Name____

Welcome to AP/ECE Physics2!

This summer work must be completed by anyone who is taking an AP /ECE Physics 2. While I will **not** grade everyone's packet for correctness, there will be a **quiz on this material the first week of class** (we will review problems on the first or second day).

The quiz is to identify areas to focus on early in the course – don't worry about it being a big grade issue. The quiz will include the following topics, each of which has its own section in this packet.

- Metric conversions and Scientific Notation
- Solving algebraic equations
- Right triangle trigonometry
- Basic kinematics
- Proportionality and graphing

Much of this packet is reference material and important reading.

*****If you are weak in any areas, then we will focus on these strongly during the beginning month of the year. You can and will succeed at this class! Deep Breaths! Remember. Physics is Phun.

If you have *any* questions please feel free to email me over the summer at fislerr@region18.org.I have no life and live to serve. (HAHA!)

AP Physics 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

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:

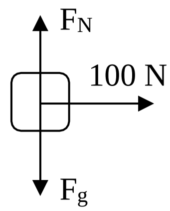
1) Draw a diagram if needed
2) List given variables on far left, include unknown variable
3) Write the full relevant equation.
4) Plug in values **including units.**
5) Solve for an answer (**including units**) and circle/box answer.
(Note: it is not necessary to show all of the mathematical steps involved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

You will need to use this process later in this packet

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 x 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:

$$a = \frac{v^2}{r}$$

multiply both sides by r: $ar = v^2$

Take square root of both sides: $v = \sqrt{ar}$

Problems:

1) Solve for v

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

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2) Solve for a

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

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3) Solve for x

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

4) Solve for Θ_2

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

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 ***g***

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

8) Solve for $\boldsymbol{v_f}$

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

9) Solve for ***x***

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

10) Solve for ***r***

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

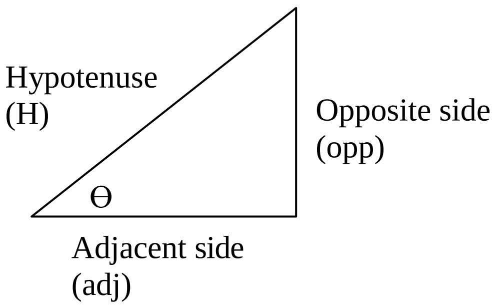
11) Solve for $\mathbf{F_A}$ in terms of ***m, g,*** and $\boldsymbol{\theta}$. (You cannot have a T in your expression)

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

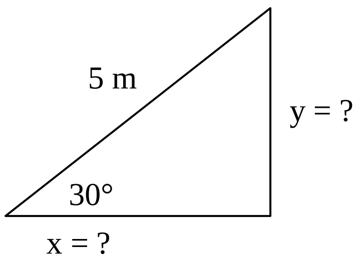
$$T\cos(\theta) = mg$$

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).

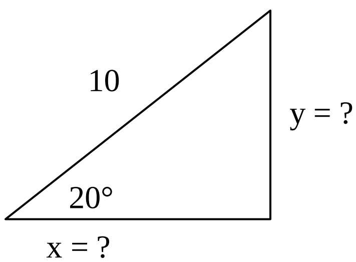


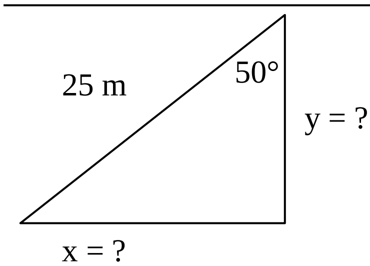
$$\boxed{\begin{aligned} \mathbf{Opp} &= \mathbf{H \cdot \sin(\Theta)} \\ \mathbf{Adj} &= \mathbf{H \cdot \cos(\Theta)} \end{aligned}}$$

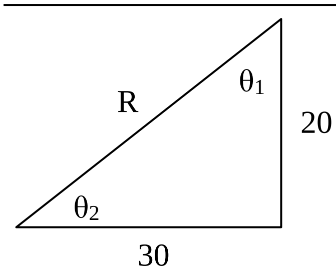


y = 5sin(30) = 2.5 m

x = 5cos(30) = 4.33 m







Determine the magnitudes of θ_1, θ_2, and R.

Basic Kinematics

Everyone in AP-Physics 2 should walk into class with a good understanding of a basic *kinematics*, which in physics is the study of *motion*.
The study of fluids, gasses charged particles in an electric field, charged particles in a magnetic field and subatomic particles, all required a basic knowledge of kinematics.

Watch the Khan Academy videos below (if needed) and answer the questions that follow, using proper solutions..

