________	____________
8) 103,000,000	____________________________	____________
9) 4.05	____________________________	____________
10) 0.093	____________________________	____________

Metric Conversions

Physics makes heavy use of the wonderfully simple metric system in which large and small numbers can be expressed with ease through use of a prefix. All of our variables (such as distance, acceleration, force, etc) may sometimes have metric prefixes. In order to use them in an equation, it is often best to convert it to the base unit without a prefix.

Express the following distances in terms of the base unit for distance, the meter. Express the answer in scientific notation if it is larger than 100 or smaller than 0.01. The first one has been done for you. Refer back to the metric system reference page if needed.

1) 65 km (kilo = 10^3 so…. 65 x 10^3 m = 6.5 x 10^4m)

2) 126 cm

3) 500 cm

4) 1,000 cm

5) 0.05 km

6) 0.10 km

7) 550 nm

8) 12 km

9) 3.8 nm

10) 84 mm

11) 2.1 Gm

12) 50 μm

13) 4000 nm

14) 50,000,000 pm

Algebraic Solutions

In AP Physics it is always helpful and often required to solve algebraic equations in the terms of variables, rather than with given values or numbers. This involves basic addition, subtraction, multiplication, and division of coefficients and variables as seen in the example below. Please solve each equation or expression for the desired coefficient. Doing this quickly and efficiently is a critical skill required for this class. It is very helpful to think of this process as "rearranging" an equation to make it more useful for a specific purpose. Do not worry if you have no idea what any of these equations mean, this is only a mathematical exercise.

Example) ***Solve for v***

$$\mathbf{a} = \frac{\mathbf{v^2}}{\mathbf{r}} \longrightarrow \boldsymbol{ra} = \boldsymbol{v^2} \longrightarrow \boxed{\boldsymbol{v} = \sqrt{\boldsymbol{ra}}}$$

Multiply both sides by 'r' *square root both sides*

Note: It is not necessary to show your mathematical work or to explain in words what you did. You only need to show the individual steps you took to arrive at your final expression.

Problems:

1) Solve for v

$$\frac{1}{2}\mathbf{mv^2} = \boldsymbol{mgh}$$

---

2) Solve for a

$$\mathbf{v_f}^2 = \mathbf{v_0}^2 + \mathbf{2(a)(\Delta x)}$$

---

3) Solve for x

$$\frac{1}{2}\mathbf{kx^2} = \frac{1}{2}\mathbf{mv^2}$$

---

4) Solve for Θ_2

$$\boldsymbol{n_1}\,\mathbf{sin}(\boldsymbol{\theta_1}) = \boldsymbol{n_2}\,\mathbf{sin}(\boldsymbol{\theta_2})$$

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5) Solve for $\boldsymbol{T_2}$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

6) Solve for $\boldsymbol{v}$

$$\frac{\mathbf{GMm}}{\mathbf{r^2}} = \frac{\mathbf{Mv^2}}{\mathbf{r}}$$

7) Solve for $\boldsymbol{r}$ in terms of ONLY **B, L, 2π, F_B, μ_0**. (In other words, you cannot have an **I** in your expression).

$$F_B = BIL$$

$$B = \frac{\mu_0 I}{2\pi r}$$

---

8) Solve for $\boldsymbol{g}$

$$T = 2\pi\sqrt{\frac{L}{g}}$$

---

9) Solve for $\boldsymbol{v_f}$

$$m_1 v_1 + m_2 v_2 = m_1 v_f + m_2 v_f$$

---

10) Solve for $\boldsymbol{x}$

$$m_1(x) = m_2(3 - x)$$

---

11) Solve for ***r***

$$\frac{m_1 v^2}{r} = m_2 g h$$

12) Solve for **F_A** in terms of ***m, g,*** and ***θ***.   (You cannot have a T in your expression)

