

HELLO 2026-2027 AP PHYS WIZards! (yeah, y'all need a better name...)

Welcome to AP Physics 1!

This course will be challenging but can also be fun and interesting on a level you've probably not experienced in any previous science course. My intent is to provide you with content and experiences that prepare you for the AP exam while also presenting opportunities for you to grow as a critical thinker, problem solver, and communicator.

- AP Physics 1 *requires a strong foundation in mathematics*. There may be times when you feel you're in another math class that consists only of word problems. That's the nature of the course – there are both qualitative and quantitative aspects that must be mastered.
- AP Physics 1 *is not just plugging in numbers*. The course focuses more on concepts. Almost every problem is new and different – including the ones on the actual AP exam. The problems are about applying the concepts to the problem at hand, not being able to follow a prescribed set of steps for a problem.
- AP Physics 1 *is very heavy on explanation* – that is, not just applying math concepts, but explaining, in depth, the concepts that underlie a problem and the reasoning behind your solution. Yes, there is writing in Physics.
- Since most of you are concurrently enrolled in AP Precalculus (or AP Calculus), this summer assignment should simply be a quick review of algebra, geometry and trigonometry together with several science basics.

All of the information you need to know for a **MINOR ASSESSMENT on Day 2** is in this packet. This is essentially the foundational knowledge and skills upon which the AP Course is built.

You can contact me throughout the summer via email – brownli@boe.richmond.k12.ga.us or via Remind (join [@dfaapphys](#))

I'll see you in August!



P.S. If you would like to get a prep book to use, I recommend [5 Steps to a 5: AP Physics 1](#) (\$29.32 on Amazon).

P.P.S. If you would like an online resource to use, I recommend [Flipping Physics](#).

Part 1: What is AP Physics 1? *(This stuff is NOT on the assessment)*

Go to <https://apcentral.collegeboard.org/courses/ap-physics-1>

We will use AP Classroom **very frequently**. You will be given a code in August so you can join AP Classroom.

Go to the “[AP Physics 1: Algebra-Based Course and Exam Description](#).” This is known as the CED.

- The Course Content starts on page 22. The Units we will cover and what percentages they make up of the Multiple Choice section of your AP Exam are listed in a table on page 23.
- Within pages 24-149, there are Unit Guides for everything we will study in this course. Take a look!
- Go to page 184. Read the Exam Overview.
- There are 4 specific free-response questions, and they are always in the same order. Identify the types and what the question asks you to do. *You will practice these later in the packet!*
- Page 189 lists different task words which will be used in free response questions. You will be expected to answer questions posed in these ways in the correct manner.
- On pages 225-226 is the Table of Information provided on the AP Exam. You are expected to use this on any assignments or assessments throughout the year. You will be given a copy to use in August, but you may want to print an additional copy on your own.

You will also gain access to a Student Workbook, which we will use **very frequently**.

You will need a binder for class materials and a [lab notebook](#). You will also need pencils, a scientific calculator (like the one you used for Chemistry), a ruler, lined paper, and graph paper.

I have the previous AP Physics 1 book that you may use over the summer – come get one if you’d like!

Part 2: Math Skill Review

Sig Fig Rules in AP Physics 1 are kinda slack. Stick with 3 sig figs for pretty much everything if you don't remember how to do them, but you won't ever get penalized for using the sig fig rules.

You should definitely be familiar with **metric prefixes** and how to convert them interchangeably. They are listed on the Table of Information, so you technically don't *need* to memorize them, but to save time, you *should* memorize them...

Arguably the most important skill in AP Physics 1 is **isolating a literal equation**; that is, solving for one of the variables in terms of the others. Often problems on the AP exam are done with variables only. Don't let the different letters confuse you. Manipulate them algebraically as though they were numbers. It is *extremely important* that you are able to correctly rearrange an equation.

Algebraically rearrange the following equations for the variable stated.

A. $U_g = mgh$;solve for h

$$\frac{U_g}{mg} = \frac{mg \cancel{h}}{mg} \quad h = \frac{U_g}{mg}$$

B. $P = \frac{\Delta W}{\Delta t}$;solve for Δt

C. $a_c = \frac{v^2}{r}$;solve for v

D. $qV = \frac{1}{2}mv^2$;solve for v

E. $y_f = y_i + v_i t + \frac{1}{2}at^2$;solve for a

F. $F = k \frac{q_1 q_2}{r^2}$;solve for q_2

G. $R = \rho \frac{l}{a}$;solve for ρ

H. $v_f^2 = v_i^2 - 2a(x_f - x_i)$;solve for x_i

I. $n_1 \sin \theta_1 = n_2 \sin \theta_2$;solve for θ_2

J. $T = 2\pi \sqrt{\frac{m}{k}}$;solve for k

Since most physics problems involve multiple laws acting at once, you often have to bridge two concepts using a shared variable (**equation systems**).