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 (ONLY IF NEEDED):

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)

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

Constant Acceleration

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

$$v_f = v_0 + at$$

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

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

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?

$v_0 = 0\ m/s$ *(starts from rest)*
$a = 5\ m/s^2$
$t = 6\ s$
$v_f = ?$

$v_f = v_0 + at$

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

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

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 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?

6) A ball is thrown horizontally off a cliff h meters high with a velocity of v0. Solve for the distance from the cliff the ball lands in terms of h, v0 and g.

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.

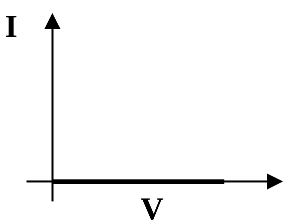
$$\boxed{I = \frac{V}{R}}$$

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 (C.o.P)*** 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

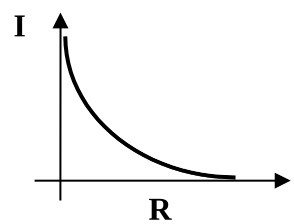
If you were to plot a directly proportional relationship, such as I vs. V, you would see a trend like the one below on the left (notice how the line passes through the origin, if there is 0 voltage there must also be 0 current). If you were to plot an inversely proportional relationship, such as I vs.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

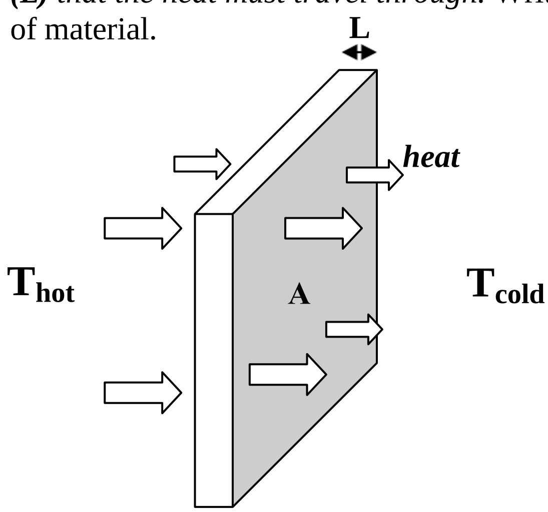
1) *The capacitance (C) of a parallel plate capacitor is directly proportional to the charge (Q) stored on the plates and is inversely proportional to the voltage (V) across the plates.* Write an equation for capacitance (C) in terms of voltage (V) and charge (Q).

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.**

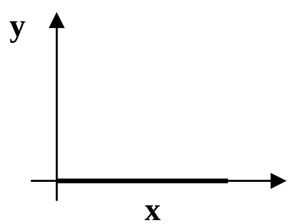
A **linear** function has a graph that is a non-horizontal line. **y = mx + b; m is the slope of the line and b is the y-intercept.** A direct proportion is a special case of a linear function, where b = 0.

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

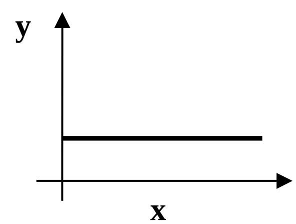
An **inverse** relation has a graph that is a hyperbola (in the first quadrant). When y is proportional to 1/x, the graph is asymptotic to the x and y axes. **y = k/x**

Graphs:

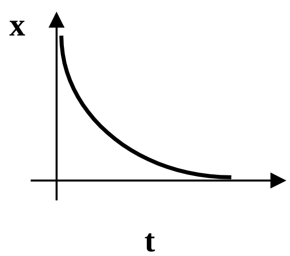
Direct Proportion



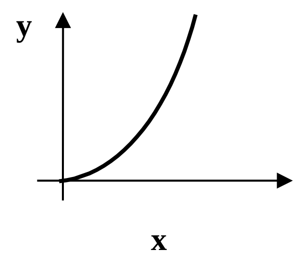
Linear



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 ____.*

<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.