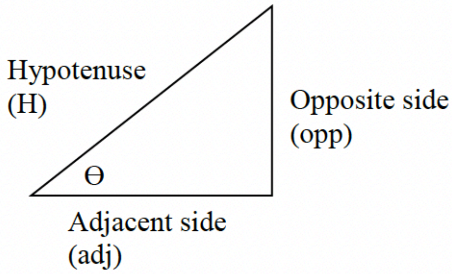
$$T\sin(\theta) = F_A$$

$$T\cos(\theta) = mg$$

Right Triangle Trigonometry

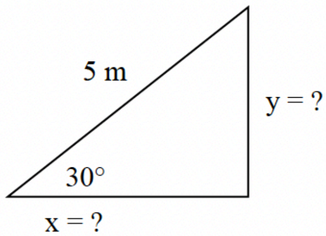
(Calculator Allowed)

Since many chapters in this course deal with two dimensions, it is crucial that you can break vectors into their horizontal (left-right) and vertical (up-down) components with ease. This means using basic trigonometry (SOH CAH TOA). However, it is often more useful to just memorize the results of using SOH CAH TOA (see below) to determine the sides of a right triangle. **The side opposite the given angle is always H·sin(Θ) and the side adjacent to the given angle is always H·cos(Θ)** (where H is the hypotenuse).



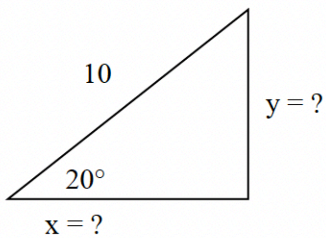
Opp = H·sin(Θ)

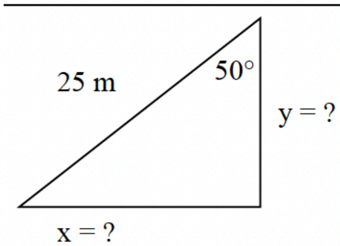
Adj = H·cos(Θ)

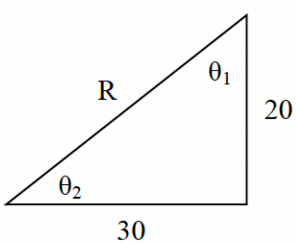


y = 5sin(30) = 2.5 m

x = 5cos(30) = 4.33 m







Determine the magnitudes of θ_1, θ_2, and R.

Proportionality

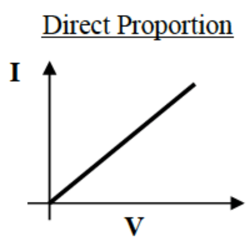
Understanding proportionality can be extremely helpful in AP Physics. When two values are ***proportional***, that means that as one increases, so does the other. When two values are ***inversely proportional***, that means as one increases, the other decreases. Ohm's law, when rearranged for current, shows both of these clearly.

$$I = \frac{V}{R}$$

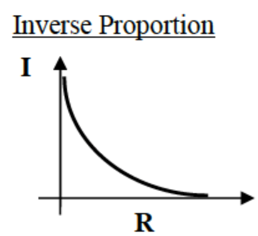
Current (I) is ***proportional*** to voltage (V). As voltage increases, so does current. Current (I) is ***inversely proportional*** to resistance (R). As R increases, I decreases. A ***constant of proportionality*** is any number included in an equation that is NOT a variable (doesn't change, is constant). There is no C.o.P. in the example to the above.

Graphs of Proportionality

If you were to plot a directly proportional relationship, such as I vs. V, you would see a trend like the one below on the left (notice how the line passes through the origin, if there is 0 voltage there must also be 0 current). If you were to plot an inversely proportional relationship, such as I vs. R, you would see a trend like the one on the right (notice how it approaches infinity and zero as R becomes very small or large respectively).



$$I = \frac{V}{R}$$

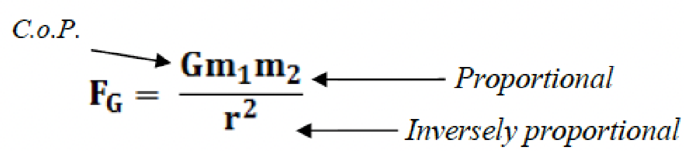


A slightly more complicated example of proportionality…

Newton's law of Gravitation is stated as follows:

> "The gravitational force (F_G) between any two masses (m_1 and m_2) is directly proportional to the mass of both objects, and is inversely proportional to the square of the distance between the masses (r)." The constant of proportionality is the "universal gravitational constant" ($G = 6.67 \times 10^{-11}$ Nm^2/kg^2).

