

Things to know about AP Physics:

- 1) This will be a challenging course. The College Board sets very high standards for this AP course. Please be mindful that this course is meant to prepare you for the rigors of college science classes. Keep a healthy perspective of your grade in the class, how much you are learning about physics and how much you are learning about yourself.
- 2) Conceptual knowledge is more important than the math. You will be expected to present unique and complicated solutions to physics problems to the class. The process of explaining your logic and reasoning is what AP Physics requires.
- 3) The textbook is your friend. We can not cover everything in class or you may not fully understand everything we cover instantly. The textbook is a well organized resource for you to review the material. We will also link digital text supports for each unit.
- 4) The internet is your friend. If you struggle with a concept, it is likely that there is a video on the internet which will explain it. If this is your preferred method of learning, use it.
- 5) The most valuable resource in this class is your peers. This class relies heavily on partner work, group work, whiteboarding and labs. Those that succeed in this class are typically the students with a willingness to both receive and give help.
- 6) This is not a class you can cram for. In order to do well in the class and on the AP exam you need to be engaged everyday.
- 7) The following is advice given to the AP Physics 1 class of 2026-27 from last year's classes.
 - a) Complete your work even if it is not graded.
 - b) Study over your old work.
 - c) Review your labs. Ask yourself, "what was the point of this lab, what did I learn from this"?
 - d) Watch and take notes on the AP Classroom Daily videos, they really do help a ton by the end.
 - e) Positive Physics really does help you know if you are doing the basic concept problems correctly, then you can move on to more complicated AP style questions.
 - f) When optional work is provided, do it!
 - g) Watch the Beat Physics videos, they help.
 - h) I should have asked more questions and contributed more in my small groups.
 - i) This class is difficult, but made me a stronger analytical thinker and critical problem solver.

To do: Go through this summer packet before the first day of class. The purpose of the summer packet is to sharpen math and science skills that you had learned during your freshman Phys-Chem class. Your goal is to complete the packet so that you can ask and answer questions about the packet with your classmates over the first few days of class. Not doing the work puts you and the entire class at a disadvantage.

For additional support on each section, please refer to the following suggested references.

- 1) Algebra Khan Academy [LINK](#)
2. Trigonometry Khan Academy [LINK](#), Libretexts Right Triangle Trig [LINK](#)
3. Vectors Khan Academy [LINK](#), Brilliant Vectors [LINK](#)
4. Interpreting Graphs Khan Academy [LINK](#), The Physics Classroom [LINK](#)
5. Mathematical Models - Understanding and Creating Graphs [LINK 1](#), [LINK 2](#)
6. Graph Linearization Quarknet [LINK](#).

1) Algebra:

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

- $v_x = v_{x0} + at$ (solve for a)

- $U_g = -\frac{Gm_1m_2}{r}$ (solve for 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)

- $v_x^2 = v_{x0}^2 + 2a_x(x - x_0)$ (solve for x_0)

- $W = Fd \cos \theta$ (solve for d)

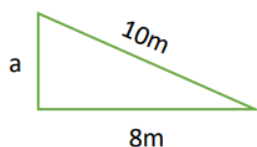
- $\sum F_c = m \frac{v^2}{r}$ (solve for v)

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 trigonometric 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.

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



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

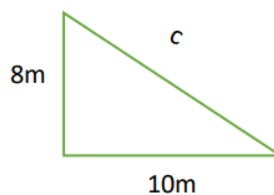
$$a^2 + 8^2 = 10^2$$

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

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

$$a = 6m$$

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



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

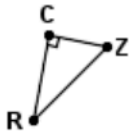
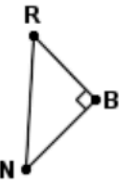
$$10^2 + 8^2 = c^2$$

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

$$c = 12.8m$$

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 = 20m
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- **Equation #2: SOHCAHTOA**
- **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

$$\sin \theta = \frac{\text{opposite}}{\text{hypotenuse}}$$

CAH

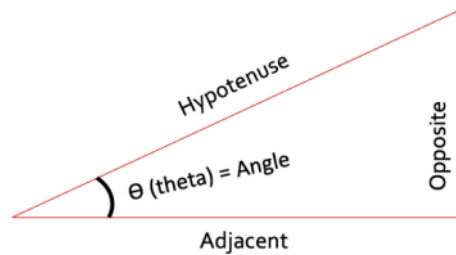
- Cosine =
- A = adjacent of θ (angle)
- H = Hypotenuse

$$\cos \theta = \frac{\text{adjacent}}{\text{hypotenuse}}$$

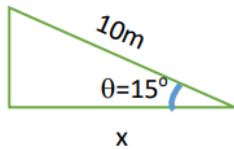
Toa

- Tangent =
- O = opposite
- A = adjacent

$$\tan \theta = \frac{\text{opposite}}{\text{adjacent}}$$



• 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.