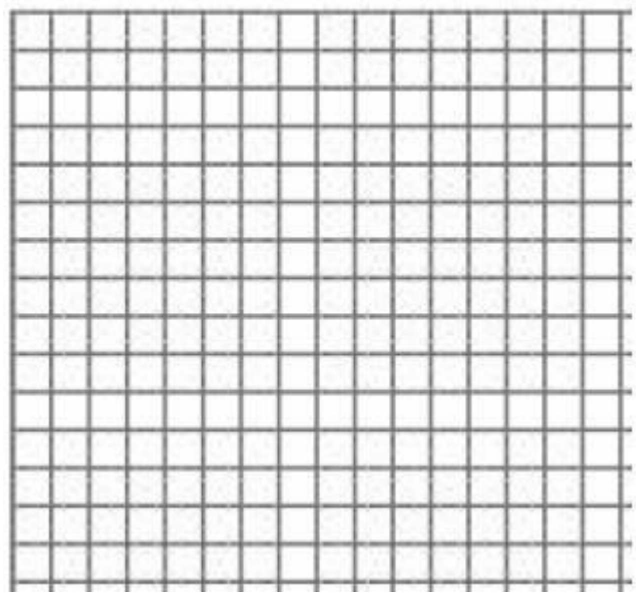
You should be familiar with constructing graphs both by hand and on a calculator.
Keep in mind:

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)

<u>Problems</u>

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

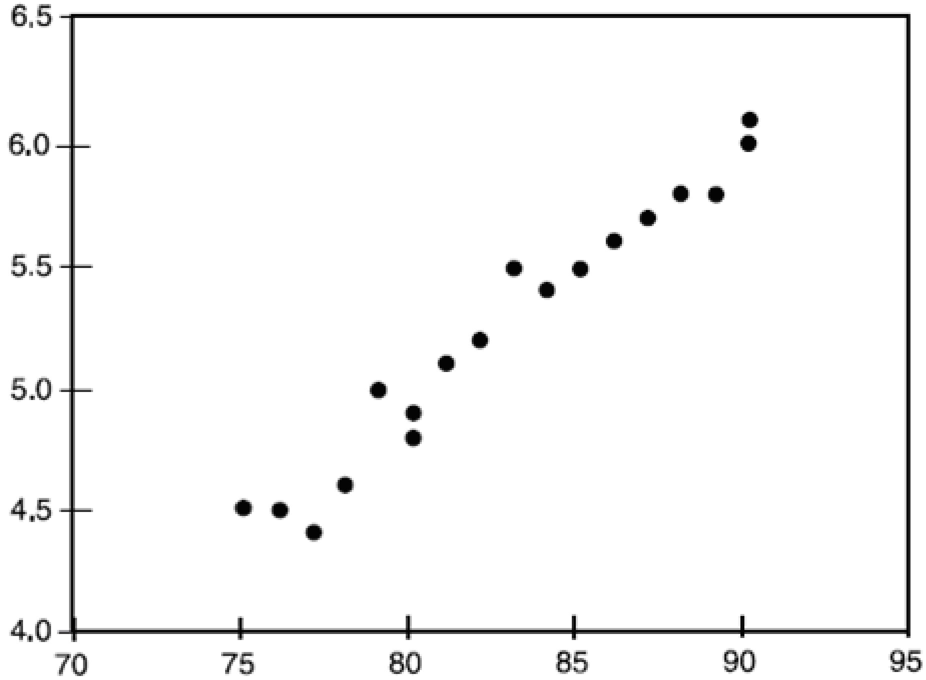


a) Determine the slope of the best fit line.

b) What type of relationship is this? Explain.

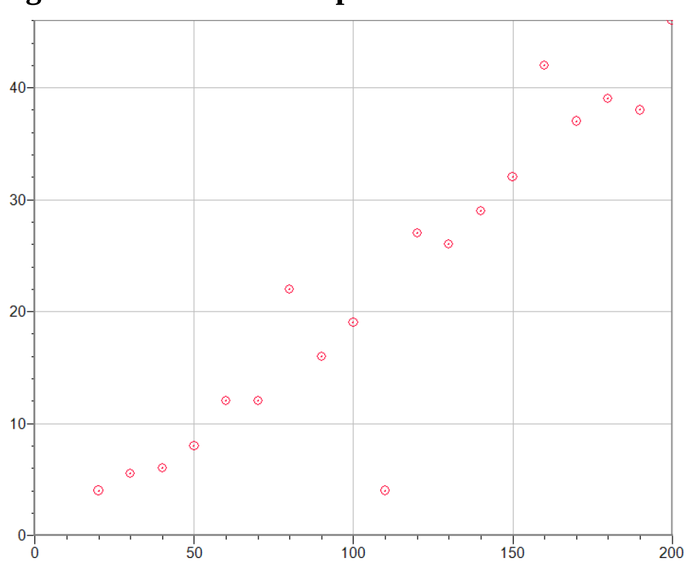
c) Describe the motion of this object. (Is it accelerating? Constant velocity? Something else?)

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



3b) Determine the equation of your best fit line in y=mx+b form.

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



4b) Determine the equation of your best fit line in y=mx+b form