For example, using the equations $K = \frac{1}{2}mv^2$ and $v = at$, solve for K in terms of m , a , and t . This means no other variables than the ones requested can show up in your answer, so v must be substituted.

$$K = \frac{1}{2}m(at)^2 \longrightarrow K = \frac{1}{2}ma^2t^2$$

- | | | |
|--|--------------------------|------------------------|
| A. Solve for F_A in terms of m , g , and θ | $T \sin \theta = F_A$ | $T \cos \theta = mg$ |
| B. Solve for a in terms of m_0 , m_1 , g , and F_f | $F_t - F_f = m_0 a$ | $m_1 g - F_t = m_1 a$ |
| C. Solve for v in terms of k , x , and m | $U_s = \frac{1}{2} kx^2$ | $K = \frac{1}{2} mv^2$ |
| <i>Hint: U and K are different variables for the same quantity</i> | | |
| D. Solve for a_c in terms of π , r , and T | $a_c = \frac{v^2}{r}$ | $v = \frac{2\pi r}{T}$ |

Variable relationships are also a large component of physics understanding.

- Linear – directly proportional ($y \propto x$) $y = kx$
 - as one variable changes, the other variable changes in the same direction by the same factor – *As y doubles, x doubles*
 - direct = both variables are in the numerator on opposite sides of the equation **OR** the variables are divided on the same side of the equation
- Quadratic – proportional to the square ($y \propto x^2$) $y = kx^2$
 - as one variable changes, the other variable changes in the same direction by the factor squared – *As y doubles, x quadruples*
- Square root – proportional to the square root ($y \propto \sqrt{x}$) $y = k\sqrt{x}$
 - as one variable changes, the other variable changes in the opposite direction by the square root of the factor – *As y quadruples, x doubles*
- Inverse – inversely proportional ($y \propto \frac{1}{x}$) $y = \frac{k}{x}$
 - as one variable changes, the other variable changes in the opposite direction by the same factor – *As y doubles, x halves*
 - inverse = one variable is in the denominator on the opposite side of the equation **OR** the variables are multiplied on the same side of the equation
- Inverse-square – inversely proportional to the square ($y \propto \frac{1}{x^2}$) $y = \frac{k}{x^2}$
 - as one variable changes, the other variable changes in the opposite direction by the square of the factor – *As y doubles, x quarters*

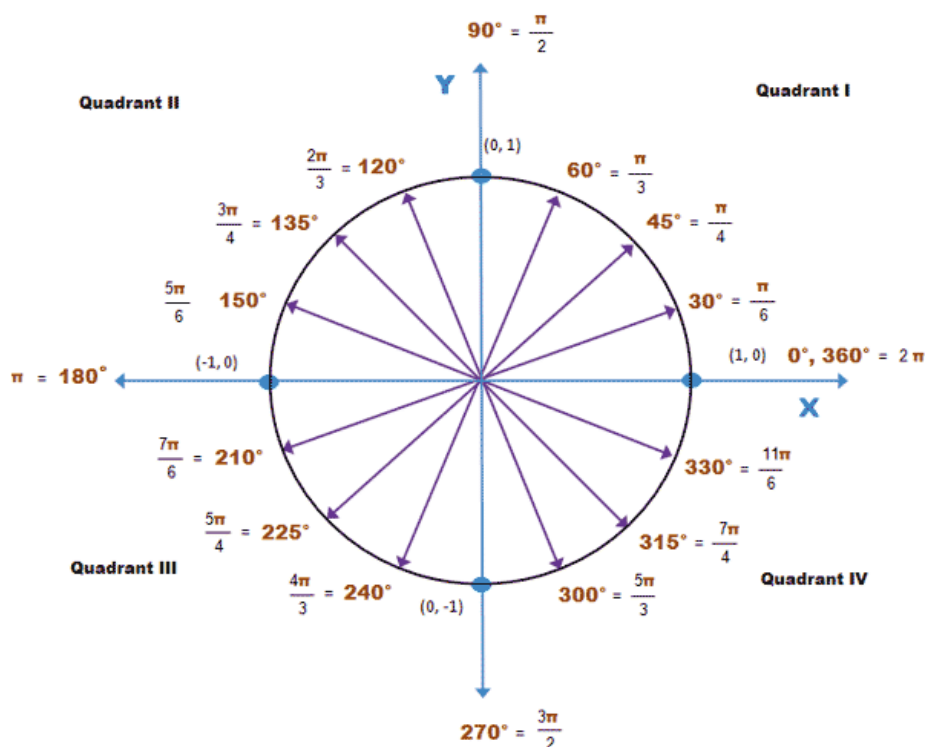
Consider the following equations: $c = ab$ $l = m - n$ $r = \frac{s^2}{t^2}$ $z = \frac{\sqrt{x}}{y}$

- How are a , b , and c related?
 *a and c are directly proportional
 b and c are directly proportional
 a and c are inversely proportional*
- How are l , m , and n related?
- How are r , s , and t related?
- How are x , y , and z related?