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

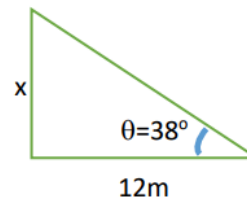
$$\cos(15) = \frac{x}{10m}$$

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

$$10m * \cos(15) = x$$

$$x = 9.65m$$

• 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.

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

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

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

$$12m * \tan(38) = x$$

$$x = 9.375m$$

Practice Problems for Equation #1: (SHOW ALL WORK)

Solve for the unknown side length using **SOHCAHTOA**.

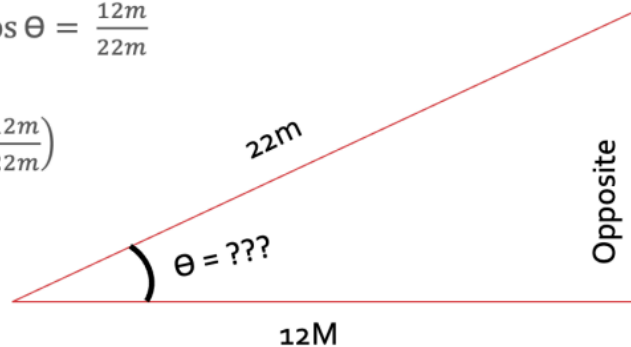
$\angle Z = 33^\circ$ $RZ = x$ $ZC = 1.5m$	$\angle E = 64^\circ$ $EP = x$ $TP = 8.1m/s$	$\angle R = 22^\circ$ $BR = x$ $NR = 22m$
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• Equation #2 use #2: When given two side lengths of a right triangle, solve for the angle, θ .

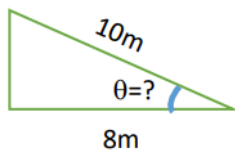
$$\cos \theta = \frac{adjacent}{hypotenuse} \rightarrow \cos \theta = \frac{12m}{22m}$$

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

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



• 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.

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

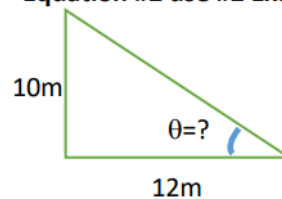
$$\cos \theta = \frac{8m}{10m}$$

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

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

$$\theta = 36.87^\circ$$

• 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.

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

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

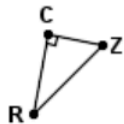
$$\cancel{\tan^{-1}}(\cancel{\tan \theta}) = \tan^{-1}\left(\frac{10}{12}\right)$$

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

$$\theta = 39.8^\circ$$

Practice Problems for Equation #2 u: (SHOW ALL WORK)

Solve for the unknown angle using $S_{OH}C_{AH}T_{OA}$.



$$\angle Z = ?$$

$$RZ = 2.2m$$

$$ZC = 1.5m$$



$$\angle E = ?$$

$$EP = 7.9m/s$$

$$TP = 8.1m/s$$



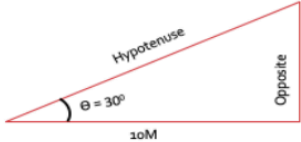
$$\angle R = ?$$

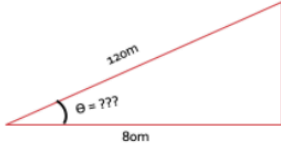
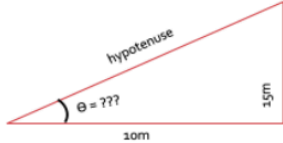
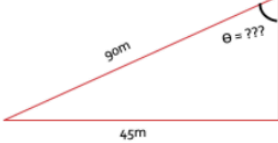
$$BR = 15m$$

