Name_______________________________________

AP PHYSICS SUMMER WORK

For both AP Physics I and II

AP Physics 1 Curriculum

- **Kinematics**
- **Linear Dynamics (Newton's Laws, momentum, oscillations)**
- **Rotational Dynamics**
- **Energy, Work, and Power**
- **Mechanical Waves and Sound**
- **Intro to Electric Circuits**

Welcome to AP Physics! This summer work must be completed by anyone who is taking an AP Physics course for the first time. If you have already taken AP Physics 1 and will be taking AP-2 next year, then you do not have any summer work. While I will **not** grade everyone's packet for correctness, there will be a **quiz on this material on the *second* day of class** (we will review problems on the first day). 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
- Basic kinematics
- Proportionality and graphing

Notice how most of these are mathematics topics. Since honors physics 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, remember that a digital copy will be available on the Conrad website in the AP Summer Work folder.

If you feel that you do not have the ability to complete this work, then you need to speak to me in person (Do not drop this course without speaking to me first). AP Physics is a difficult course and it is important that you get off to a good start.

If you have *any* questions please feel free to email me at john.castellaneta@redclay.k12.de.us

AP Physics 1 Summer Assignment

Read all information carefully and complete all problems. You must show your 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 become so. 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 this on the board: μ 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

<u>**Answers and Solutions**</u>

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:

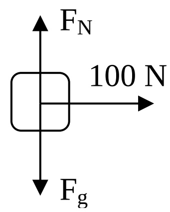
1) Draw a diagram if needed
2) List given variables on far left, include unknown variable
3) Write the full relevant equation.
4) Plug in values **including units.**
5) Solve for an answer (**including units**) and circle/box answer.
   (Note: it is not necessary to show all of the mathematical steps involved in solving an equation)

<u>Example of a full solution:</u>

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*

100 *N* = (50 *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

You will need to use this process later in this packet…

<u>**Significant Figures**</u>

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 ($V = \frac{4}{3}\pi r^3$) 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 that precisely. He can only accurately report the volume to two 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 $\longrightarrow$ 3 sig figs

$a = 2.0$ m/s^2 $\longrightarrow$ **2 sig figs** $\longrightarrow$ **Report your answer with 2 sig figs**

$\Delta x = 2052$ m $\longrightarrow$ 4 sig figs

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

$$\mathbf{v_f = 91\ m/s}$$

So all we really need to be able to do is determine the **total number** of sig figs.

<u>**Rules for determining the number of sig. figs:**</u>

Rule	Example	# of sig figs
1) All non-zero numbers are significant.	33,451	5
2) Any zeros in between non-zero numbers are significant.	7052	4
3) All zeros shown at the end of a number AND to the right of a decimal point are significant.	30.00	4
4) Zeros to the left of non-zero numbers in a number smaller than one are NOT significant.	0.0000000053	2
5) All zeros 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 write a number in sci. notation, they are NOT significant.	0.0000034 = 3.4×10^{-6}	2

Significant Figure Practice:

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

246.32	________	1.008	________	700000	________
107.854	________	0.00340	________	350.670	________
100.3	________	14.600	________	1.0000	________
0.678	________	0.0001	________	320001	________

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.

Kilo = 10^3 so…

1) 65 km --------> 65×10^3 m = $\boxed{6.5 \times 10^4 \text{ m}}$

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

(For help see <http://www.khanacademy.org/math/algebra/solving-linear-equations-and-inequalities>)

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***

$$\mathbf{a} = \frac{\mathbf{v}^2}{\mathbf{r}} \xrightarrow{\text{Multiply both sides by 'r'}} \boldsymbol{ra} = \boldsymbol{v}^2 \xrightarrow{\text{square root both sides}} \boxed{\boldsymbol{v} = \sqrt{\boldsymbol{ra}}}$$

