AP Physics 1 Summer Assignment

Welcome to AP Physics 1!

Before we dive into the exciting world of physics, we're going to dust off some of your algebra skills with this summer assignment.

You'll see equations on the following pages that may look unfamiliar or intimidating — that's okay! You are **not** expected to understand the physics behind them yet. For now, treat each equation like a puzzle: your job is simply to **manipulate the variables algebraically**, just like you did in Algebra 1 and Geometry.

Most of you took Geometry last year, and I know your algebra might be a bit rusty — that's exactly why this assignment exists. It's designed to help you review key skills like rearranging equations, solving for unknowns, and working with variables and fractions, all in preparation for the kind of thinking we'll do in AP Physics 1.

So don't worry about what acceleration or momentum *means* yet — just practice treating the equations as tools to solve for different variables. You'll build confidence with the math now, and we'll layer in the physics understanding once the school year begins.

You've got this — and I can't wait to explore physics with you this fall!

— Mr. Ferguson

Here is a list of common physical quantities and their units. In each of the problems below, make sure your answers have the correct units.

Basic Mechanics

- **Length / Distance** – meter (m)
- **Mass** – kilogram (kg)
- **Time** – second (s)
- **Velocity / Speed** – meters per second (m/s)
- **Acceleration** – meters per second squared (m/s²)
- **Force** – newton (N) → 1 N = 1 kg·m/s²
- **Energy / Work** – joule (J) → 1 J = 1 N·m
- **Power** – watt (W) → 1 W = 1 J/s
- **Momentum** – kilogram·meters per second (kg·m/s)
- **Impulse** – newton·second (N·s)

The **4 big kinematic equations** describe motion with constant acceleration. Each equation relates different variables:

- v: final velocity
- v_i: initial velocity
- a: acceleration
- t: time
- x: final position
- x_i: initial position
- $\Delta x = x - x_i$: displacement (change in position)

Kinematic Equation 1: $v = v_i + at$

This equation gives the final velocity after time t, starting from an initial velocity v_i and accelerating at rate a.

Problem 1.
Jasmine is rollerblading. She ends up going 14 m/s after accelerating at 2 m/s² for a certain amount of time. If she started at 6 m/s, how long was she accelerating?

Problem 2.
A rocket is accelerating at 10 m/s² for 4 seconds. If it reaches a final speed of 80 m/s, what was its starting speed?

Problem 3.
A sprinter starts a race at a speed of 3 m/s and reaches a final speed of 11 m/s after running for 4 seconds. What was the sprinter's acceleration?

Kinematic Equation 2:

$$\Delta x = \frac{1}{2}(v + v_i)t$$

This equation finds the displacement by using the average of the initial and final velocities over a time t.

Problem 4.
A vehicle travels 600 meters in 10 seconds. If it started at 20 m/s, what was its final speed?

Problem 5.
A person runs from rest to a final speed of 8 m/s. If they travel 48 meters in that time, how long did it take?

Problem 6:
A cyclist travels 180 meters in 12 seconds. By the end of that time, their speed is 20 m/s. What was their initial speed?

Kinematic Equation 3:

$$x = x_i + v_i t + \frac{1}{2} a t^2$$

This equation calculates displacement from the starting speed, acceleration, and time.

Problem 7.
A dog starts running at 3 m/s and accelerates at 1 m/s². After 40 meters, how long was it running?

Problem 8.
A cyclist accelerates at 0.5 m/s² for 6 seconds and travels 60 meters during that time. What was their starting speed?

Problem 9.
A car starts with a speed of 10 m/s and travels 150 meters in 5 seconds. What was the car's acceleration?

Kinematic Equation 4: $v^2 = v_i^2 + 2a\Delta x$

This equation relates velocity, acceleration, and displacement without involving time.

Problem 10.
A skateboarder starts at 2 m/s and accelerates at 3 m/s² over a distance of 10 meters. What is their final speed?

Problem 11.
A ball rolls to a stop from an initial speed of 6 m/s. If it was slowing down at a rate of 1.5 m/s², how far did it roll before stopping?