In equation form, this looks like:



Proportionality Practice Problems

Write an equation based on the stated proportionality of the given law.
(It's OK if you have no idea what some of these laws mean… this is just a mathematical exercise)

1) The capacitance (C) of a parallel plate capacitor is directly proportional to the charge (Q) stored on the plates and is inversely proportional to the voltage (V) across the plates.

Write an equation for capacitance (C) in terms of voltage (V) and charge (Q).

2) The force (F) needed to stretch a spring is directly proportional to both the stiffness of the spring (k) and the distance (x) that it is stretched.

Write an equation for the force (F) needed to stretch a spring.

3) The power (P) dissipated in a circuit element is proportional to the square of the voltage (V) across the element and inversely proportional to the resistance (R) of the element.

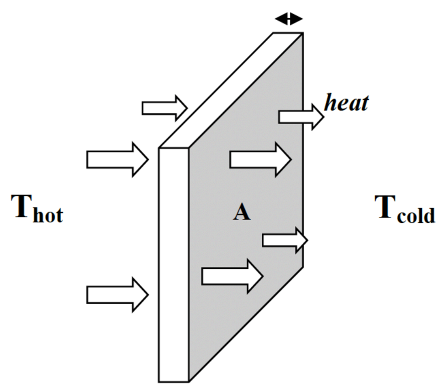
Write an equation for the power (P) dissipated in a circuit element in terms of voltage and resistance.

4) The period (T) of an oscillator is inversely proportional to the frequency (f) of the oscillator.

Write the equation for the period of an oscillator in terms of frequency.

5) The rate of heat transfer (H) through a rectangular slab of material (seen below) is proportional to the temperature difference (ΔT) from end to end of the slab, the cross sectional area (A) of the slab, and the thermal conductivity of the material (k). It is inversely proportional to the length of the slab (L) that the heat must travel through.

Write the equation for the rate of heat transfer (H) through a slab of material.



Mathematical Relationships and Graphs

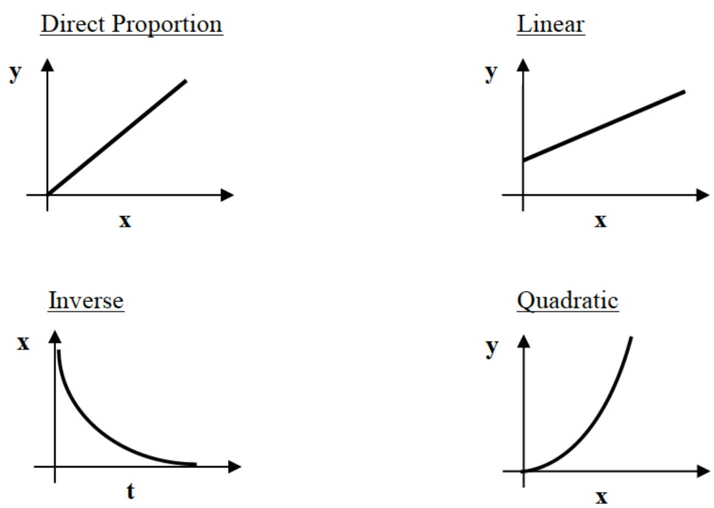
A **direct proportion** is a function whose graph is a non-horizontal line that passes through the origin. (y = kx; k is the constant of proportionality and is *the slope of the graph*.)