$$NR = 22m$$

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:
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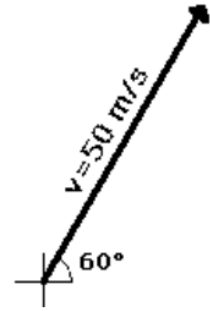
Solve for theta	 Using the triangle above, solve for θ.	 Using the triangle above, solve for θ.	 Using the triangle above, solve for θ.
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Find θ_B  $\overline{BV} = 15.61$ $\overline{BM} = 9$ $\overline{VM} = 12.75$	Find θ_F  $\overline{FL} = 0.88$ $\overline{NL} = 1.25$ $\overline{FN} = 1.53$	Find θ_Y  $\overline{TJ} = 0.23$ $\overline{YJ} = 0.41$ $\overline{YT} = 0.34$
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3) Vectors:

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

- **Vector Definition:** 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).

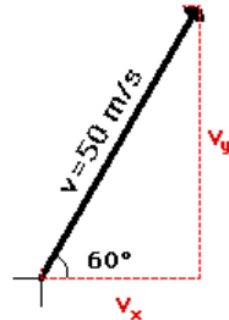


Oftentimes we will be interested in just determining the size of one of the **components** (parts) of the vector.

- **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

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



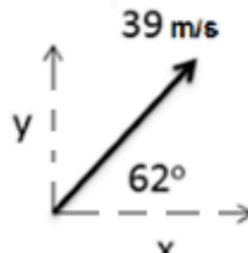
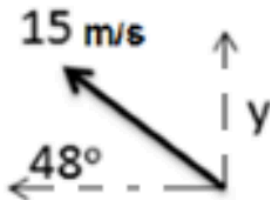
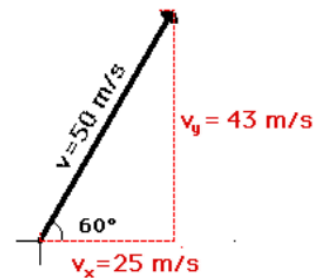
Now let's rearrange the basic equations for getting the vector components.

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.

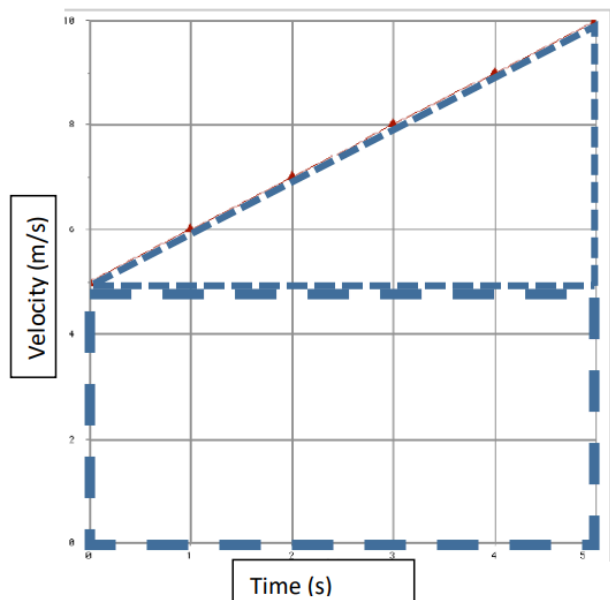
1. What are the x and y components of the vectors shown below?
2. Also, do not concern yourself with negative numbers at this point. PSYW (Please show your work!)



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:



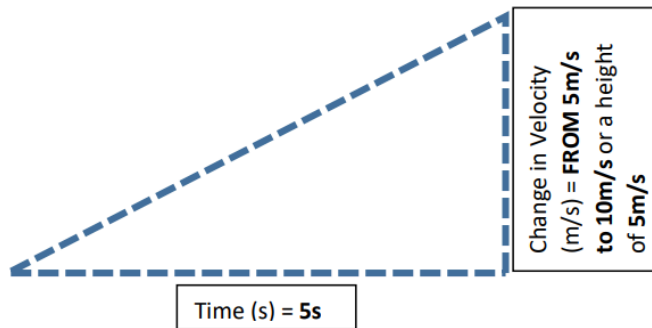
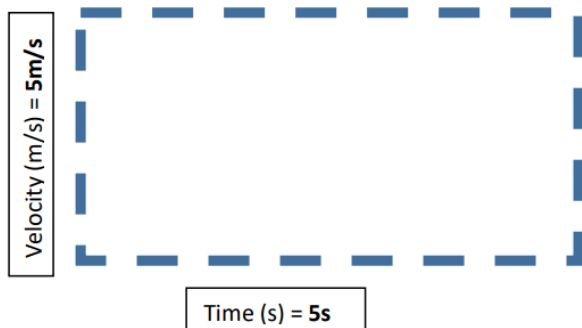
First, let's describe and determine the slope.