Problem 12.
A motorcycle speeds up from 12 m/s to 28 m/s while covering a distance of 160 meters. What was its acceleration?

Conservation of Energy Equation:

$$\frac{1}{2}mv_i{}^2 + mgh = \frac{1}{2}mv_f^2$$

This equation says:

- The **initial total mechanical energy** (kinetic + potential) at height h and speed v
- equals the **final kinetic energy** at the ground (where potential energy is zero).

Problem 13: Solve for Final Speed
A rock is thrown downward from the top of a 45-meter cliff with an initial speed of 5 m/s. What is its speed just before it hits the ground?
$\left(g = 9.8 \text{ m/s}^2\right)$

Problem 14: Solve for Initial Speed
A diver jumps off a 10-meter platform and hits the water moving at 14 m/s. What was the diver's speed at the moment of the jump?
$\left(g = 9.8 \text{ m/s}^2\right)$

Problem 15: Solve for Height
A ball is dropped $(v_i = 0)$ from a certain height and reaches the ground with a speed of 20 m/s. From what height was it dropped?
$\left(g = 9.8 \text{ m/s}^2\right)$

When analyzing an **Atwood machine** (a system with two masses connected by a string over a frictionless pulley), you typically get **two equations**: one from **Newton's Second Law** for each mass.

Let's define:

- m_1: mass on one side
- m_2: mass on the other side
- T: tension in the string
- a: acceleration of the system (same magnitude for both masses)
- g: acceleration due to gravity

Assuming $m_2 > m_1$ (so the system accelerates with m_2 going down and m_1 going up), the equations are:

Equation for m_1:

$$T - m_1 g = m_1 a$$

Equation for m_2:

$$m_2 g - T = m_2 a$$

Problem 16.

Use those equations to solve for a and T in terms of $m_1, m_2,$ and g.

When **two objects collide and stick together**, it's a **perfectly inelastic collision**, and **momentum is conserved**.

Conservation of Momentum Equation:

$$m_1v_1+m_2v_2=(m_1+m_2)v_f$$

Where:

- m_1, m_2: masses of the two objects
- v_1, v_2: velocities before the collision (signs matter — one will be negative if they're moving toward each othe
- v_f: common final velocity after sticking together

Problem 17:
A 3 kg cart is moving to the right at 4 m/s, and a 2 kg cart is moving to the left at 6 m/s. The carts collide and stick together. What is their final velocity after the collision?

Problem 18:
A 0.3 kg ball is rolling to the right at 6 m/s. It collides with a stationary 0.5 kg ball, and they stick together. What is their final velocity after the collision?

Problem 19: Same Direction Collision
A 1.5 kg cart is moving to the right at 5 m/s. Ahead of it, a 2 kg cart is moving in the same direction at 2 m/s. The faster cart catches up and collides with the slower one, and they stick together after the collision. What is their final velocity?

Types of Equations and Graphs:

Problem 20:
Look again at **Kinematic Equation 1**; it's a function of t:

$$v = v_i + at$$

- What kind of function is it?

- What does its graph look like?

Problem 21:
Look again at **Kinematic Equation 2**; it's also a function of t:

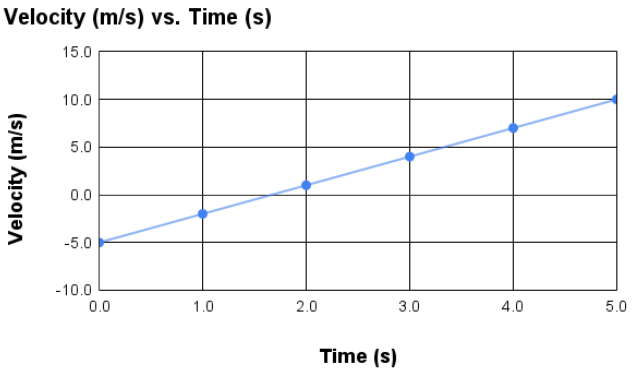
$$x = x_i + v_i t + \frac{1}{2}at^2$$

- What kind of function is it?

- What does its graph look like?