Most of the quantities in physics are **directional**, which makes them **vectors**. All vectors have both a magnitude (number + unit) and direction (sign or degree).

You will be both *using* vector quantities and *solving for* vector quantities throughout the year. AP Physics 1 problems are confined to using either single-axis (1-dimensional) vectors or two-axis (2-dimensional) vectors. You can either combine individual vectors (**components**) into a single vector (**resultant**), or you can separate (**resolve**) a resultant into its components.

We will use the Cartesian coordinate plane and the Polar coordinate system to describe the vectors.



Most of the time you should be in **degree mode!** There are only a couple of topics where radians are used, but most of those are solved in terms of π anyhow, so you likely won't have to change the mode.

1-D examples:

$$\vec{A} + \vec{B} = \vec{R} \quad \xrightarrow{\quad} \quad \xrightarrow{\quad} + \quad \xrightarrow{\quad} = \quad \xrightarrow{\quad}$$

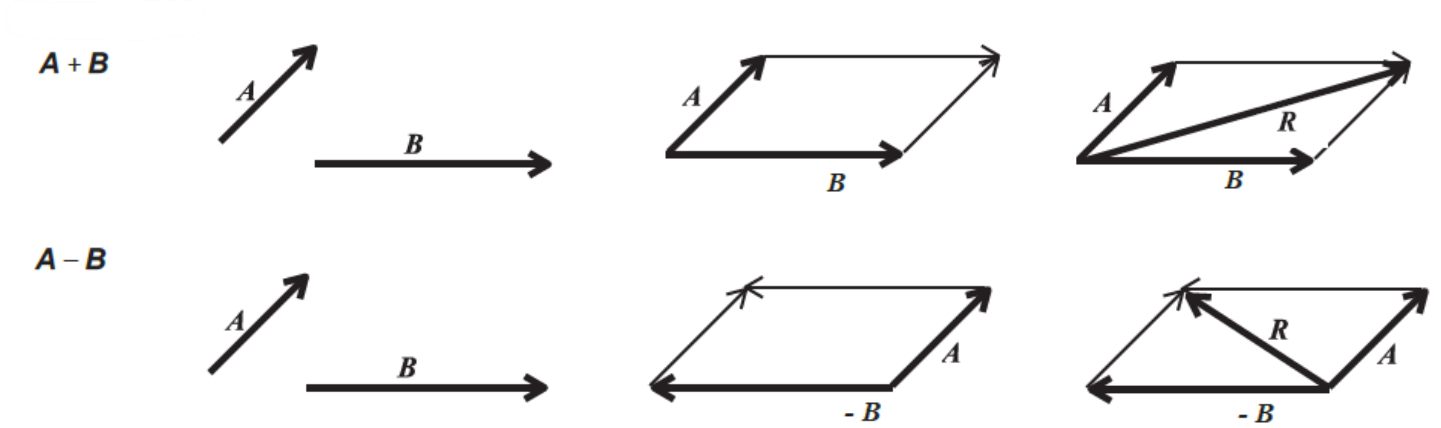
$$\vec{A} - \vec{B} \text{ is really } \vec{A} + -\vec{B} = \vec{R} \quad \xrightarrow{\quad} + \quad \xleftarrow{\quad} = \quad \xrightarrow{\quad}$$