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 $1 \frac{m}{s}$ or $1 \frac{m}{s^2}$

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** = $L \times W$
For our example, instead of $L \times W$ we will use $H \times W$.

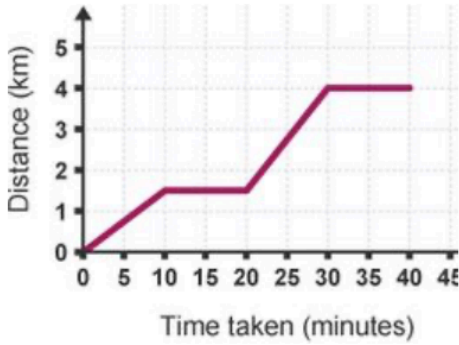
- H - Velocity = 5m/s
- W - Time = 5s
 - $H \times W = 5 \frac{m}{s} \times 5s = 25 \frac{m}{s} \times s \rightarrow 25m$
 - **AREA = DISTANCE**

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

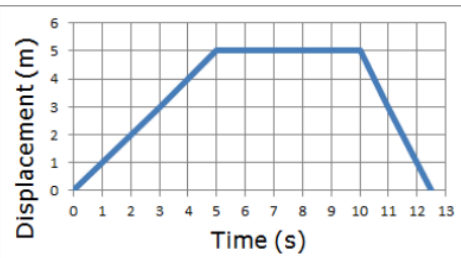
- h - Change in Velocity = 10m/s - 5m/s = 5m/s
- b - Time = 5s
 - $\frac{1}{2} b \times h = \frac{1}{2} (5s) \times (5 \frac{m}{s})$
= $12.5 \frac{m}{s} \times s \rightarrow 12.5m$
 - **AREA = DISTANCE**

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

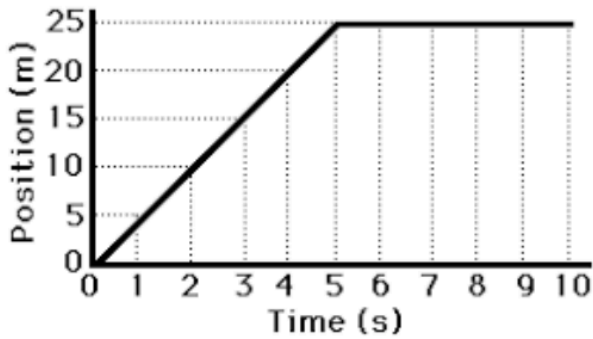
Directions: For each graph identify what the slope represents, what units the slope would have, the area under the graph and units for the area.



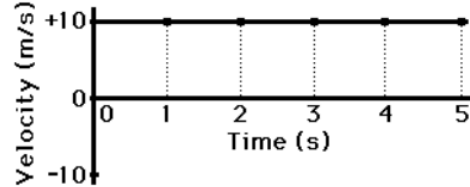
- 2) Solve for the following:
- Slope(s) of the line:
 - Area under the line:



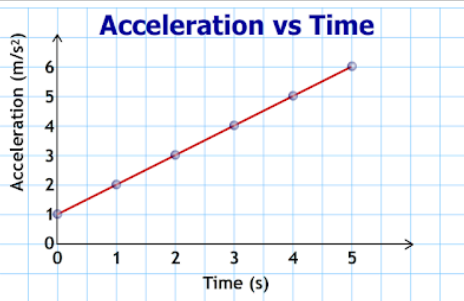
- 4) Solve for the following:
- Slope(s) of the line:
 - Area under the line:



- 3) Solve for the following:
- Slope(s) of the line:
 - Area under the line:



