Acceleration Practice

Q03

acceleration = change in **velocity** over some time

Consider the following situations:

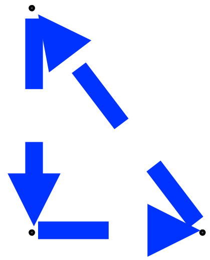
- a car slowing down at a stop sign
- a ball being swung in a circle at constant speed
- a vibrating string (ex: plucked guitar string)
- a person driving down a straight section of highway at constant speed with her foot on the accelerator

In how many of the situations is the object accelerating?

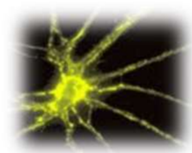
A. 0 **B. 1** **C. 2** **D. 3** **E. 4**

Reviewing Through Misconceptions

Research suggests that students learn better when they directly confront common misconceptions



- Displacement ≠ distance $\Delta x = x_f - x_i$
- Velocity ≠ speed, speed is distance over time, while average velocity is displacement over time.
- Instantaneous just means at a particular moment, not averaged.
- While the magnitude of the instantaneous velocity is the instantaneous speed, this is not necessarily the case for the average velocity and avg speed.



- Negative acceleration does NOT mean you are slowing down, sign depends on if the direction it is being pulled/pushed is the positive direction
- You can accelerate without ever changing your speed. But what must change then?

Equations of Motion

- I’m about to walk you through how a certain equation of motion we will use is derived.
- There is no need for you to understand the derivation, but I find that some students like it when they understand where it comes from.
- If you get confused, that’s ok! What’s most important is that you now how to use the formulas which we will practice next!

Motion at Constant Acceleration

Special case when *a* does not change with time

Notation:

$t_f = t \quad t_i = 0$

$x_f = x \quad x_i = x_o$

$v_f = v \quad v_i = v_o$

$$a = \frac{v_f - v_i}{t_f - t_i} \Rightarrow a = \frac{v - v_o}{t} \Rightarrow \boxed{v = v_o + at}$$

$$v_{avg} = \frac{x_f - x_i}{t_f - t_i} \Rightarrow v_{avg} = \frac{x - x_o}{t} \Rightarrow x = x_o + v_{avg} t$$

Similar derivations lead to more equations (see book):

$$\boxed{v_{avg} = \frac{v + v_o}{2}} \qquad \boxed{\Delta x = v_o t + \tfrac{1}{2} a t^2} \qquad \boxed{v^2 = v_o^2 + 2a\Delta x}$$

Constant acceleration equations. Only use if acceleration constant (most problems)

Might have a problem you have to break into steps (e.g. before/after brakes)

Which formula to use?

Constant a or not

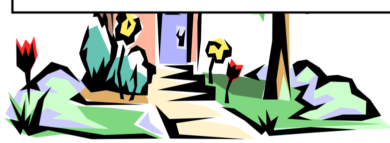
$$\bar{v} \equiv \frac{\Delta x}{\Delta t}$$

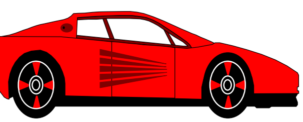
$$v = v_o + at$$

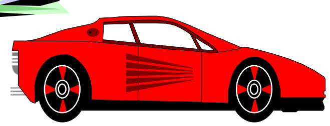
$$v^2 = v_o^2 + 2a\Delta x$$

$$v_{avg} = \frac{v + v_o}{2}$$

$$\Delta x = v_o t + \tfrac{1}{2} a t^2$$







v = final velocity

$v_o = v_i$ = initial velocity

Pro Tip #3: List what you know and need to know in variable form

- 1 equation with one unknown is solvable.
- 2 equations with two unknowns is solvable.
  - Pro Tip # 4: Practice helps you pick best formulas!

Practice Problem

A 50 gram superball traveling at 25 m/s bounces off a brick wall and rebounds at 22 m/s. A high-speed camera records this event. If the ball is in contact with the wall for 3.5 ms, what is the magnitude of the average acceleration of the ball for that time interval where it is in contact with the brick wall?

Planning a Strategy

A certain car is capable of accelerating at a rate of 0.60 m/s^2. How long does it take for this car to go from a speed of 55 mi/h to a speed of 60 mi/h?

What are our pro tips?

Draw picture and frame. List the knowns & unknowns

Want: Δt Know: v_o, v_f, a

Make sure your knowns have correct units/signs.

$v = v_o + a\,\Delta t$ rearrange: $\Delta t = (v - v_o)/a$

Can we just plug in our numbers?

Will need to convert mi/h to what? (or m/s^2 to what?)

While could do either, I find easier to stick to SI units.

While chasing its prey in a short sprint, a cheetah starts from rest and runs 45 m in a straight line, reaching a final speed of 72 km/h. (a) Determine the cheetah's average acceleration during the short sprint, and (b) find its displacement at $t = 3.5s$.