$$+250 + 150 = +400$$

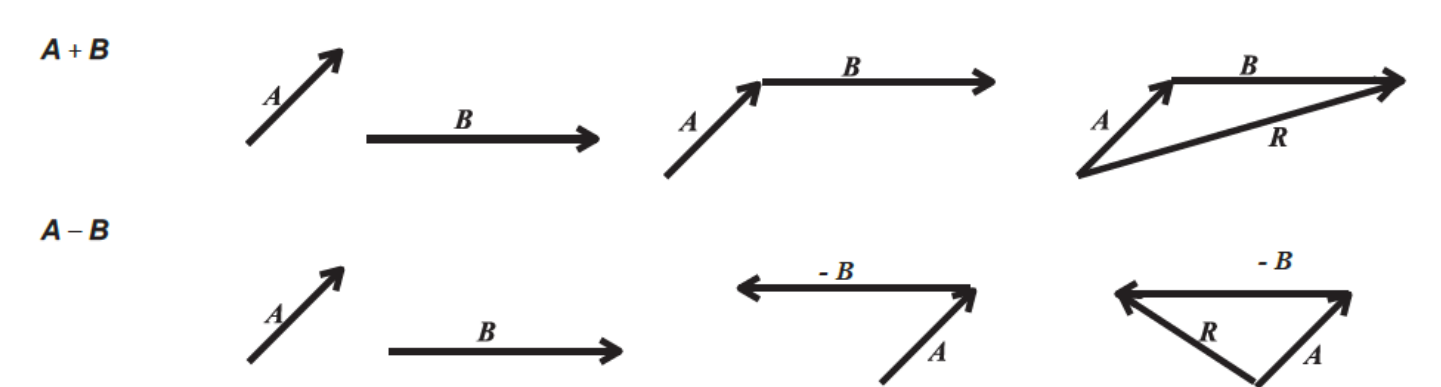
- A. Combine +250 and +150
- B. Combine +250 and -150
- C. Combine -250 and +150
- D. Combine -250 and -150

2-D examples:

Parallelogram method (best for concurrent events)



Tip-to-Tail method (best for sequential events)



Practice drawing the resultants for these vectors using each method for both addition and subtraction:

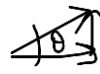


On the Table of Information you will see several references to **trigonometric functions**, including Quadrant 1 of the unit circle and right triangle identities.

Yes, they are on the paper, but you *should* have them memorized to save you time.

Use trig to **combine** these component vectors (legs) and determine the magnitude and angle of the resultant vector (hypotenuse):

- A. $x = 325$ $y = 99$
- B. $x = -0.75$ $y = -1.25$
- C. $x = -32$ $y = 16$
- D. $x = 0.0065$ $y = -0.0090$

$$\sqrt{325^2 + 99^2} = 340 \quad \theta = \tan^{-1}\left(\frac{99}{325}\right) = 17^\circ$$


Vector resolution is done when the resultant vector is not along either axis (like diagonal movement) or the quantities on each axis are independent of each other.

Use trig to **resolve** these resultant vectors into their x and y components: *pay attention to signs!*

- A. $890 @ 150^\circ$
- B. $0.00556 @ 60^\circ$
- C. $6.50 @ 345^\circ$
- D. $7.5 \times 10^4 @ 180^\circ$
- E. $12 @ 265^\circ$



$$x = 890 \cos 150^\circ = -770$$
$$y = 890 \sin 150^\circ = 450$$

Part 3: Graphing

The goal of a physics experiment is to determine how two sets of measurements are related to each other. In some physics experiments, you do not have clearly defined independent and dependent variables. Instead, your focus is in understanding the two things you are measuring and why you need to measure them. Once you have two sets of measurements, your next step is to create the graph.

NEVER free-hand sketch a graph. **NEVER** use data table points to determine a slope (use the best fit line only). **ALWAYS** label the axes and include units.

Use either graph paper or graphing software. Use the x-axis for the independent variable (that which is experimentally varied; also known as the manipulated variable – the “cause” of the change) and the y-axis for the dependent variable (that which is a function of the independent variable; also known as the responding variable – the “effect” caused by the other variable).

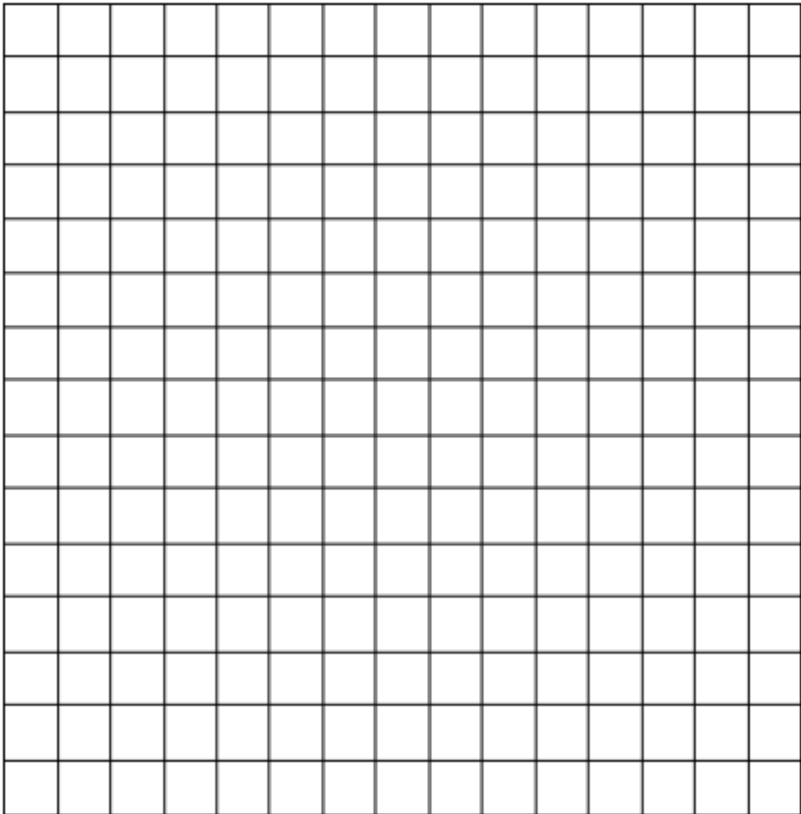
For example, if your graph is position vs. time, position is on the y-axis and time is on the x-axis. You are attempting to see how the position varies with time, or stated in another way, you are studying “time dependent position.” You should always use a ruler if possible.

