Name: Hour:

AP Physics 1: Summer Assignment

2024-2025 School Year

Purpose: This summer assignment is to intended to help you to become familiar with the basic math skills required to be successful in AP Physics 1. Failure to work through this summer assignment will put you at a disadvantage throughout the year. Your focus should be to understand the material in this handout, not to rush through and complete this assignment.

For additional support on each section, please reference the following links:

1) **Algebra**
   - a. https://www.khanacademy.org/math/algebra-home
     - i. Or Google 'Khan Academy Algebra'
   - b. https://ocw.mit.edu/courses/18-701-algebra-i-fall-2010/
     - i. Or Google ' MIT Algebra'
2) **Trigonometry**
   - a. https://www.khanacademy.org/math/trigonometry
     - i. Or Google ' Khan Academy Trigonometry'
   - b. https://math.libretexts.org/Courses/Fullerton_College/Math_100%3A_Liberal_Arts_Math_(Claassen_and_Ikeda)/02%3A_Geometry/2.10%3A_Right_Triangle_Trigonometry
     - i. Or Google ' Libretexts Right Tirangle Trigonometry;
3) **Vectors:**
   - a. https://www.khanacademy.org/math/precalculus/x9e81a4f98389efdf:vectors
     - i. Or Google ' Khan Academy Vectors'
   - b. https://brilliant.org/courses/vectors/
     - i. Or Google ' Brilliant Vectors'
4) **Interpreting Graphs:**
   - a. https://www.khanacademy.org/math/algebra/x2f8bb11595b61c86:linear-equations-graphs/x2f8bb11595b61c86:slope/e/slope-from-a-graph
     - i. Or Google ' Khan Academy Solpe of Graph'
   - b. https://www.physicsclassroom.com/class/1DKin/Lesson-4/Determining-the-Area-on-a-v-t-Graph
     - i. Or Google 'The Physics Classroom Determining the Area on a vt graph'
5) **Mathematical Models – Understanding and Creating Graphs**
   - a. https://science.clemson.edu/physics/labs/tutorials/graph/index.html
     - i. Or Google ' Clemson Physics Graphs'
   - b. https://phys.libretexts.org/Courses/University_of_California_Davis/UCD%3A_Physics_9HA__Classical_Mechanics/1%3A_Motion/1.5%3A_Graphing
     - i. Or Google ' LibreText Physics Graphing'
6) **Graph Linearization:**
   - a. https://quarknet.org/content/how-linearize-curved-data-plot
     - i. Or Google 'Quarknet Linearize Curved Data'

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1) Algebra:

Directions: Using the provided equations, solve for the unknown using basic algebra concepts. ***SHOW ALL STEPS!***

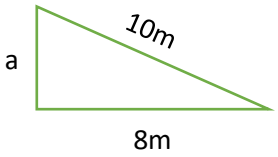
- $v_x = v_{xo} + at$ *(solve for a)*
- $U_g = -\frac{Gm_1m_2}{r}$ $(solve\ of\ m_1)$
- $d = \frac{1}{2}at^2$ *(solve for t)*
- $\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$ *(solve for α)*
- $\sin\theta = \frac{opp}{hyp}$ *(solve for hyp)*
- $F_g = G\frac{Mm}{r^2}$ *(solve for r)*
- $a^2 + b^2 = c^2$ $(solve\ for\ b)$
- $mgh = \frac{1}{2}kx^2$ *(solve for k)*
- $T = 2\pi\sqrt{\frac{m}{k}}$ $(solve\ for\ k)$
- ${v_x}^2 = {v_{xo}}^2 + 2a_x(x - x_o)$ *(solve for x_o)*
- $W = Fd\cos\theta$ $(solve\ for\ d)$
- $\sum F_c = m\frac{v^2}{r}$ $(solve\ for\ v)$

2) Trigonometry:

In physics the most commonly used trigonometry will be right-triangle trig, or 90° triangle trig. In other classes and the occasional physics setup the use of non-right-triangle trig functions can be helpful but due to the x-axis being horizontal and the y-axis being vertical, and including gravity, we will focus on trigonometic functions that deal with breaking resultants down into the X-axis and Y-Axis only.

- **Equation #1:** $a^2 + b^2 = c^2$ (Pythagorean's Theorem)
- **Equation #1 use:** When given two sides of a right triangle equation #1 can be used to solve for the unknown side.