A **linear** function has a graph that is a non-horizontal line.
(y = mx + b; m is the slope of the line and b is the y-intercept. A direct proportion is a special case of a linear function, where b = 0)

A **quadratic** function has a graph that is a parabola.
(When y is proportional to x^2, the graph goes through the origin and has a slope that increases as x increases. $y = ax^2 + bx + c$)

An **inverse** relation has a graph that is a hyperbola (in the first quadrant).
(When y is proportional to 1/x, the graph is asymptotic to the x and y axes. $y = k/x$)

<u>Graphs:</u>



<u>Graphing</u>

Graphing and analyzing data is a critical component of physics. You will do this for almost every single lab, and there will be numerous questions asking you to analyze graphs.

You should be familiar with constructing graphs both by hand and on a calculator.

Keep in mind:

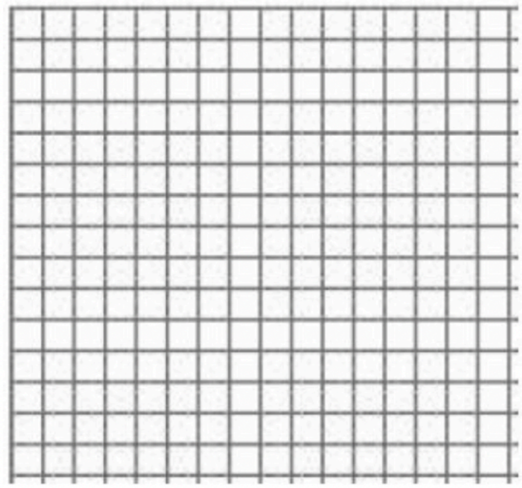
1) When told to graph *Apples vs. Oranges*, the first thing (*apples*) goes on the Y-axis.
2) Label both axes with units.

3) Choose an appropriate scale on your own, fit it to the graph (don't cram your data into a corner)

Problems

1) Plot *Distance vs. Time* from the data below (*remember, distance = y-axis*). Draw a **best fit** straight line through the points. Calculate the slope of this **best fit line.**

Time (s)	Distance (m)
0	2.0
1	4.1
2	5.8
3	7.9
4	10.1



a) Determine the slope of the best fit line.

b) What type of relationship is this? Explain.

c) Describe the motion of this object. (Is it accelerating? Constant velocity? Something else?)

2) Use the equation $K = \frac{1}{2}mv^2$ to first calculate the kinetic energy of objects of different speeds, all with a mass of 1 kg. Then graph *Kinetic Energy (y-axis) vs. Velocity (x –axis)* on graph on the left.

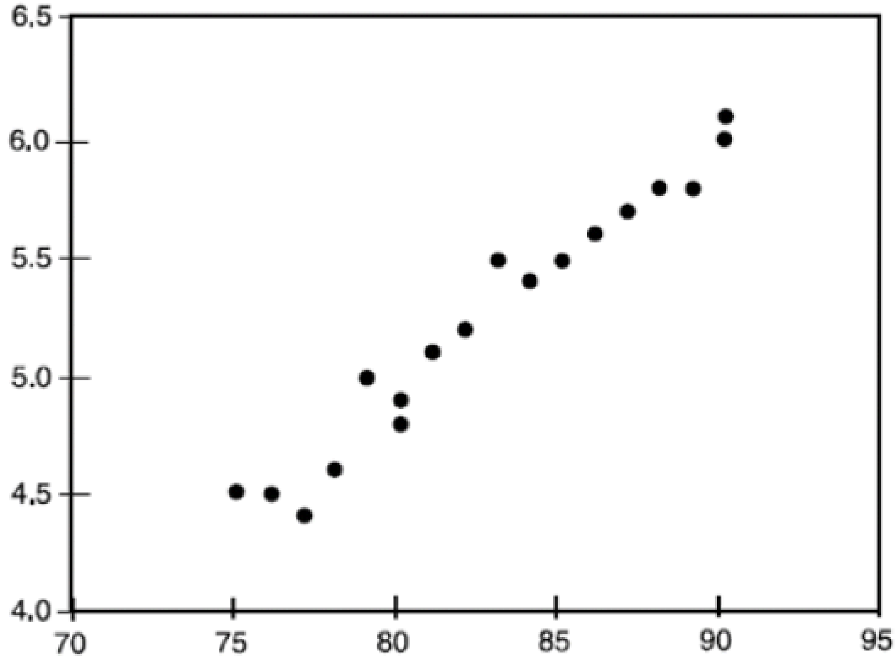
Next, calculate v^2 by squaring each value for velocity. On the graph on the right, graph Kinetic Energy vs. v^2. Remember to title each graph and label the axes, including units!