Let’s say we need to determine the spring constant, or the measure of the stiffness/strength, of a vertically hanging spring. To do this we need to set up an experiment with a spring loaded with various masses. The spring stretches different amounts when we add different sized masses. During this experiment, we measure two quantities, the weight (force) in newtons hanging on the spring and the stretch of the spring in meters. A table of results is below. **Graph the data.**

Force (N)	Stretch (m)
0.2	0.15
0.4	0.35
0.6	0.65
0.8	0.75
1.1	1.30
1.5	1.60
2.0	2.10

Slope (with units) =

Equation =



This is a typical graph of a physics experiment. The data should clearly show the relationship between the two sets of measurements. In this case, it is a linear relationship. The line is a “trend line” or “line of best fit” or “best-fit line.” All data does not fall on the line, but that is to be expected when dealing with real data.

However, your best-fit line should always include equal numbers of points above and below the line. You do **NOT** – in any way – need to use a graphing calculator to determine this line!

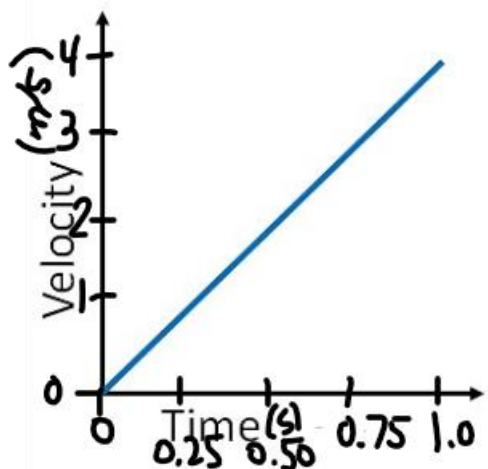
Also, consider if the point (0, 0) has physical meaning. For our example, ask yourself, “Would the spring stretch at all if zero mass was hanging?” The answer is no. Therefore, the trend line should pass through (0,0). The answer to other experiments may not always be “yes,” and that’s when your trend line does *not* have to pass through the origin.

The value representing the best-fit line is called the **slope**, which measures how fast one quantity changes compared to another – the units for the value qualify the quantities.

For example, a graph of velocity (~speed) in meters, or **m/s**, versus time in seconds, or **s**, would result in an acceleration measured in **m/s/s**, or **m/s²**. If the value of the slope is 4 m/s², this means that the velocity changes by 4 m/s with every second of time that passes. If the slope is 8 m/s², there is a greater velocity change in the same amount of time **or** the same velocity change takes *less* time; either way, the acceleration is greater!

The equation for the spring constant graph’s trend line follows the linear slope form of $y = mx + b$, or $F = mx + b$. Determine the **slope (with units)** and write the **equation for this data** (omit the y-intercept, b , since the y-axis was intercepted at 0.)

In addition to examining the data line, the area under the line on the graph often has meaning. Let’s look at the velocity vs time graph mentioned earlier:



To determine the area under the graph, we would be determining the area under a triangle with a height of 4 meters per second and a base of 1.0 second.

$$A = \frac{1}{2} \frac{4 \text{ m}}{\text{s}} \times 1.0 \text{ s} = 2 \text{ m}$$

So what does this value mean? The unit is the key -- this is how **far** the object travels in that 1 second of time!

Only graphs with a y-axis that represents a rate of change of the x-quantity will have an area that has meaning.

Return to the spring constant graph and determine the area under the graph (including units). What do you think that area represents?