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

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

---

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

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

---

5) Solve for $\boldsymbol{T_2}$

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

---

6) Solve for $\boldsymbol{v}$

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

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

$$\boldsymbol{F_B = BIL}$$

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

---

8) Solve for ***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 ***x***

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

---

11) Solve for ***r***

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

---

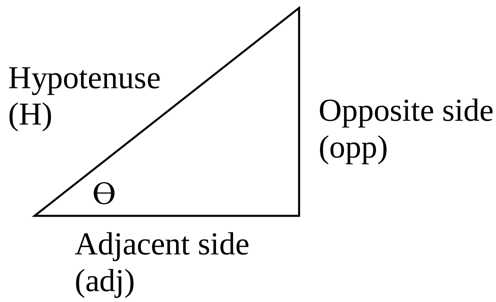
12) Solve for $\mathbf{F_A}$ in terms of ***m, g,*** and ***θ***.   (You cannot have a T in your expression)

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

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

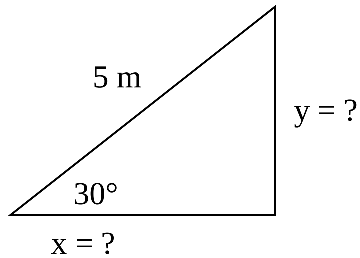
Right Triangle Trigonometry
(Calculator allowed)

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).



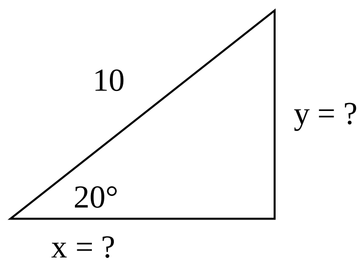
$$\textbf{Opp} = \textbf{H}\cdot\textbf{sin}(\Theta)$$

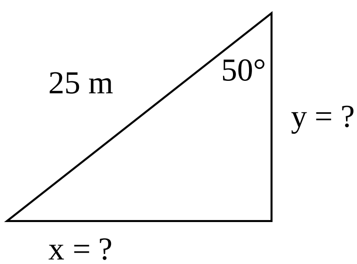
$$\textbf{Adj} = \textbf{H}\cdot\textbf{cos}(\Theta)$$

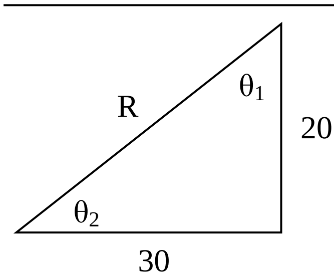


$y = 5\sin(30) = 2.5$ m

$x = 5\cos(30) = 4.33$ m







Determine the magnitudes of θ_1, θ_2, and R.

Basic Kinematics

Everyone in AP-Physics 1 should walk into class with a good understanding of a basic *kinematics*, which in physics is the study of *motion*. Watch the Khan Academy videos below and answer the questions that follow, using proper solutions. Even if you've taken physics before, the following videos are still required. Believe it or not, none of you are experts on kinematics. This is a good practice for what's called a *flipped classroom*, where you learn content at home using video lessons and text, and then put that learning to use in the classroom. We will do this occasionally throughout the year.

As you are watching, keep in mind that the KA videos sometimes use slightly different variables than we will be using. The variables we will use for kinematics are listed below.

x = x-axis position (horizontal position)
y = y-axis position (vertical position)
Δx or Δy = change in position a.k.a. displacement
v_0 = initial velocity (pronounced *v-nought*, as in "velocity at time $t = 0s$")
v = final velocity, velocity after some amount of time
a = acceleration

Khan Academy Videos

Go to:
https://www.khanacademy.org/science/physics/one-dimensional-motion

Watch:

1) Displacement, velocity, and time
- **Introduction to vectors and scalars**
- **Calculating average velocity or speed**
- **Solving for time**
- **Displacement from time and velocity example**
- **Instantaneous speed and velocity**

2) Acceleration
- **Acceleration**
- **Airbus A380 take-off time**
- **Airbus A380 take-off distance**
- **Why distance is area under velocity-time line**

3) Kinematic Formulas and Projectile Motion
- **Average velocity for constant acceleration**
- **Acceleration of aircraft carrier takeoff**
- **Deriving displacement as a function of time, acceleration, and initial velocity**
- **Plotting projectile displacement, acceleration, and velocity**

Once you have watched these videos, solve the basic kinematics problems on the next page. Remember to write full solutions to your problems as explained earlier in this packet. The first problem has been done for you. **Some kinematics equations have been provided for you below.**

Constant Velocity
(only applies for NO acceleration)

$$\mathbf{v} = \frac{\Delta \mathbf{x}}{\mathbf{t}}$$

Constant Acceleration

$$\mathbf{a} = \frac{\Delta \mathbf{v}}{\mathbf{t}}$$

$$\mathbf{v_f} = \mathbf{v_0} + \mathbf{at}$$

$$\Delta \mathbf{x} = \mathbf{v_0 t} + \frac{1}{2}\mathbf{at^2}$$

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

Basic Kinematics Problems

1) A car begins from rest and accelerates at a rate of 5 m/s^2 for 6 seconds.
What is the cars final velocity?