- What would change if the acceleration was zero? $(a = 0)$

Problem 22:
Here is a v vs. t graph.



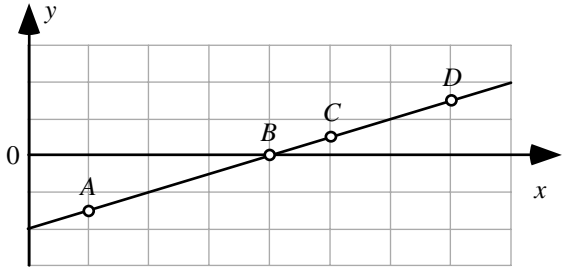
- What is a?

- What is v_i?

- Approximately, when is the object at rest?

A1-RT01: Line Graph I—Slope

Four points are labeled on a line.



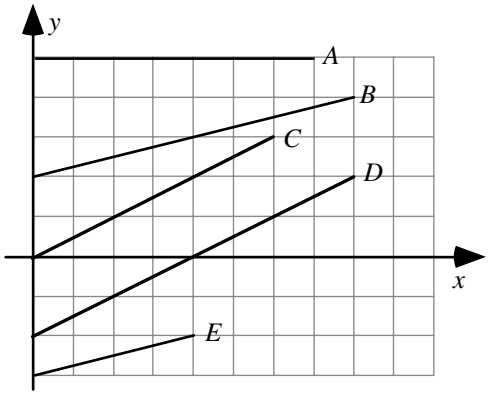
Rank the magnitudes (sizes) of the slopes of the line at the labeled points.

				OR			
☐	☐	☐	☐		☐	☐	☐
1 Greatest	2	3	4 Least		All the same	All zero	Cannot determine

Explain your reasoning.

A1-RT02: Y-X GRAPH LINES—SLOPE

Shown are several lines on a graph.



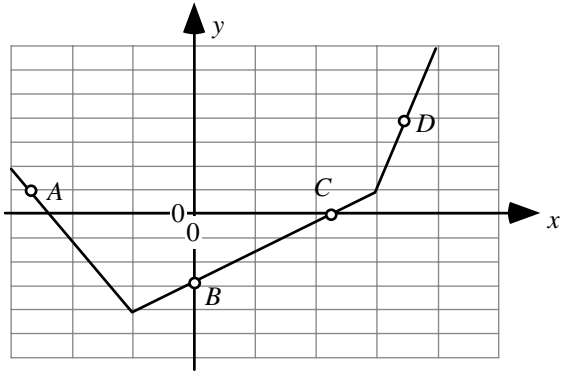
Rank the slopes of the lines in this graph.

					OR			
1 Greatest	2	3	4	5 Least		All the same	All zero	Cannot determine

Explain your reasoning.

A1-RT03: COMPLEX LINE GRAPH—MAGNITUDE OF SLOPE

Four points are labeled on a graph.



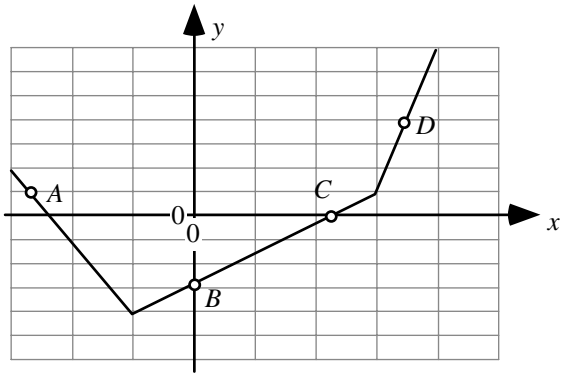
Rank the magnitudes (sizes) of the slopes of the graph at the labeled points.

				OR			
1 Greatest	2	3	4 Least		All the same	All zero	Cannot determine

Explain your reasoning.

A1-RT04: COMPLEX LINE GRAPH—SLOPE

Four points are labeled on a graph.



