# College Physics A - PHY 2053C

## Equations of Motion


01/26/2023

My Office Hours:
Wednesday 11:00 AM - 1:00 PM

212 Keen Building

# Warm-up Questions

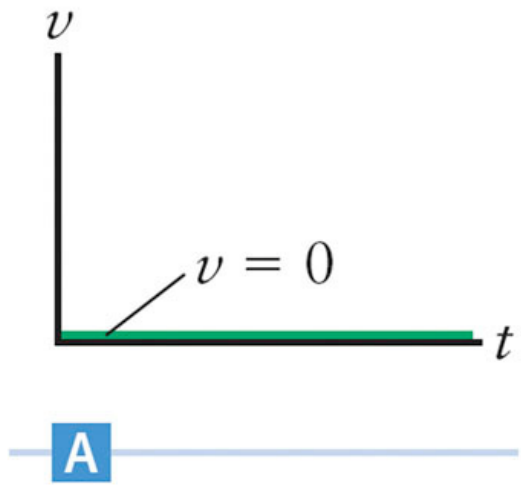
1. How is acceleration defined?
2. A projectile is launched at an angle of 30°.

   Is there any point on the trajectory where $\vec{v}$ and $\vec{a}$ are parallel to each other?
3. Is the velocity of the projectile zero at its maximum height?
4. How can something that is moving at a constant speed still be accelerating?

# Example: Velocity = 0

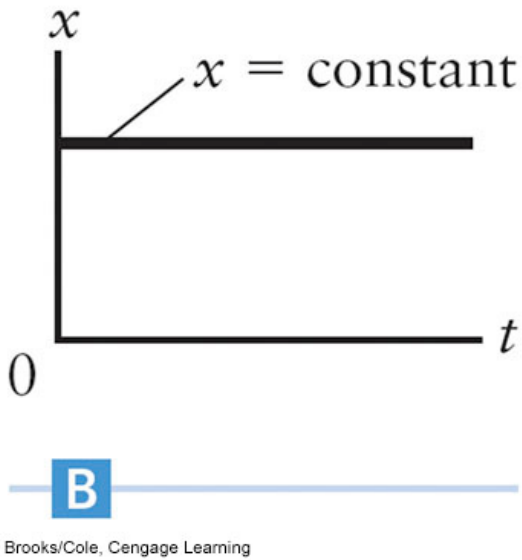
The velocity is zero.

➜ On the graph, the line is at $v = 0$.




The position is constant:

- Not moving, no change in position.
- On the graph, just a horizontal line.



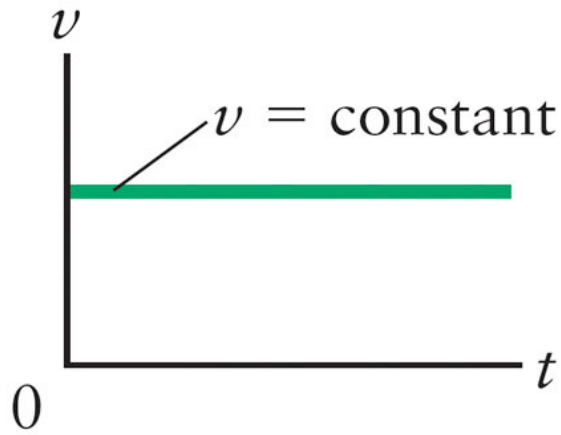
# Example: Velocity $\neq 0$

The velocity is not zero.

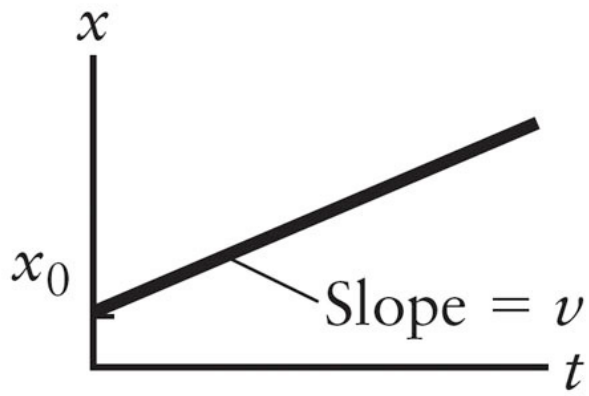
➜ On the $v$-$t$ graph, the line is at $v = \text{constant}$ value: $v = v_0$.

The position is changing steadily:

- Same $\Delta x$ each second: $\Delta x = v \cdot \Delta t$ or $x = x_0 + v \cdot t$.
- On the graph, an upward sloping straight line.
- Slope of the $x$-$t$ curve is equal to the value of velocity.




A




B

# Example: Constant Acceleration

## The acceleration is a constant:

- On the *a*-*t* graph, a straight horizontal line: $v = v_0 + a \cdot t$.
- Value depends on the total force exerted on (and mass of) the object.