But what if the graph is curved? Here is where the fun begins! If we get a nonlinear relationship (a curved graph) between our physical quantities, it will be one of the same variable relationships discussed earlier: quadratic, square root, inverse, or inverse-square. *You should be familiar with what each of these curved graphs looks like!*

However, since only calculus can be used to accurately evaluate the nature of curves, we need to convert those curves into lines. This is called **linearizing the data**, and it's probably the most important data analysis skill you can learn in an AP Physics course.

Here is how to linearize a data set:

1. Graph the original data.
2. Determine the type of relationship you determined your graph represents based on its shape (quadratic, inverse, square root, or inverse-square).
3. Manipulate your data's x values according to this relationship.
For example, if the relationship is quadratic, x changes to x^2 , so square all your x values.
If the graphed shape would have been a square root curve, you'd take the square root of all your x values.
4. Create a graph of the new data.
5. Use the slope-intercept form of the new best-fit line to create the exact relationship for your data.

Below is a sample set of data that represents an object's position as a function of time, or position vs. time.

Follow the above steps to **linearize the data**.

Plug the manipulated data into the blank column in the data table.

Identify the *relationship* of the original data, calculate the *slope* of the linearized data, determine the *equation* for the linearized best-fit line, and finally determine the *area* under the linear graph.

Explain what the slope and area *mean* from a physical sense.

Relationship =

Slope (with units) =

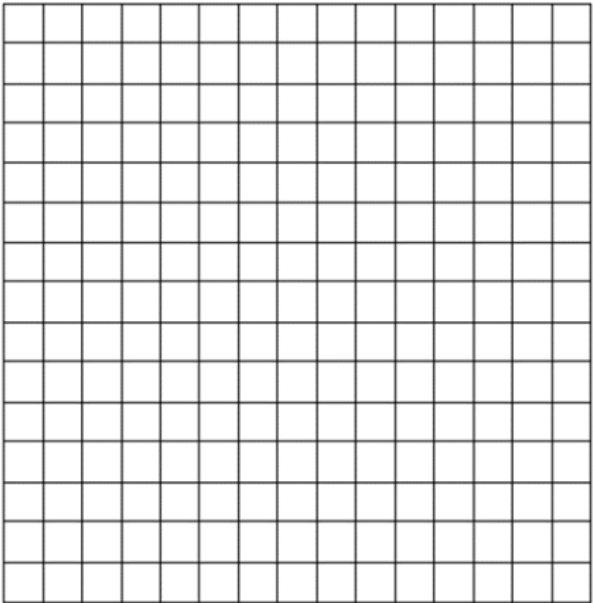
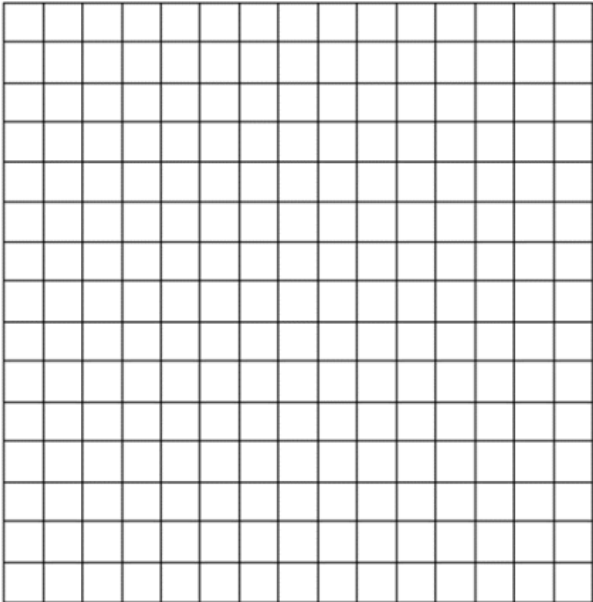
What does it mean?

Equation =

Area =

What does it mean?

Position (m)	Time (s)	
5	0.0	
10	1.0	
16	1.5	
26	2.0	
36	2.5	
51	3.0	



Part 4: The Free Response Questions (This stuff is NOT on the assessment)

AP Physics 1 is not just about getting the right answer: it is about *explaining your reasoning, using mathematical relationships, and connecting multiple representations of physics concepts*.

The free-response questions (FRQs) on the AP exam are designed to assess these skills.

The example FRQs in this packet are included to:

- Introduce the types of questions you will encounter on the AP exam
- Show how physicists communicate thinking clearly using words, equations, and diagrams
- Highlight how problems are structured in a multi-step, reasoning-based format
- Help you begin to recognize how concepts, mathematics, and representations work together

You are not expected to know how to solve these questions yet. Instead, focus on:

- Noticing how each part builds on the previous one
- Observing how explanations use relationships between variables, not just numbers
- Becoming familiar with the style and expectations of AP-level problem solving

These examples are meant to give you a preview of the thinking you will develop throughout the year.