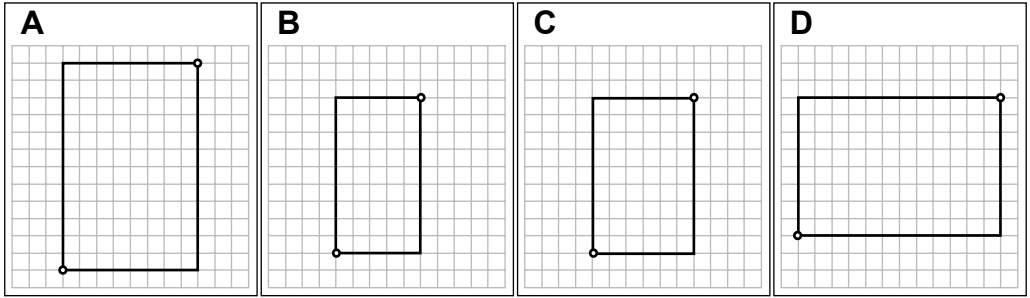
Rank the slopes of the graph at the labeled points.

				OR			
1 Greatest	2	3	4 Least		All the same	All zero	Cannot determine

Explain your reasoning.

A1-RT05: Four Rectangles—Slope of Diagonals

In each case, a rectangle is drawn on a grid.



Rank the slopes of the diagonals between the points marked with dots for these rectangles.

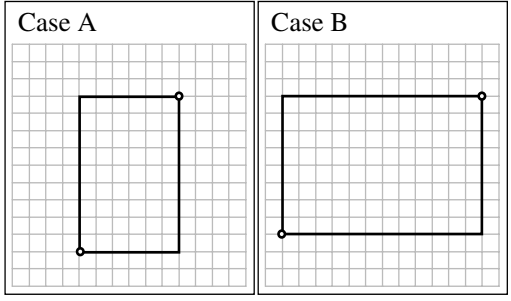
				OR			
1 Greatest	2	3	4 Least		All the same	All zero	Cannot determine

Explain your reasoning.

A1-WWT06: RECTANGLE—SLOPE OF DIAGONALS

In each case, a rectangle is drawn on a grid. A student makes the following statement in comparing the slopes of the diagonal lines connecting the corners marked by dots:

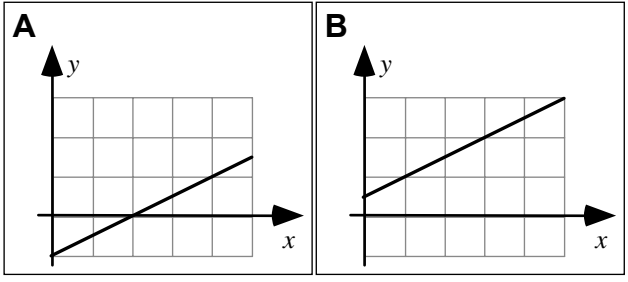
> "The steepness of a line depends on how much the line rises compared to its run. For Case A the rise is 9, and the run is 6, and the difference between rise and run is 3. For Case B, the rise is 8 and the run is 12 and the difference is minus 4. Case B has a smaller slope than Case A, and in Case B the slope is negative."



What, if anything, is wrong with this student's statement? If something is wrong, identify and explain how to correct all errors. If this statement is correct, explain why.

A1-CT07: LINE GRAPH II—SLOPE

Shown are two graphs.

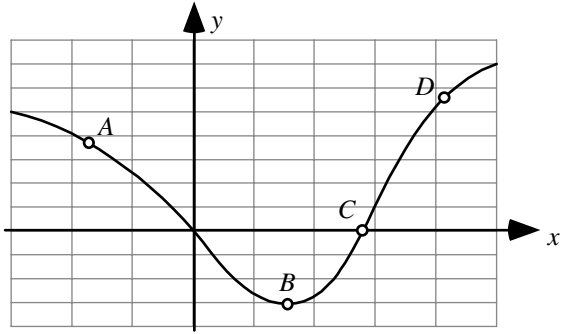


Is the slope of the graph (i) *greater in Case A*, (ii) *greater in Case B*, or (iii) *the same in both cases?* _____

Explain your reasoning.

A1-RT08: CURVED LINE GRAPH—SLOPE

Four points are labeled on a graph.