- **Equation #1 Example #1:**



10m is the **hypotenuse** and **ALWAYS side C**
8m is **not the hypotenuse** and can be **EITHER A or B**

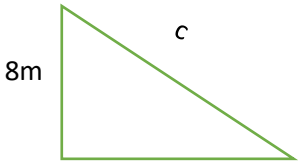
$$a^2 + 8^2 = 10^2$$

$$10^2 - 8^2 = a^2$$

$$a = \sqrt{10^2 - 8^2}$$

a= 6m

- **Equation #1 Example #2:**



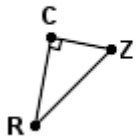
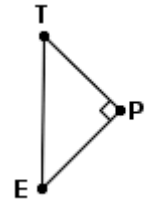
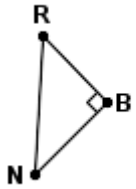
10m is the **not hypotenuse** and can be **EITHER A or B**
8m is **not the hypotenuse** and can be **EITHER A or B**

$$10^2 + 8^2 = c^2$$

$$\sqrt{10^2 + 8^2} = c$$

c= 12.8m

Practice Problems for Equation #1: (SHOW ALL WORK)
Using Pythagorean's Theorem, solve for the unknown side length.

		
CR = 4.2m RZ = *x* ZC = 1.5m	ET = 22m/s EP = *x* TP = 8.1m/s	BR = *x* NR = 22m BN = 20

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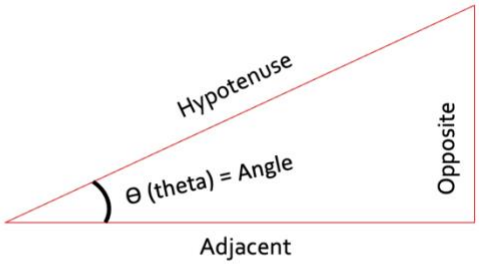
- **Equation #2: $S_{OH}C_{AH}T_{OA}$**
- **Equation #2 use #1:** When given a side and an angle, on a right triangle, solve for an unknown side.

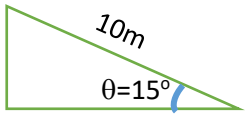
SOH
- Sine =
- O = opposite of Θ (angle)
- H = Hypotenuse
- $\sin\theta = \frac{opposite}{hypotenuse}$

CAH
- Cosine =
- A= adjacent of Θ (angle)
- H= Hypotenuse
- $\cos\theta = \frac{adjacent}{hypotenuse}$

Toa
- Tangent=
- O= opposite
- A= adjacent
- $\tan\theta = \frac{opposite}{adjacent}$



- **Equation #2 use #1 Example:**



10m is the **HYPOTENUSE since it is across from the 90° angle**
x is the **ADJACENT since it is next to the measured angle.**

$$\cos\theta = \frac{adj}{hyp}$$

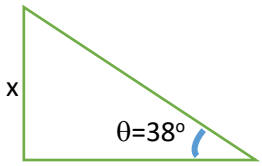
$$\cos(15) = \frac{x}{10m}$$

$$10\text{m} * \cos(15) = \frac{x}{10m} * 10m$$

$$10\text{m} * \cos(15) = x$$

$$x = 9.65\text{m}$$

- **Equation #2 use #2 Example:**



12m is the **ADJACENT since it is next to the measured angle.**
x is the **OPPOSITE since it is across from the measured angle.**

$$\tan\theta = \frac{opp}{adj}$$

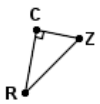
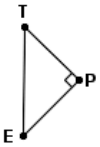
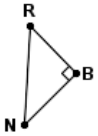
$$\tan(38) = \frac{x}{12m}$$

$$12\text{m} * \tan(38) = \frac{x}{12m} * 12m$$

$$12\text{m} * \tan(38) = x$$

$$x = 9.375m$$

Practice Problems for Equation #1: (SHOW ALL WORK)
Solve for the unknown side length using $S_{OH}C_{AH}T_{OA}$.

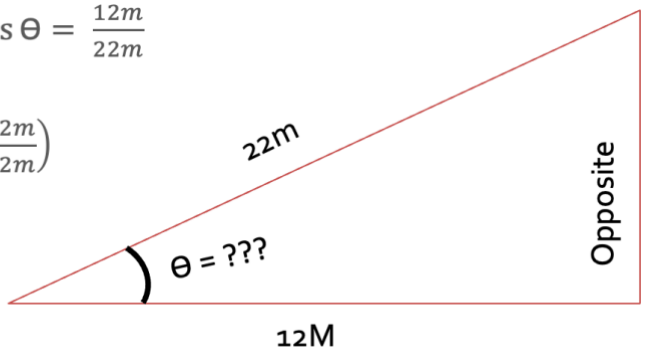
		
$\angle Z = 33°$ $RZ = x$ $ZC = 1.5\text{m}$	$\angle E = 64°$ $EP = x$ $TP = 8.1\text{m/s}$	$\angle R = 22°$ $BR = x$ $NR = 22\text{m}$

- **Equation #2 use #2:** When given two side legnths of a right triangle, solve for the angle, θ.