$v_o = 0\ m/s$ (starts from rest)

$a = 5\ m/s^2$

$t = 6\ s$

$v_f = ?$

$v_f = v_o + at$

$v_f = 0 + (5 m/s^2)(6 s)$

$\boxed{v_f = 30\ m/s}$

2) A truck travelling at 30 m/s slams on the breaks and comes to a stop after 7 seconds.

a) What is the value of the truck's acceleration? Is it positive or negative?

b) How far did the truck travel in this time?

3) A 7000 kg train car moving at 5 m/s accelerates at a constant rate of 1 m/s^2 for 15 seconds. How far does the train car travel in this time?

4) A car is travelling at a constant speed of 30 m/s. How long does it take it to travel 110 meters?

5) A car travelling 25 m/s on a highway accelerates to 35 m/s over a time period of 11 seconds. How far does it travel in this time?

6) You are driving along I-95 at 30 m/s when you decide to pass the slow elderly driver in front of you. You change lanes and accelerate at 3.5 m/s^2 for 5 seconds. What is your final velocity after 5 seconds?

7) A baseball is thrown straight up into the air with an initial velocity of 15 m/s.

a) What maximum height will it reach?

b) How long will it be in the air before it returns to the height it was thrown?

8) A car is travelling with an unknown initial velocity. For a brief period of time, the car accelerates with an acceleration of a = ☺. During this time, the car experiences a displacement '♓' and ends up with a final velocity of 'Φ'.
Write an equation for the initial velocity 'v_0' of the car in terms of ☺, ♓, and Φ.

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.

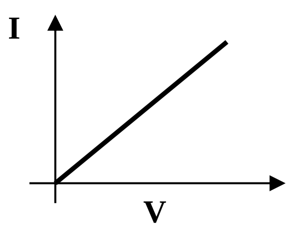
$$\boxed{I = \frac{V}{R}}$$

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 left.

Graphs of Proportionality

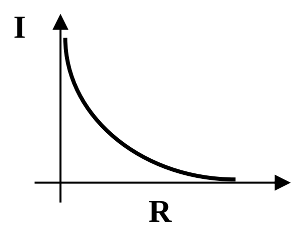
If you were to plot a directly proportional relationship, such as I vs. V, you would see a trend like the one below on the left (notice how the line passes through the origin, if there is 0 voltage there must also be 0 current). If you were to plot an inversely proportional relationship, such as I vs. 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).

Direct Proportion



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

Inverse Proportion



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:

C.o.P.

$$F_G = \frac{Gm_1m_2}{r^2}$$

Proportional

Inversely proportional

<u>Proportionality Practice Problems</u>

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)

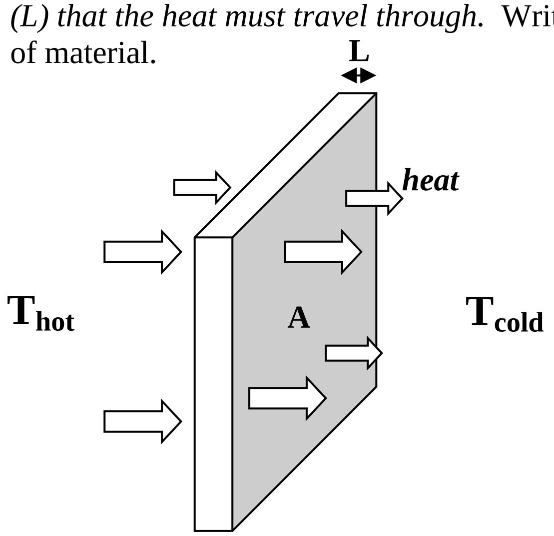
1) *The capacitance (C) of a parallel plate capacitor is directly proportional to the charge (Q) stored on the plates and is inversely proportional to the voltage (V) across the plates.* Write an equation for capacitance (C) in terms of voltage (V) and charge (Q).