Rank the slopes of the graph at the labeled points.

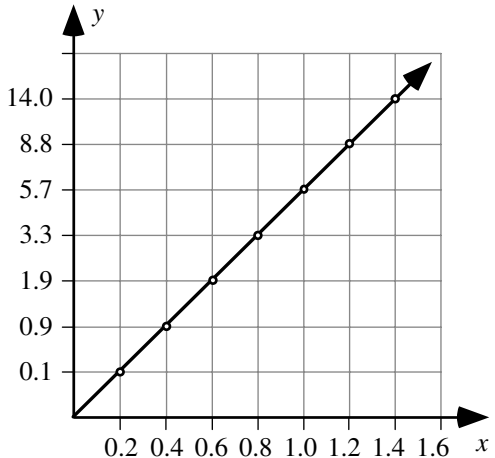
				OR			
1 Greatest	2	3	4 Least		All the same	All zero	Cannot determine

Explain your reasoning.

A1-WWT09: TWO COLUMNS OF DATA—DATA GRAPH

A student uses data from a table to make a graph as shown.

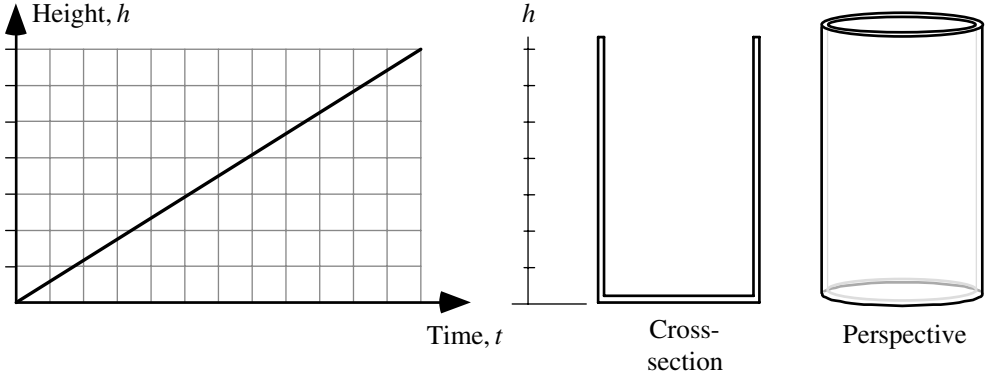
x	y
0.2	0.1
0.4	0.9
0.6	1.9
0.8	3.3
1.0	5.7
1.2	8.8
1.4	14.0



What, if anything, is wrong with this graph? If something is wrong, identify and explain how to correct all errors. If this statement is correct, explain why.

A1-WWT12: Filling a Cylindrical Glass—Height of Water-Time Graph

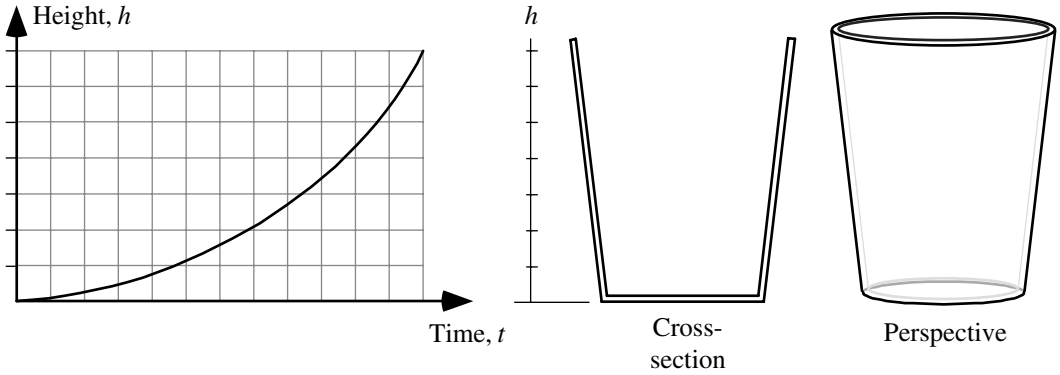
A cylindrical glass is filled using a tap with a constant flow rate of 4 ml per second. A student graphs the height of the water in the glass as a function of time as shown:



What, if anything, is wrong with this graph? If something is wrong, identify and explain how to correct all errors. If this is correct, explain why.