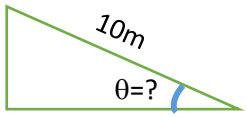
$$\cos\Theta = \frac{adjacent}{hypotenuse} \rightarrow \cos\Theta = \frac{12m}{22m}$$

$$\cos^{-1}(\cos\Theta) = \cos^{-1}\left(\frac{12m}{22m}\right)$$

$$\Theta = \cos^{-1}\left(\frac{12m}{22m}\right)$$



- **Equation #2 use #2 Example #1:**



10m is the **HYPOTENUSE since it is across from the 90° angle**
8m is the **ADJACENT since it is next to the measured angle.**

$$\cos\theta = \frac{adj}{hyp}$$

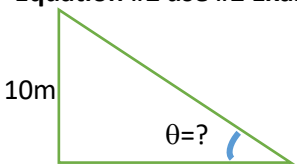
$$\cos\theta = \frac{8m}{10m}$$

$$\cos^{-1}(\cos\theta) = \cos^{-1}(\frac{8m}{10m})$$

$$\theta = \cos^{-1}(\frac{8m}{10m})$$

$$\theta = 36.87°$$

- **Equation #2 use #2 Example #2:**



12m is the **ADJACENT since it is next to the measured angle.**
10m is the **OPPOSITE since it is across from the measured angle.**

$$\tan\theta = \frac{opp}{adj}$$

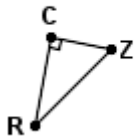
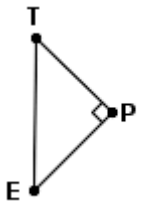
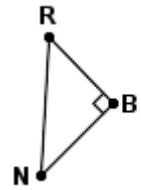
$$\tan\theta = \frac{10}{12}$$

$$\tan^{-1}(\tan\theta) = \tan^{-1}(\frac{10}{12})$$

$$\theta = \tan^{-1}(\frac{10}{12})$$

$$\theta = 39.8°$$

Practice Problems for Equation #2 u: (SHOW ALL WORK)
Solve for the unknown angle using SOHCAHTOA.

		
∠Z = ? RZ = 2.2 ZC = 1.5m	∠E = ? EP = 7.9m/s TP = 8.1m/s	∠R = ? BR = 15m NR = 22m

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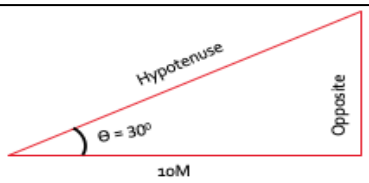
Additional Trigonometry Review:

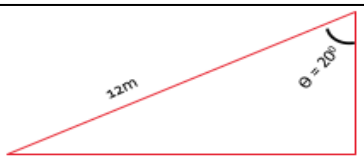
****Please note that the following triangles ARE NOT TO SCALE****

Solve for side lengths



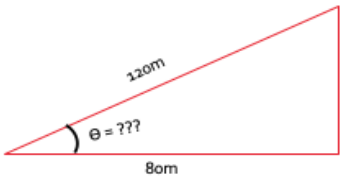
- Using SohCahToa, solve for the unknown sides:

- Using SohCahToa, solve for the unknown sides:

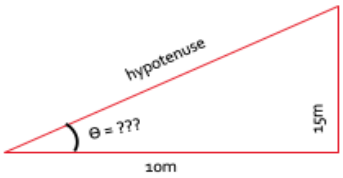


- Using SohCahToa, solve for the unknown sides:

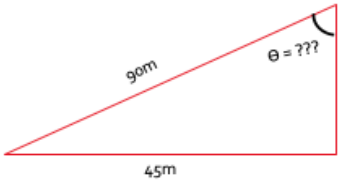
Solve for theta



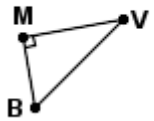
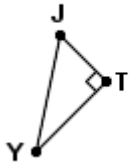
- Using the triangle above, solve for Θ.



- Using the triangle above, solve for Θ.



- Using the triangle above, solve for Θ.

Find ΘB	Find ΘF	Find ΘY
		
$\overline{BV}$ = 15.61	$\overline{FL}$ = 0.88	$\overline{TJ}$ = 0.23
$\overline{BM}$ = 9	$\overline{NL}$ = 1.25	$\overline{YJ}$ = 0.41
$\overline{VM}$ = 12.75	$\overline{FN}$ = 1.53	$\overline{YT}$ = 0.34

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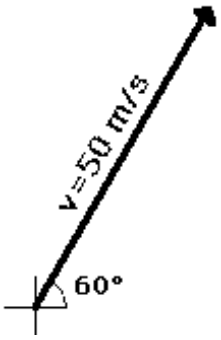
3) Vectors:

One of the most used mathematical concepts in physics is the **vector**.