#1 Mathematical Routines – MR (10 pts; suggested time 20-25 min)

A student investigates the motion of an object of mass m sliding down a frictionless incline at an angle θ to the horizontal.

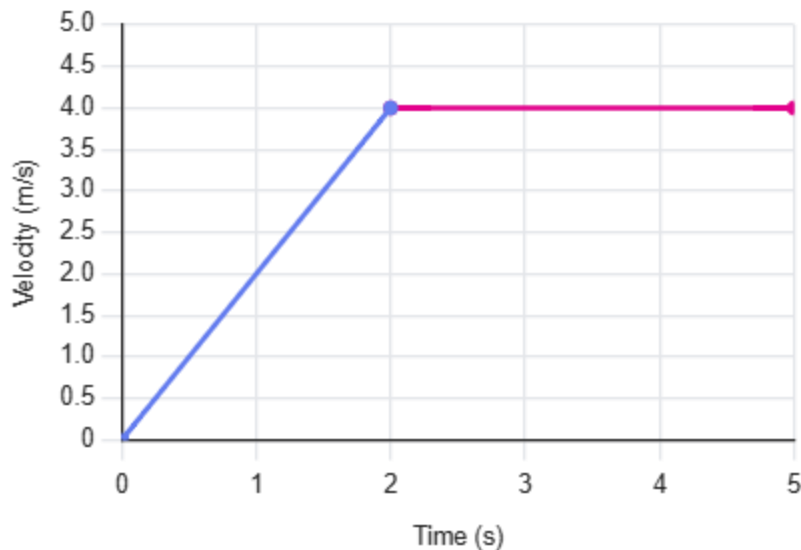
- a) Starting from Newton's Second Law, derive an expression for the acceleration of the object in terms of g and θ .
- b) The student now considers how the acceleration changes if the angle is increased. Without doing any numerical calculations, determine whether the acceleration increases, decreases, or remains the same as θ increases. Justify your answer using your equation from part (a).
- c) A second object of mass $2m$ is placed on the same incline. Using your expression from part (a), determine how the acceleration of this object compares to that of the original object. Justify your answer mathematically.
- d) Friction is now introduced, with coefficient of kinetic friction μ_k . Write a new expression for the acceleration of the object in terms of g , θ , and μ_k .

Answers:

- a) $\Sigma F = ma$
 $mg \sin \theta = ma$
 $a = g \sin \theta$
- b) As θ increases, $\sin \theta$ increases. Since $a = g \sin \theta$, the acceleration increases as θ increases.
- c) The mass m does not appear in the equation $a = g \sin \theta$, so acceleration is independent of mass. Therefore, the object of mass $2m$ has the same acceleration as the original object.
- d) $f_k = \mu_k mg \cos \theta$
 $\Sigma F = mg \sin \theta - f_k = ma$
 $mg \sin \theta - \mu_k mg \cos \theta = ma$
 $a = g(\sin \theta - \mu_k \cos \theta)$

#2 Translation Between Representations – TBR (12 pts; suggested time 25-30 min)

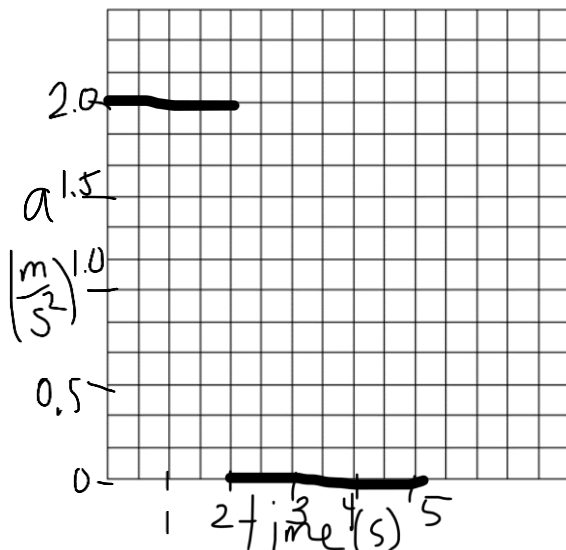
A cart moves along a straight horizontal track. The graph below shows the cart's **velocity as a function of time**.