A1-WWT13: Filling Tapered Glass—Height of Water-Time Graph

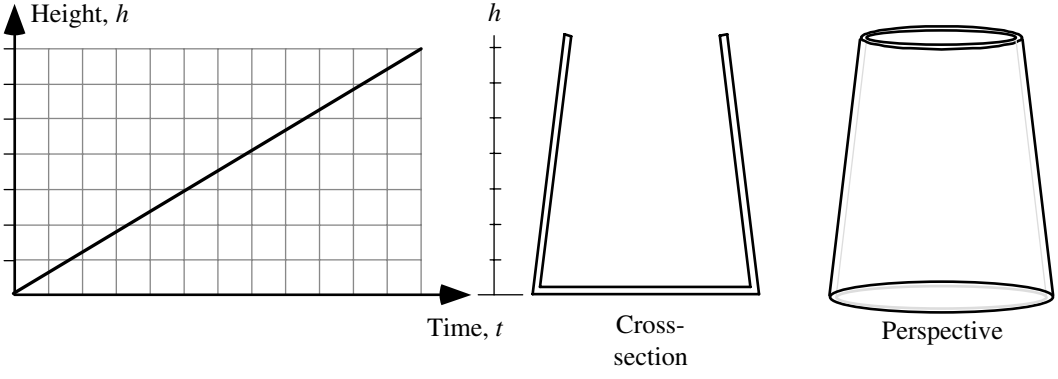
A glass is tapered so that it is wider at the top than at the bottom. The glass is filled using a tap with a constant flow rate of 4 ml per second. A student graphs the height of the water in the glass as a function of time as shown:



What, if anything, is wrong with this graph? If something is wrong, identify and explain how to correct all errors. If this is correct, explain why.

A1-WWT14: Filling Inverted Tapered Glass—Water Height-Time Graph

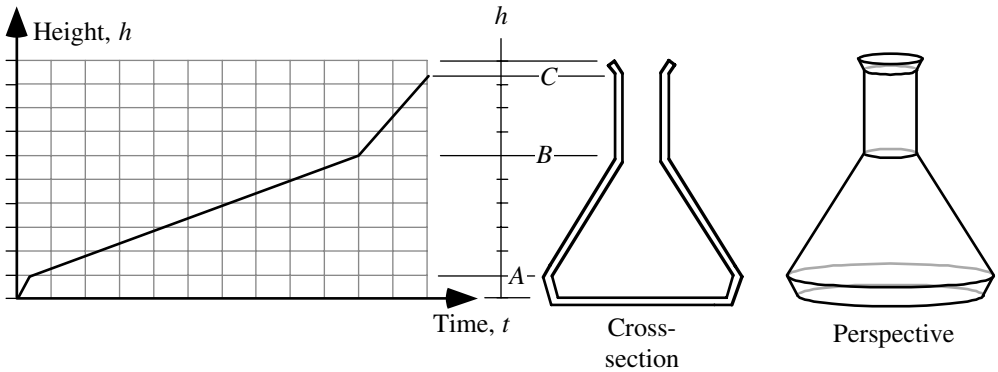
A glass is tapered so that it is narrower at the top than at the bottom. The glass is filled using a hose with a constant flow rate of 4 ml per second. A student graphs the height of the water in the glass as a function of time as shown:



What, if anything, is wrong with this graph? If something is wrong, identify and explain how to correct all errors. If this is correct, explain why.

A1-WWT16: Filling Complex Flask at Constant Rate—Height of Water-Time Graph

A flask has the complicated shape shown. The flask is filled using a hose with a constant flow rate of 4 ml per second.