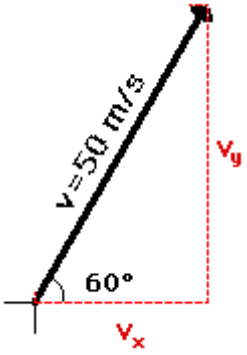
- **Vector Defintion:** A vector is a quantity that has both magnitude (size) and direction.
- **Vector Example:** The vector to the right represents the velocity of an object at 50 m/s (magnitude) at an angle of 60° (direction).



Oftentimes we will be interested in just determining the size of one of the **components** (parts) of the vector.

- **Component Definition:** A part of a vector that only moves through the X or Y Axis. A vector will generally have both a horizontal and vertical component.
- **Component Example:** An object traveling at 50 m/s at an angle of 60°, is traveling both in the horizontal and vertical directions. How do we determine the amount though? We know from trigonometry that

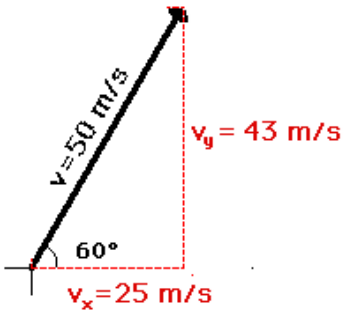
$$\cos\theta = \frac{v_x}{v} \quad \text{and} \quad \sin\frac{v_y}{v}$$



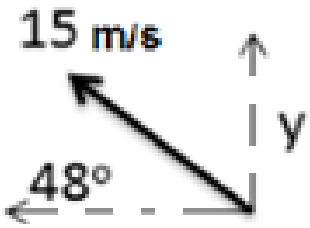
Rearranging we get the basic equations for getting vector components.

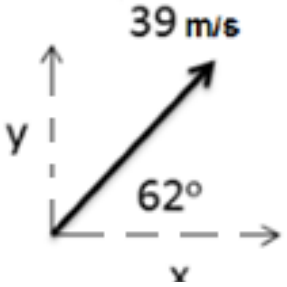
$$v_x = v\cos\theta \quad \text{and} \quad v_y = v\sin\theta$$

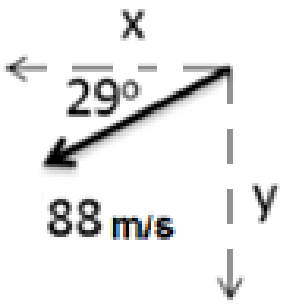
Check for yourself that that the values in the figure to the right are correct.

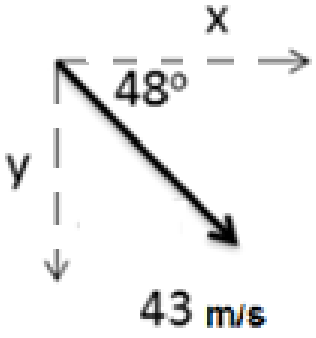


1. What are the x and y components of the vectors shown below?
2. Also, do not concern yourself with negative numbers at this point. PSYW (Please show your work!)









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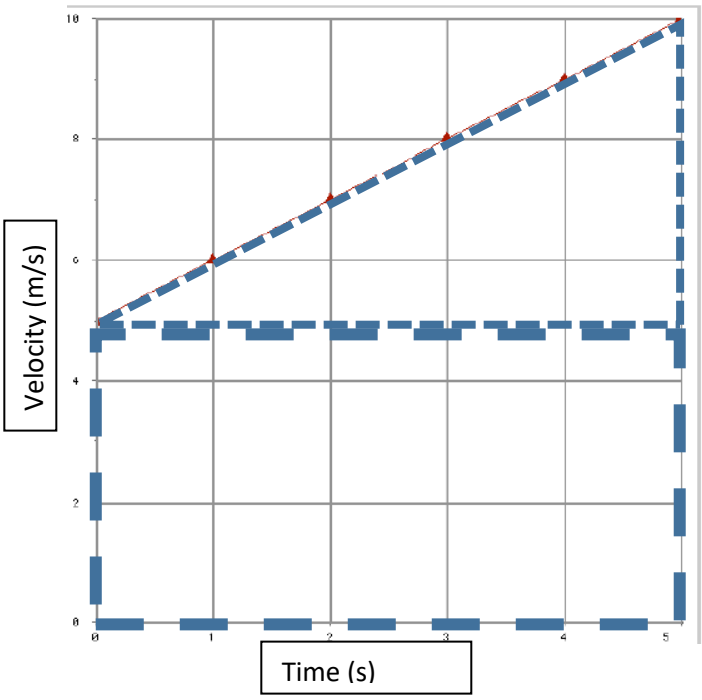
4) Interpreting Graphs:

In physics, the area under a graph or the slope of a graph can hold meaningful information. In this section, we will focus on how to find the area under the graph and identify units for the area under the graph. Additionally, we will review how to find slope and determine units for a given slope.