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 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.**

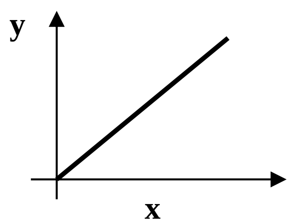
A **linear** function has a graph that is a non-horizontal line. **$y = mx + b$; m is the slope of the line and b is the y-intercept.** A direct proportion is a special case of a linear function, where b = 0.

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. **$y = ax^2 + bx + c$**

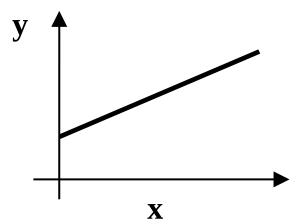
An **inverse** relation has a graph that is a hyperbola (in the first quadrant). When y is proportional to 1/x, the graph is asymptotic to the x and y axes. **$y = k/x$**

Graphs:

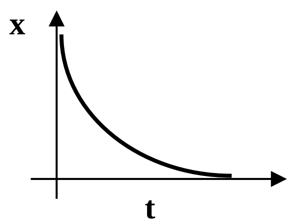
Direct Proportion



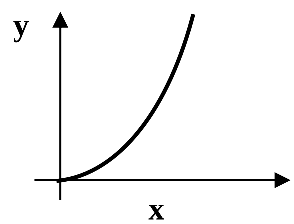
Linear



Inverse



Quadratic



Identify the variable relationships.

1. *$F = -kx$, (F vs. x) This function is ________________________________. K represents the __________________________ of the graph.*
2. *$U = mgh$, (U vs. h) This function is ________________________________. mg represents the __________________________ of the graph*
3. *$x = ½ at^2$ (x vs. t) This function is ________________________________. Its graph will look like ____. If x is graphed vs. t^2 the slope will be __________________________.*
4. *$a=F/m$ (a vs. m). This function is _____________________________________. Its graph will look like ____.*

Graphing

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.

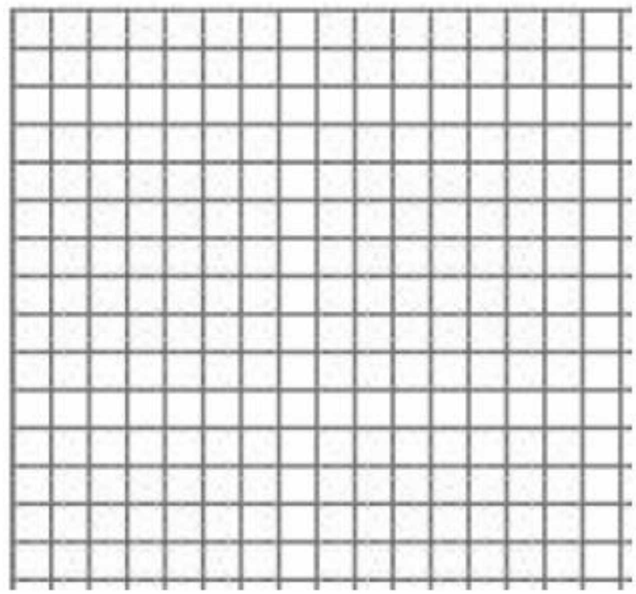
You should be familiar with constructing graphs both by hand and on a calculator.
Keep in mind:

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.