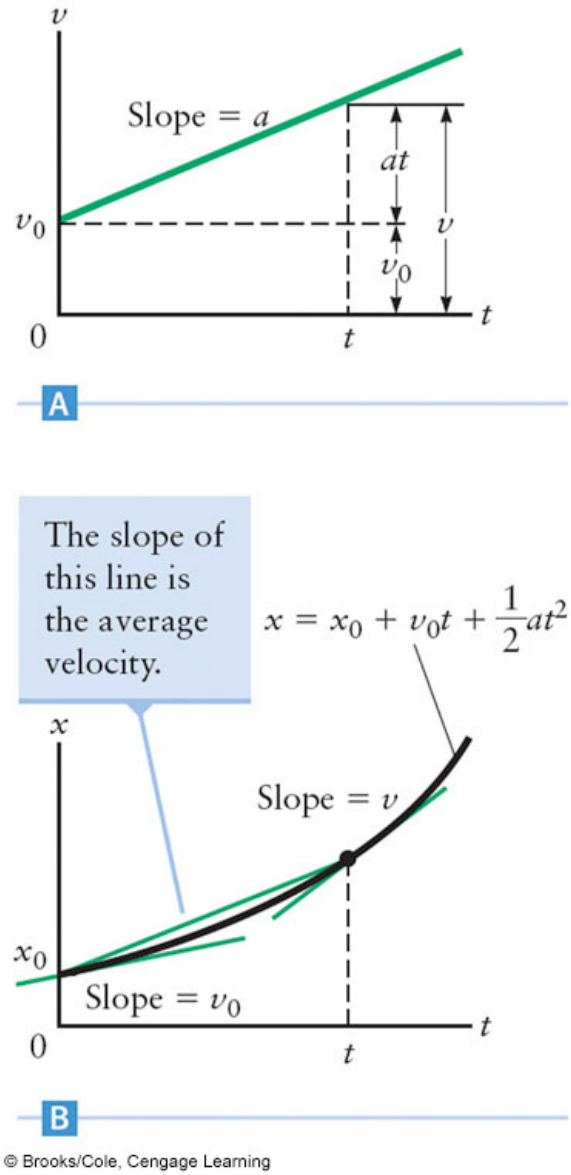
## The velocity is changing:

- On the *v*-*t* graph, this is an upward sloping straight line.

## The position is changing:

- On the *x*-*t* graph, a curved line is observed:

$$x = x_0 + v_0 \cdot t + \frac{1}{2} a \cdot t^2.$$



# Equations of Motions

## Equations to Describe Motion with Constant Acceleration:

$$v = v_0 + a\,t \tag{1}$$

$$x = x_0 + v_0\,t + \frac{1}{2}\,a\,t^2 \tag{2}$$

$$v^2 = v_0^2 + 2\,a\,(x_f - x_0)\,, \tag{3}$$

where $v_0$ is the velocity at some initial time $t = 0$, $x_0$ is the position at some initial time $t = 0$. Equation (3) eliminates time $t$ from the equation.

Which equation should be used depends on what information you are given in a particular problem and what you are asked to find.

# Problem 1

Bob throws a ball straight up at 20 m/s, releasing the ball 1.5 m above the ground. What is the maximum height of the ball? What is the ball's impact speed as it hits the ground?

MODEL: What models, physical laws, or general physics concepts should be applied? What are you looking for? What assumptions or estimations are needed? Guesstimate a reasonable answer with units. Consider limiting cases.

VISUALIZE: Draw a pictorial diagram labeled with variables your model. What is known? What is not? Draw any physics diagrams that would be useful.

SOLVE: Write down the equations that apply to this problem. Indicate in WORDS how you plan to solve the problem. Algebraically solve for the unknown variable in terms of the known variables. Substitute known values and calculate answer.

ASSESS: Is your result believable? Does the algebraic result make sense for any limiting cases that might improve your understanding of the result?? Does the answer agree with the prediction in your Model? Check your answer and units.

# Problem 2

A ball rolls along a smooth horizontal floor at speed $v$, then starts up a ramp that makes an angle $\theta$ with the horizontal. How high does the ball go up the ramp? (Assume the ball does not reach the end of the ramp.)

# Problem 3

## Simultaneous splat

Some students decide to make headlines in the Tallahassee Democrat by dropping watermelons from the 7th floor of the Keen building, which is at a height of 24 m. The resulting explosions of the watermelons are really fun to watch. Someone decides it would be fun to try and throw a watermelon straight down from the 7th floor, and simultaneously drop a watermelon from the walkway on the second floor, at a height of 4 m, and see if they can have them simultaneously splat on the ground by landing at the same time.

1. What is the velocity of the watermelon dropped from the second floor when it reaches the ground?
2. With what velocity should the student on the 7th floor throw her watermelon downward so that it reaches the ground at the same time as the watermelon dropped from the second floor?
3. What is the velocity of the watermelon thrown from the 7th floor when it reaches the ground?

For each step (c)-(e), try to work in symbols as much as possible, substituting numbers for these symbols only at the very end.