A student graphs the height of the liquid in the flask as a function of time as shown above and makes the following statement:

> *"At first the flask is getting wider, so the graph increases quickly, then it gets narrower, so the height doesn't increase as quickly. Then, when the water reaches the neck, the flask stays a constant width, so the height increases at a constant rate."*

What, if anything, is wrong with this graph? If something is wrong, identify and explain how to correct all errors. If this is correct, explain why.

A1-WWT17: Cars and Trucks in Parking Lot—Statement

A student is told that the equation $3y = x$ represents the statement:

"There are three times as many cars as pickup trucks in the parking lot." She says, "The letter x represents the cars, and the letter y represents the pickups."

What, if anything, is wrong? If something is wrong, identify and explain how to correct all errors. If this is correct, explain why.

A1-SCT18: Inches and Feet—Equation

To express the relationship between inches and feet, someone writes "12*I* = 1*F*." Three students discussing this relation state:

Amy: *"The letter I is used as a unit in this case. There aren't any variables in this equation."*

Bea: *"The letter I is a variable and represents the number of inches."*

Cari: *"That can't be right, because if I let I equal 12 inches, then I get 144 inches equals 1F. And there are only 12 inches in a foot."*

With which, if any, of these students do you agree?

Amy _____ Bea _____ Cari _____ None of them_____

Explain your reasoning.

A1-WWT19: Boys and Girls on Dance Floor—Equation

A student is asked to represent the statement *"For every 5 girls on the dance floor there are 3 boys"* using G to represent the number of girls and B to represent the number of boys. He writes $5G = 3B$.

What, if anything, is wrong? If something is wrong, identify and explain how to correct all errors. If this is correct, explain why.

A1-WWT20: Students and Teachers—Equation

A student is asked to represent the statement *"There are 42 more students than teachers in the classroom"* using S for the number of students and T for the number of teachers. She writes $S = T + 42$.

What, if anything, is wrong? If something is wrong, identify and explain how to correct all errors. If this is correct, explain why.

A1-WWT21: Texting and Cost—Statement

A student is told that the equation $7y = 4x$ represents the statement *"For every 7 hours of texting I get charged 4 dollars."* She says, *"The letter* x *represents the number of hours of texting, and the letter* y *represents the number of dollars I am charged."*

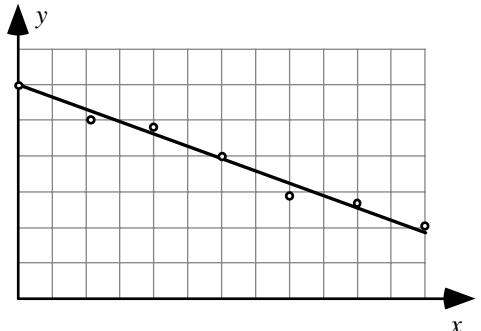
What, if anything, is wrong? If something is wrong, identify and explain how to correct all errors. If this is correct, explain why.

A1-WWT22: Line Data Graph—Interpretation

A student makes the following claim about some data that he and his lab partners have collected:

"Our data show that the value of y decreases as x increases. We found that y *is inversely proportional to* x*."*

What, if anything, is wrong with this statement? If something is wrong, identify and explain how to correct all errors. If this statement is correct, explain why.



A1-WWT26: INVERSE QUANTITIES—STATEMENT

A student is solving a problem using an equation that includes the variables *x, y,* and *z.* She says,

> *"We need to simplify the equation* $\frac{1}{x}=\frac{1}{y}+\frac{1}{z}$ *and then solve for* z. *First we invert, which gives* $x = y + z$. *Then we solve for* z *by subtracting* y *from both sides, and we get* $z = x - y$."

What, if anything, is wrong? If something is wrong, identify and explain how to correct all errors. If this is correct, explain why.