- 1) Solve for the following:
- Slope(s) of the line:
 - Area under the line:



- 5) Solve for the following:
- Slope(s) of the line:
 - Area under the line:

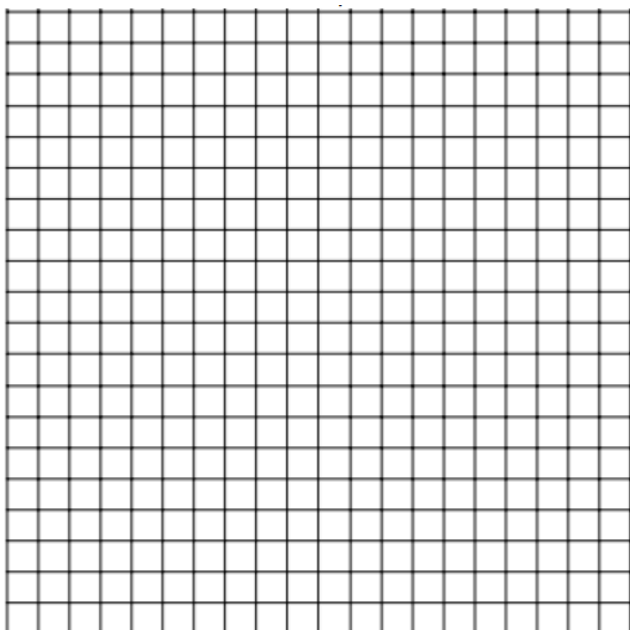
5) Mathematical Models – Understanding and Creating Graphs:

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.

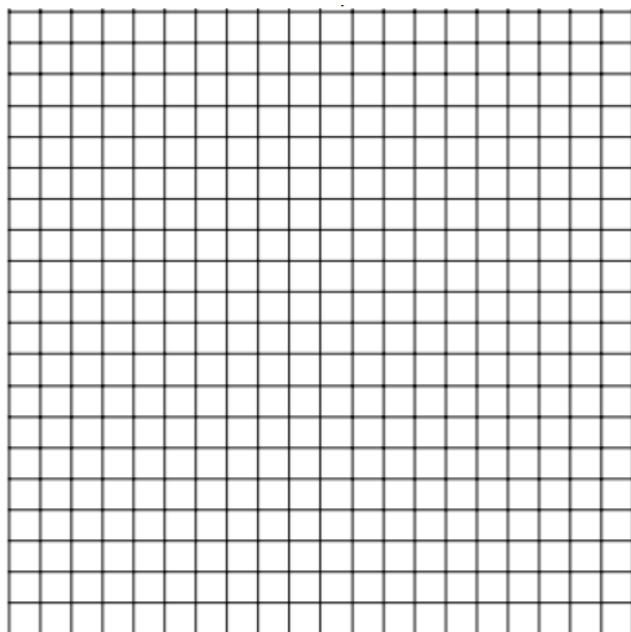
6) Linearization:

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.



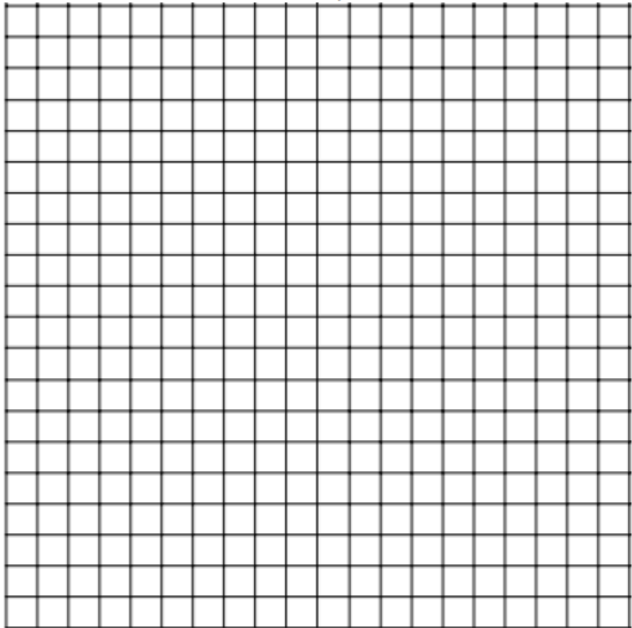
Hopefully you noticed that the line wasn't straight. It is difficult to get the equation for a line that isn't straight unless you have a computer. Or unless you know how to use linearization, which is the process of transforming a curvy line into a straight line so that you can analyze it. How does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