Example 1:



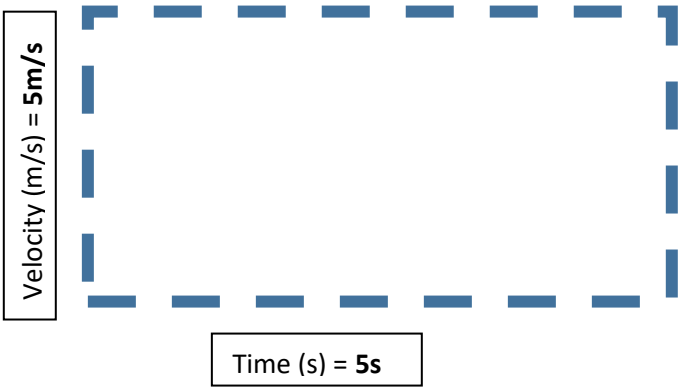
First, let's describe and determine the slope.

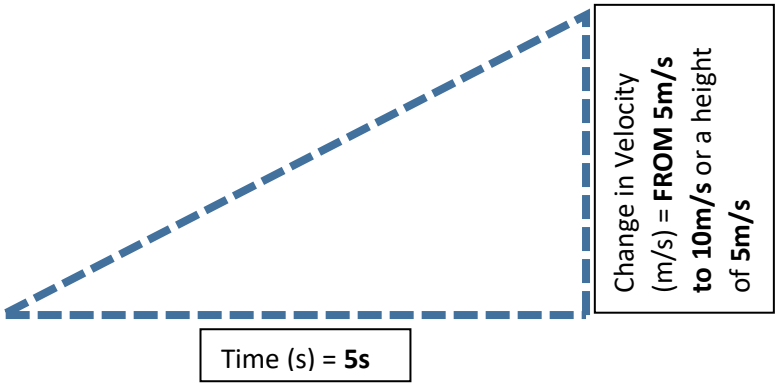
Description of the slope:

- The slope is **CONSTANT** and **POSITIVE.**
- The **Y-INTERCEPT** is **5m/s,** meaning the starting speed is 5m/s
- Using the slope equation of: $m = \frac{y_2 - y_1}{x_2 - x_1}$ and identifying points yields, $m = \frac{8m/s - 6m/s}{3s - 1s} = 1$.
- Since the units on the bottom of the equation are ***s, seconds,*** and the units on the top of the equation are ***m/s, meters per second*** the unit of the slope would be $\mathbf{1}\frac{\boldsymbol{m}}{\frac{\boldsymbol{s}}{\boldsymbol{s}}}$ ***or*** $\mathbf{1}\frac{\boldsymbol{m}}{\boldsymbol{s^2}}$

Now, let's look at the area under the graph.

- The area **MUST** first be broken down into geometry that we can solve for! The area under the line can be broken down into a triangle and a rectangle as indicated by the shapes outlined on the graph.





To determine the ***Area of a Rectangle = L x W***

For our example, instead of ***L x W*** we will use ***H x W.***

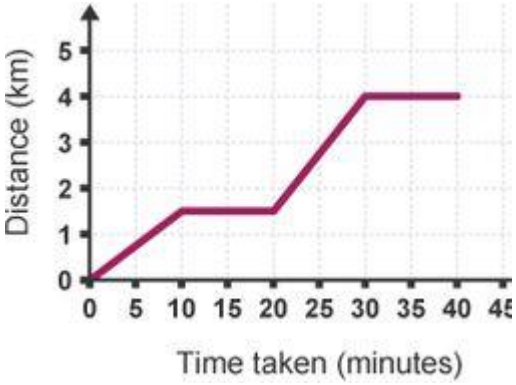
- H - Velocity = 5m/s
- W – Time = 5s
  - H x W = $5\frac{m}{s}\ x\ 5s = 25\frac{m}{s} * s \rightarrow 25m$
  - **AREA = DISTANCE**

To determine the ***Area of a Triangle =*** $\frac{1}{2}\boldsymbol{b} * \boldsymbol{h}$

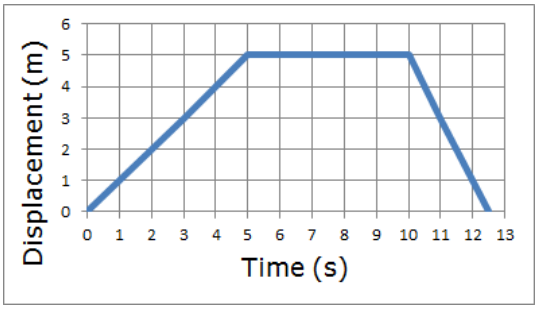
- h - Change in Velocity =10m/s - 5m/s = 5m/s
- b – Time = 5s
  - $\frac{1}{2}\boldsymbol{b} * \boldsymbol{h} = \frac{1}{2}\ (5\boldsymbol{s})\boldsymbol{x}\left(5\frac{\boldsymbol{m}}{\boldsymbol{s}}\right)$ $= \mathbf{12.5}\frac{\boldsymbol{m}}{\boldsymbol{s}} * \boldsymbol{s} \rightarrow \mathbf{12.5}\boldsymbol{m}$
  - **AREA = DISTANCE**