A1-QRT27: STATEMENT—DOUBLING EQUATION

A. $y = 2x$

B. $y = 3x$

C. $y = 2x + 7$

D. $y = -4x$

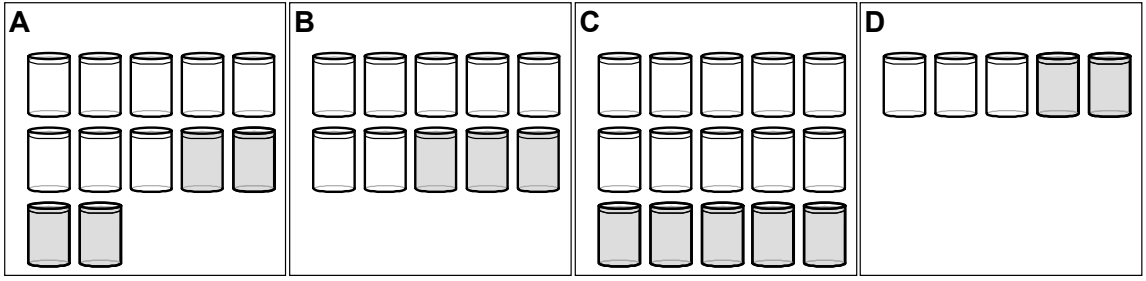
E. $y = x^2$

Which, if any, of these equations is consistent with the statement *"If* x *doubles, then* y *also doubles?"*

Explain your reasoning.

A1-RT28: Lemonade from Concentrate—Flavor Strength

Four students are mixing lemonade using a lemonade concentrate and water. They all have different recipes. In the diagrams, the darker cans represent lemonade concentrate and the lighter cans represent water.



Rank the mixtures based on how strongly flavored they are.

				OR			
1 Greatest	2	3	4 Least		All the same	All zero	Cannot determine

Explain your reasoning.

A1-RT29: Four Basketball Players—Free-Throw Skills

Four basketball players have the following statistics for free-throws:

	Name	Baskets Made	Baskets Missed
A	Aliza	13	6
B	Berta	14	3
C	Claudia	7	3
D	Diana	6	3

Based only on this small amount of data, rank the free-throw skills of the players.

☐ ☐ ☐ ☐ OR ☐ ☐ ☐

1 Greatest 2 3 4 Least All the same All zero Cannot determine

Explain your reasoning.

A1-QRT30: Four Basketball Players—Making Teams

Four basketball players have the following statistics for free-throws:

	Name	Baskets Made	Baskets Missed
A	Amalie	43	12
B	Beth	77	18
C	Cami	61	19
D	Diethra	58	11

(a) Based only on their free-throw statistics, choose teams for a 2-on-2 basketball game that is as evenly matched as possible.

Explain your reasoning.

(b) For the teams you have chosen (and again based only on their free-throw statistics), which team is likely to win?

Explain your reasoning.

A1-SCT34: Coal Mine Rescue Shaft—Time

Three students are working on the following problem:

> *"If it takes 70 hours to dig a coal mine rescue shaft 300 feet deep, how long should it take to dig another coal mine rescue shaft 1,500 feet deep?"*

The students make the following contentions:

Ally: *"Since it took 70 hours to dig 300 feet it will take five times as long to dig five times as deep, so it will take 350 hours."*

Bill: *"It takes them a little less than a quarter of an hour to dig one foot, so I get 349.5 hours, which almost agrees with Ally, but I am not sure who has the right answer."*

Clyde: *"The workers were able to dig at a rate of 4.29 feet per hour for the first shaft, so if they can do the same for the second it will take 349.7 hours. So I think we all agree and the numbers only differ because of rounding errors."*

With which, if any, of these students do you agree?

Ally _____ Bill _____ Clyde _____ None of them _____

Explain.

A1-QRT35: Pennies—Number of Pennies

Since 2,000 pennies have a mass of n kg, how many pennies would be needed to produce a mass of $1.6n$ kg? Explain.

A1-TT36: Six Page Physics Test—Weight

A certain physics test, which is several pages long, is copied on 20-pound paper (500 sheet have a weight of 20 pounds) so the weight per test is 0.25 pounds. The class has 39 students, so the instructor makes 40 copies of this test. What is the weight of the paper that he brings to class on test day?

A student presented with this problem carries out the following analysis:

> *"To find the total weight of the paper in the tests I need to divide the 40 copies by the 0.25 test/pound, and that will give me 16 pounds."*

The student's analysis is wrong; identify the problem and explain how to correct it.