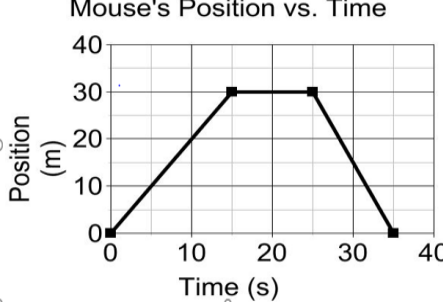
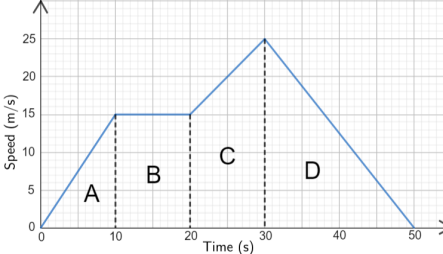
- Now graph area vs. radius^2 , i.e. put area on the y-axis and radius^2 on the x-axis.



- 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.

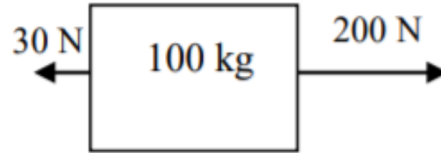
We will be able to linearize many different graph shapes besides parabolas. Stay tuned!

7) Physics Review

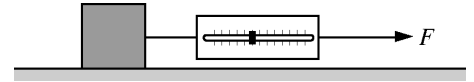
$\vec{v}_{avg} = \frac{\Delta \vec{x}}{\Delta t}$ Average velocity Displacement Time interval	Mouse's Position vs. Time 	What's the mouse's distance from 0-30 seconds? What's the mouse's speed from 0-30 seconds? What's the mouse's displacement from 0-30 seconds? What's the mouse's velocity from 0-30 seconds?
$\vec{a}_{avg} = \frac{\Delta \vec{v}}{\Delta t}$ Average acceleration rate Change in velocity Time interval		What was the acceleration from 0-10s? 10-20s? 20-30s? 30 to 50s?
$v_x = v_{x0} + a_x t$ $x = x_0 + v_{x0} t + \frac{1}{2} a_x t^2$ $v_x^2 = v_{x0}^2 + 2 a_x (x - x_0)$ v_0 initial velocity v final velocity	A car, initially traveling 20.0 m/s speeds up at a rate of 3.00 m/s² for 4.0 seconds. What was the car's final speed? unit How far did the car travel during this time? unit	A rocket, launched from rest, steadily increases speed at a rate of 14.0 m/s² for 4.40s interval while burning fuel. After running out of fuel, the rocket continues upward but slows steadily at a rate of 10 m/s² What was the rocket's maximum speed during the ascent? unit How far did the rocket rise while burning fuel? unit What is the rocket's maximum height? unit

$$\vec{a}_{\text{sys}} = \frac{\sum \vec{F}}{m_{\text{sys}}} = \frac{\vec{F}_{\text{net}}}{m_{\text{sys}}}$$

Net Force (total Force)
Mass of the system



$F_{\text{net}} =$
Acceleration =



In a lab, a 4 kg block is attached to a spring scale, and both are pulled to the right on a horizontal surface, as shown above. Friction between the block and the surface is 12 N. What is the acceleration of the block when the scale reads 32 N?

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

Kinetic Energy (moving)
Energy is in units of Joules

Find the kinetic energy of a 1300 kg Toyota traveling at 9.5 m/s along Ridgeland Avenue.

An 80 kg physics student is running down the hallway with 360 J of kinetic energy. What is the student's running velocity?

$$\Delta U_g = mg\Delta y$$

or $U_g = mgh$

Stored gravitational potential energy

Rick Winters is a professional high diver. The 70 kg diver is 53 meters (172 feet) above the water. How much gravitational potential energy does he have before he dives?

A 135 kg barbell is lifted 80 cm above your chest while bench pressing at the gym. How much U_g does the lifted barbell have?