FOR THIS GRAPH, THE AREA TOTAL (Area from Rectangle + Area of Triangle) = Total distance traveled = 37.5m

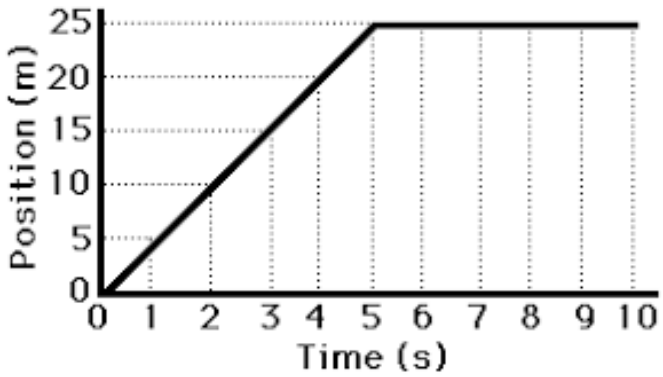
Directions: For each graph identify what the slope represents, what units the slope would have, the area under the graph and units for the area.



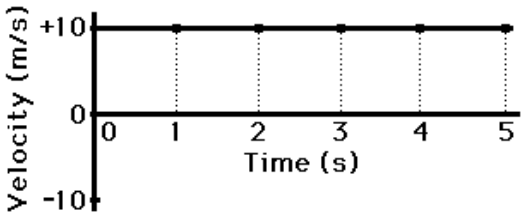
2) Solve for the following:
   a. Slope of the line:
   b. Area under the line:



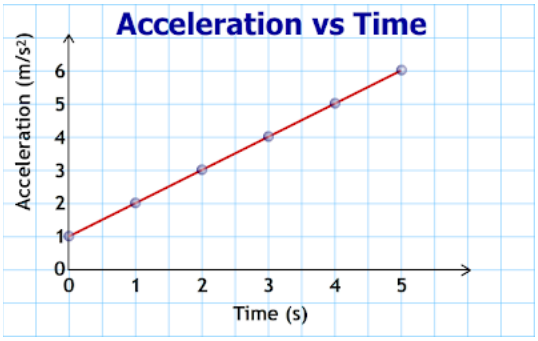
4) Solve for the following:
   a. Slope of the line:
   b. Area under the line:



3) Solve for the following:
   a. Slope of the line:
   b. Area under the line:



1) Solve for the following:
   a. Slope of the line:
   b. Area under the line:



5) Solve for the following:
   a. Slope of the line:
   b. Area under the line:

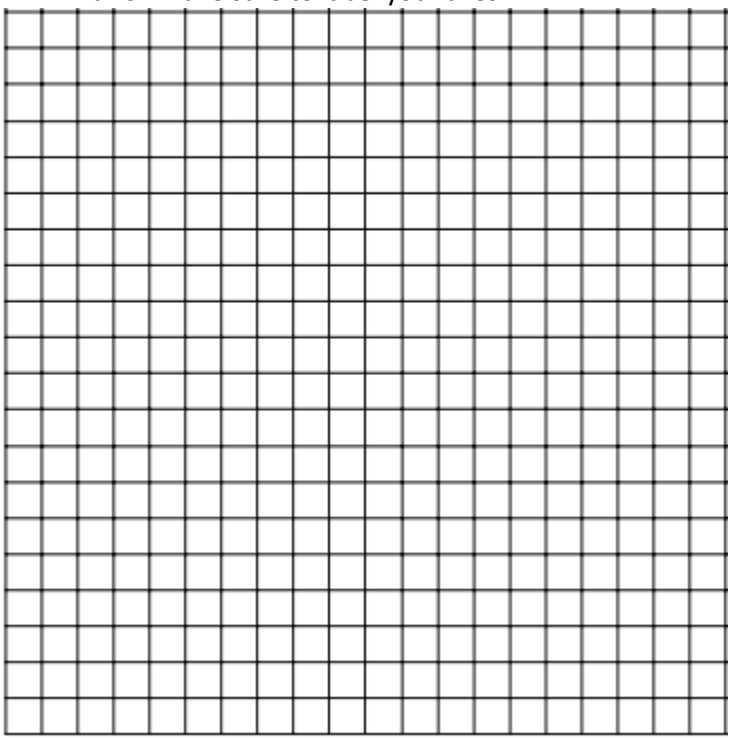
5) Mathematical Models – Understanding and Creating Graphs:

One of the most useful tools of physics is the mathematical model. A mathematical model is an equation that represents the relationship between two or more variables. In AP Physics 1, all of the equations you will use will be applied in a lab setting.