v (*m/s*)	v^2 (*m^2/s^2*)	Mass (*kg*)	K (*Joules*)
1.0		1.0	
2.0		1.0	
3.0		1.0	
4.0		1.0	
5.0		1.0	
6.0		1.0	

a) Draw a best fit *line* OR *curve* depending on your graph. (is it linear or curved?)

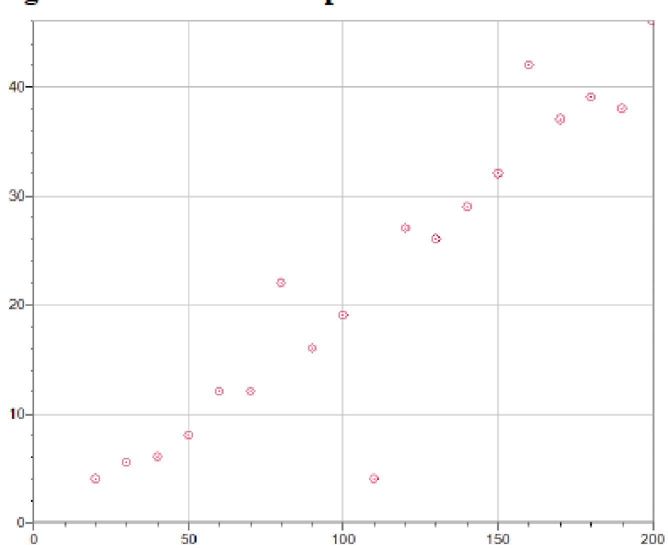
b) What conclusion can you make about the relationship between kinetic energy and velocity from these two graphs? (i.e. what is kinetic energy proportional to?)

3a) Draw a best fit straight line for the scatter plot below.



3b) Determine the equation of your best fit line in slope-intercept form.

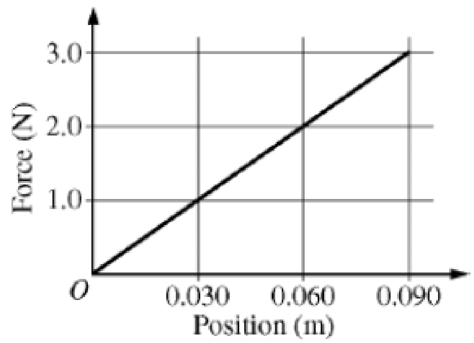
4a) Draw a best fit straight line for the scatter plot below.



4b) Determine the equation of your best fit line in slope-intercept form.

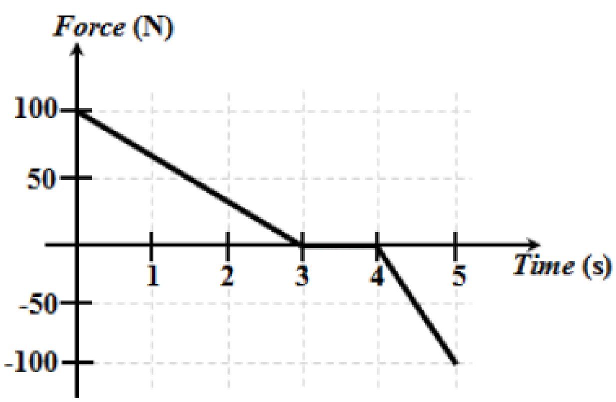
5) Determine the total *area under the curve* (the area enclosed by the curve and the x-axis) for each of the following graphs. Be sure to take into account *negative area* when a portion of a line is in a negative quadrant. You may mark your final answer as "*A* = ______".

a)



b)

c)



d)