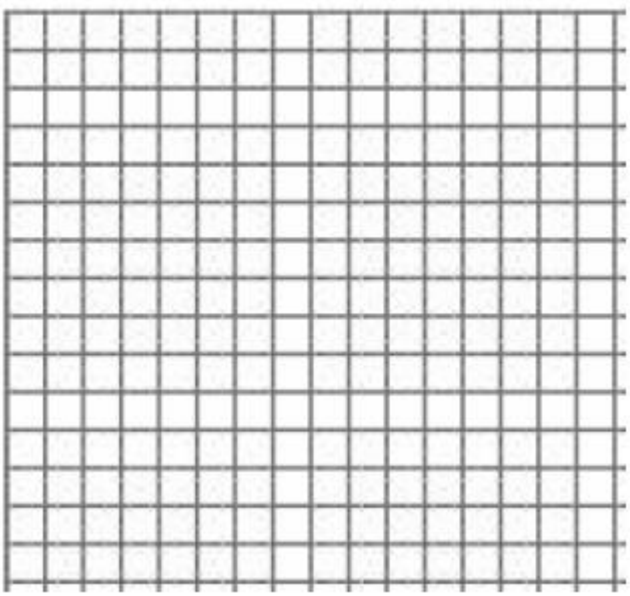
b) What type of relationship is this? Explain.

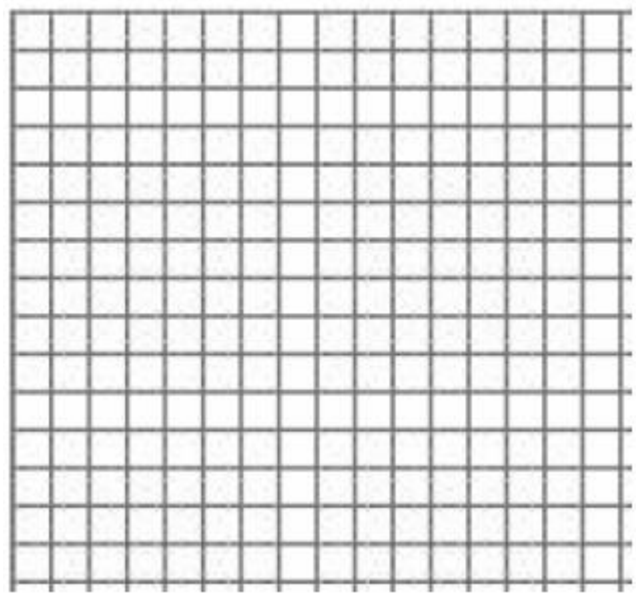
c) Describe the motion of this object. (Is it accelerating? Constant velocity? Something else?)

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	

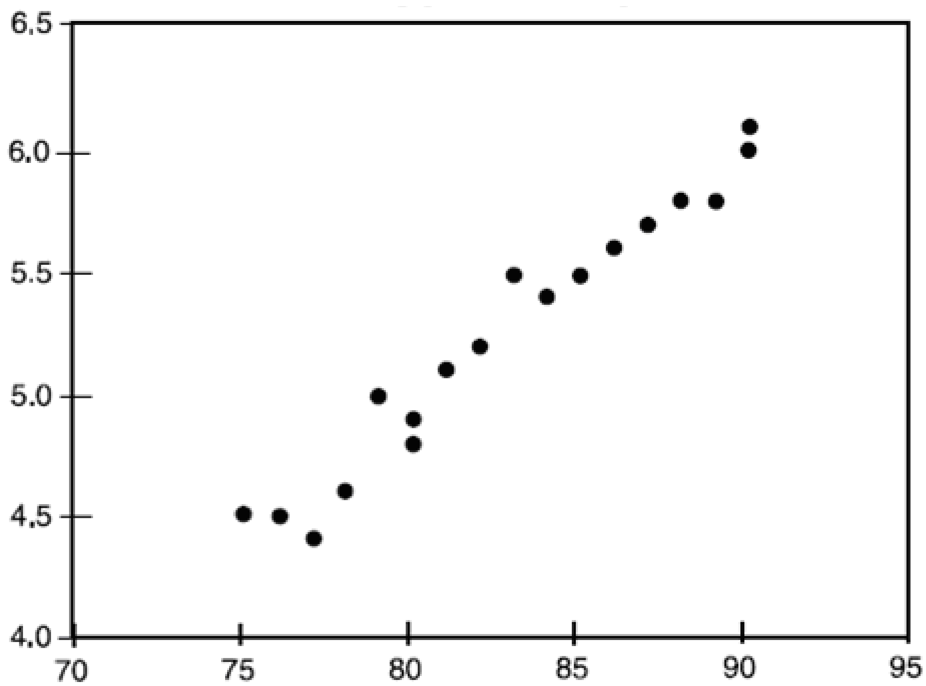




a) Draw a best fit *line* OR *curve* depending on your graph. (is it linear or curved?)