For example, a student wanted to experimentally determine the relationship between a circle's diameter and its circumference. Here is the data that student collected.

Diameter (cm)	Circumference (cm)
5.0	15.7
10.0	31.4
15.0	47.1
20.0	62.8
25.0	78.5

- Graph the data and draw a line of best fit. Make sure to plot diameter on the x-axis and circumference on the y-axis. Make sure to label your axes.



- Create an equation in the form y = mx + b for the resulting line, where y is the variable on the y-axis, m is the slope, x is the variable on the x-axis, and b is the y-intercept.

- What does the slope of this line represent? Hint: The national holiday is celebrated on March 14th each year.

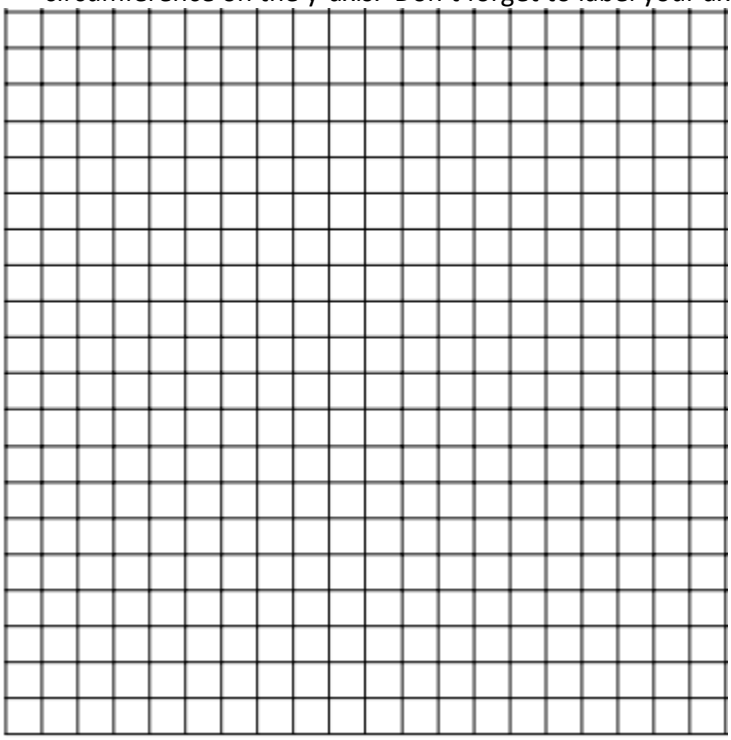
6) Linearization:

How do we create a mathematical model for a line that isn't straight?

For example, a student wanted to experimentally determine the relationship between a circle's area and its radius. Here is the data that student collected.

radius (cm)	area (cm^2)
5.0	78.5
10.0	314.2
15.0	706.9
20.0	1256.6
25.0	1963.5

- Graph the data on the graph below and draw a line of best fit. Make sure to plot diameter on the x-axis and circumference on the y-axis. Don't forget to label your axes.



- What shape is the line?

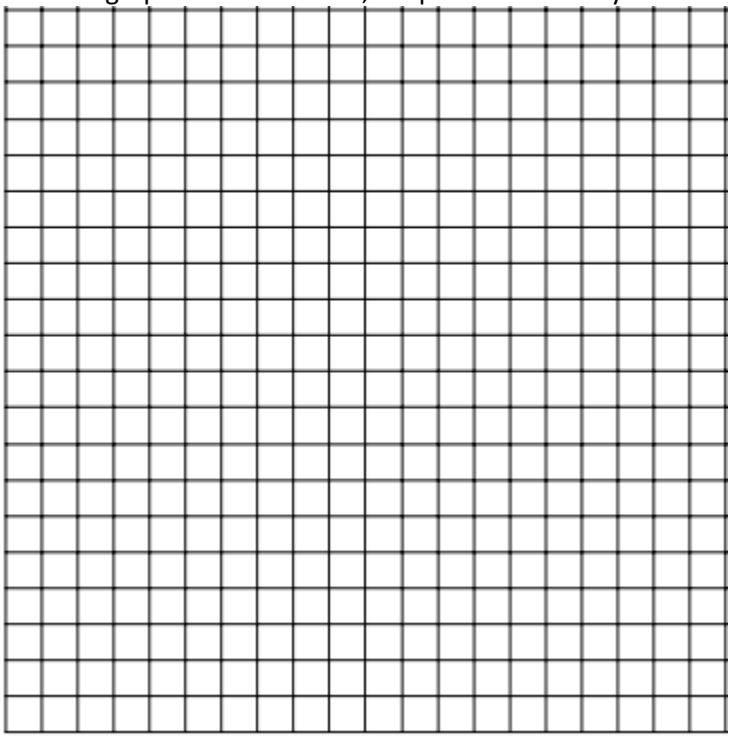
Hopefully you noticed that the line wasn't straight. It is difficult to get the equation for a line that isn't straight unless you have a computer. Or unless you know how to use linearization, which is the process of transforming a curvy line into a straight line so that you can analyze it. How does that work?