- Describe the motion of the cart during the time interval from $t = 0$ to $t = 5$.
- Determine the acceleration of the cart during the first 2 seconds.
Explain how you obtained your answer using the graph.
- Calculate the total displacement of the cart from $t = 0$ to $t = 5$.
Explain how the graph represents this quantity.
- Sketch a graph of acceleration vs. time for the cart over the interval from $t = 0$ to $t = 5$.

Answers:

- From $t = 0$ to $t = 2$ s, the cart has a constant positive acceleration
From $t = 2$ to $t = 5$ s, the cart is in equilibrium (net force is 0) because the velocity is constant
- $a = \Delta v / \Delta t = (4 - 0) / (2 - 0) = 2 \text{ m/s}^2$
Acceleration is the slope of the velocity-time graph
- The area under the velocity-time graph is displacement
Triangle from $0 - 2$ s = $\frac{1}{2} \times 2 \times 4 = 4$ m
Square from $2 - 5$ s = $3 \times 4 = 12$ m
 $12 + 4 = 16$ m
-



#3 Experimental Design and Analysis – LAB (10 points; suggested time: 25-30 minutes)

A student is given a battery-operated toy car and is asked to design an experiment to determine the constant velocity of the car as it moves across a horizontal floor.

- a) In the table below, list the quantities that would be measured in your experiment, the symbol used to represent each quantity, and the equipment that would be used to measure each quantity.

Quantity to be Measured	Symbol for Quantity	Equipment for Measurement

- b) Describe the steps of the experimental procedure to be used to determine the velocity. Include any steps necessary to reduce experimental uncertainty. Give enough detail so that another student could replicate the experiment.
- c) Explain how the measured quantities listed in part (a) would be used to determine the velocity of the car.
- d) A second student performs the experiment but notices the car slows down slightly as it nears the end of its motion. Explain how this would affect the relationship between the measured quantities.

Answers:

a)

Quantity to be Measured	Symbol for Quantity	Equipment for Measurement
distance traveled	d	meter stick
time	t	stopwatch

- b)
1. Use a meter stick and masking tape to mark a starting line and four additional lines at distances of 0.5m, 1.0m, 1.5m, and 2.0m from the start.
 2. Place the car at the starting line and turn it on.
 3. Use a stopwatch to measure the time it takes for the car to travel from the start to the 0.5m mark.
 4. Repeat the measurement for five trials at this distance to minimize the impact of random timing uncertainty from human reaction time.
 5. Repeat steps 3 and 4 for the remaining distances (1.0m, 1.5m, 2.0m).
- c) To determine the velocity, plot a graph of distance (d) vs. time (t). Since the car moves at a constant speed, the data will follow the linear relationship $d = vt$. A line of best fit will be drawn through the data points. The slope of this best-fit line represents the velocity of the car.
- d) If the car slows down, the relationship between distance (d) and time (t) will no longer be linear. As the velocity decreases, the car will cover less distance in each subsequent time interval. On a distance vs. time graph, this would cause the data points to "curve" downward, meaning the slope (velocity) is decreasing over time.

#4 Qualitative/Quantitative Translation – QQT (8 pts; suggested time 15-20 min)

A block of mass m is attached to a horizontal spring with spring constant k . The block is pulled to the right a distance x_0 from equilibrium and released from rest on a frictionless surface.

(a) Describe the motion of the block immediately after it is released.

In your description, include the direction of the block's velocity and acceleration.

(b) Using an appropriate physics principle, determine the speed of the block as it passes through the equilibrium position ($x = 0$).

(c) Now consider a second spring with a larger spring constant $2k$. The same block is pulled the same distance x_0 and released.

Determine how the speed at equilibrium compares to that in part (b).

Justify your answer mathematically.

(d) If the initial displacement is doubled to $2x_0$, determine how the maximum speed of the block changes.

Support your answer with appropriate reasoning.

Answers:

a) Immediately after release, the spring exerts a restoring force to the left. Since $F = ma$, the acceleration is to the left. As the block begins moving from rest, its velocity also points to the left.

b) Use conservation of energy: $\frac{1}{2} kx^2 = \frac{1}{2} mv^2$ $v = x_0 \sqrt{\frac{k}{m}}$

c) $v = x_0 \sqrt{\frac{2k}{m}} = \sqrt{2} x_0 \sqrt{\frac{k}{m}}$

Since v is proportional to $\sqrt{k}$, doubling k while keeping m and x_0 constant results in the speed being multiplied by a factor of $\sqrt{2}$

d) $v = (2x_0) \sqrt{\frac{k}{m}} = 2 \left(x_0 \sqrt{\frac{k}{m}} \right)$

Based on the expression derived in part b, v is directly proportional to the initial displacement x_0 . Therefore, doubling the displacement results in exactly double the maximum speed.