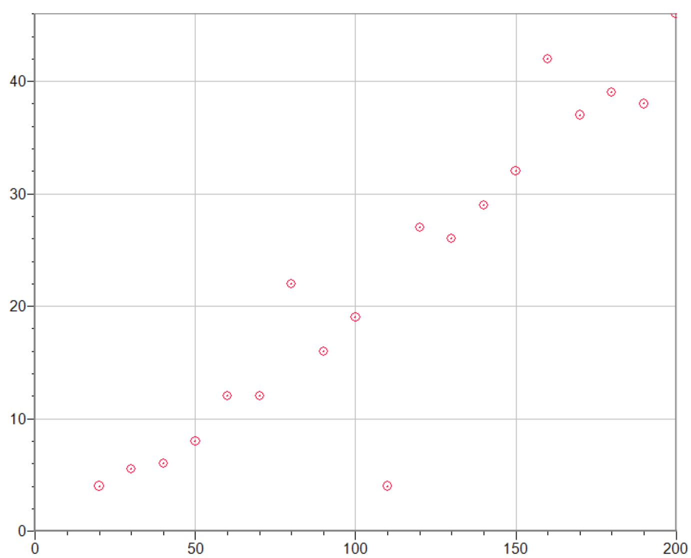
b) What conclusion can you make about the relationship between kinetic energy and velocity from these two graphs? (i.e. what is kinetic energy proportional to?)

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.

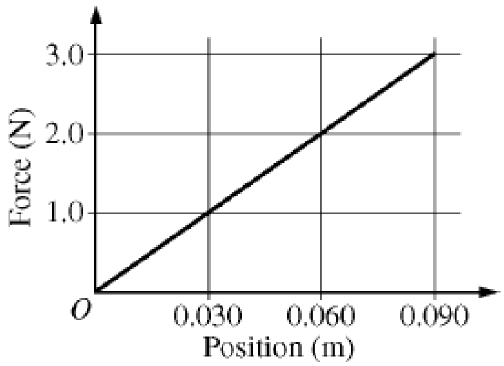
4a) Draw a best fit straight line for the scatter plot below.



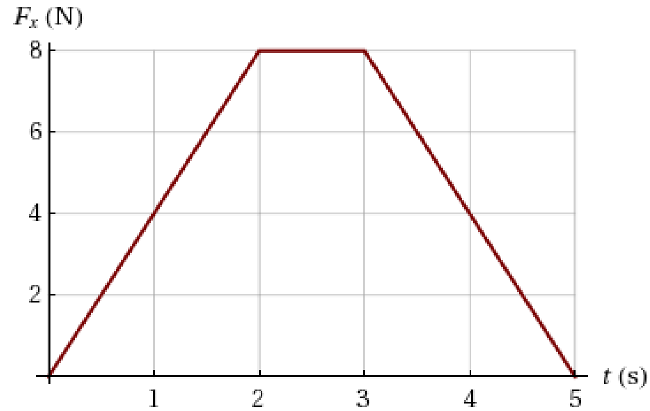
4b) Determine the equation of your best fit line in slope-intercept form.

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* = ______".

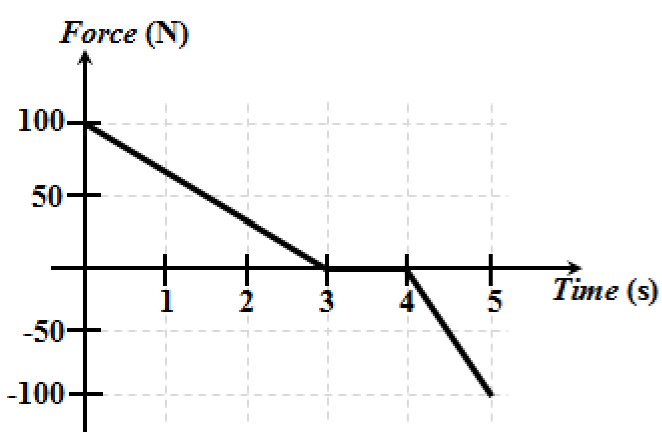
a)



b)



c)



d)