The line in the previous graph looks like a parabola. We know from math class that a parabola can be represented by the equation $y = Ax^2$, where A is some constant.

- Try this: since radius was on the x-axis in the last graph, calculate the values of radius^2.

radius (cm)	radius^2 (cm^2)	area (cm^2)
5.0		78.5
10.0		314.2
15.0		706.9
20.0		1256.6
25.0		1963.5

- Now graph area vs. radius^2, i.e. put area on the y-axis and radius^2 on the x-axis.



- Create an equation in the form $y = mx + b$ for the resulting line, where y is the variable on the y-axis, m is the slope, x is the variable on the x-axis, and b is the y-intercept. Remember that x in this case will be radius^2, not just radius.

- To check your answer, compare the equation you created to the equation for the area of a circle. They should be identical.

We will be able to linearize many different graph shapes besides parabolas. Stay tuned!

7) Experimental Design:

A key skill to any science class is experimental design. AP Physics 1 is no different, you will need to have and develop skills required to identify variables, control uncertainty, clearly outline a procedure, and collect, analyze, and interpret data to support a claim.

Variables:

- **Independent Variable (IV) Definition:** The variable that is changed to see if or how it affects the dependent variable. Each experiment should only have **ONE** independent variable.
- **Dependent Variable (DV) Definition:** The variable that is measured to see if or how it was affected by the independent variable.
- **Constants Definition:** While not a variable, these are items that are kept the same throughout an experiment so as not to affect the results. Oftentimes constants could be another independent variable and as such must be kept the same for each experiment as there should only be one tested independent variable.

Types of Data: Both types of data should be collected in **ALL EXPERIMENTS!**

- **Quantitative Data Definition:** Data that is represented by numbers.
- **Qualitative Data Definition:** Data that **IS NOT** represented by numbers. This is generally a result of an observation about the experiment that could drive uncertainty (error) or help to confirm results.

Procedure:

- **Procedure Definition:** A clearly outlined and ordered list of steps required to complete an experiment.
- **Required Parts for Procedures:**
  - Independent variable is identified, how the variable will be changed and measured is clear.
  - Dependent variable is identified, how the variable will be measured is clear.
  - Explicitly state how the independent variable will be changed to get multiple data points (dependent variables) per trial, and what will be kept constant between each trial.
  - Explicitly state multiple trials will be completed and which specific data will be averaged to reduce experimental error.
  - Explicitly state how the data will be used to support the experimental claim.

Experimental Design Example:

- **Essential/ Driving Question** (Provided by lab): How does the roughness of a surface affect the motion of an object when the object is pulled across the surface?
- **Claim/ Hypothesis:** The rougher that a surface an object slides over will result in a lower acceleration because an increased amount of friction.

  IV **DV**
- **Materials Required:** Friction board, force gauge, stopwatch, block.

- **Procedure:**

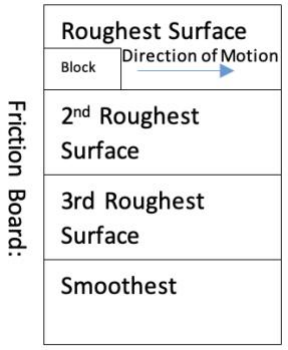
  1) Using a block and force gauge, attach the force gauge so that the block can be pulled horizontally across a flat surface.

  2) Starting with the roughest surface on the friction board, measure the distance across the board then, start the block from rest and pull with a constant horizontal force until the block has completely crossed the friction board. Start the timer at the same time a force is applied to the block and stop timing when the block is completely off of the surface. Record the time when the block reaches ¼ across, the middle, ¾ across, and the whole distance.

  3) Repeat step 2, twice more for the roughest surface, or until multiple sets of data are precise.

  4) Repeat steps 2 and 3 for remaining surfaces, applying the same force each time.

  5) Using $x_f = x_i + v_i t + \frac{1}{2}at^2$, determine the acceleration for each surface.



Experimental Design Setup:
Now it's your turn, using the Essential/Driving Question, develop an experiment in the space provided below. Include all of the outlined steps above.

Essential/ Driving Question: *How can the speed of an RC car be determined?*