Review – Tools of the Trade

Converting Units

(Practice, See Me)

Estimation (not often)

Significant Figures (Lab)

(for homework, using 4 digits is a good plan)

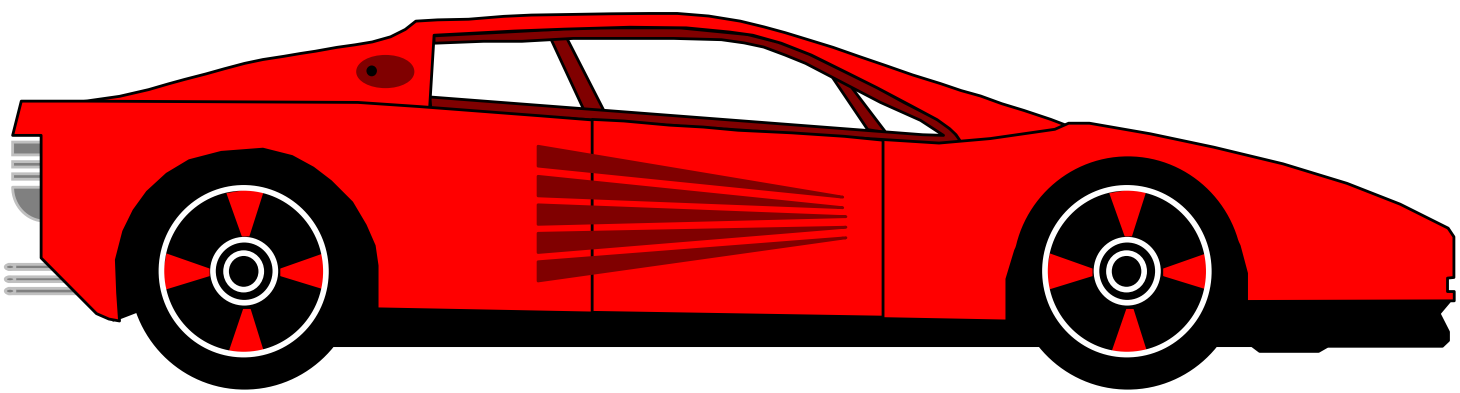
Reminders:

Tonight's HW due at 11:59PM

(Median score is 21.7/20)

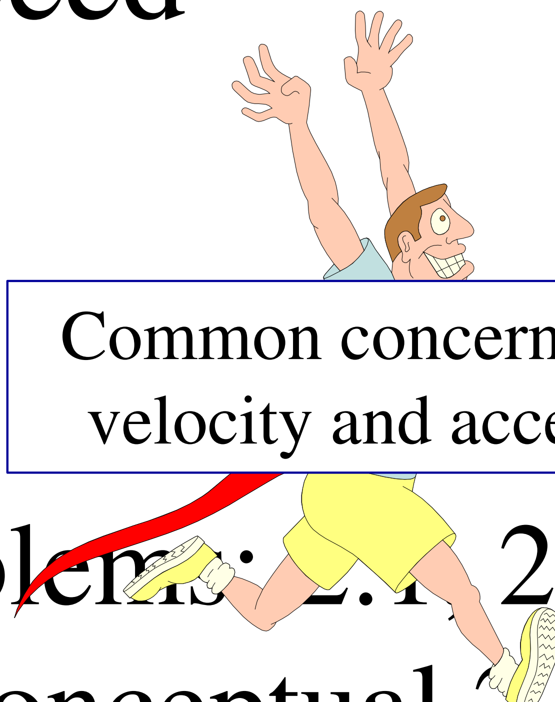
First quiz on Wednesday. Practice problems on Cengage.

How do we understand the motion of a car (and other stuff)?



Main Ideas in Class Today

- Motion in one dimension
- Displacement
- Velocity and Speed
- [illegible]



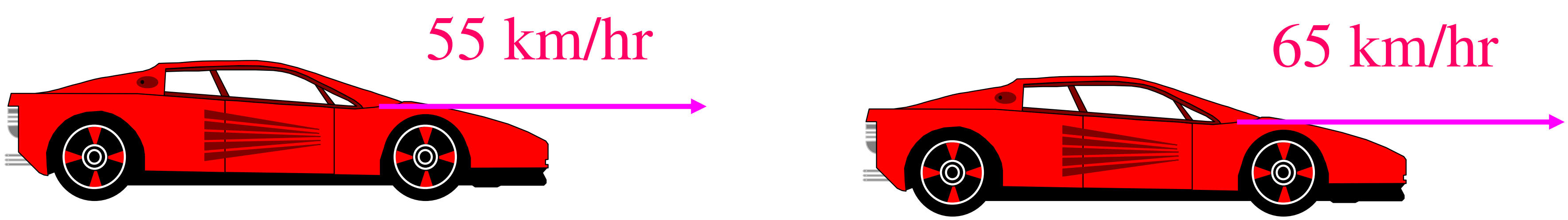
Common concerns: instantaneous velocity and acceleration, speed

Extra Practice Problems: 2.1, 2.3, 2.5, 2.7, 2.13, 2.21, Conceptual 2.1, 2.3, 2.5

Frame of Reference

- Describes how measurement of displacement, velocity or acceleration is made
  - Ex: Two cars moving in the same direction at 55 km/hr and 65 km/hr

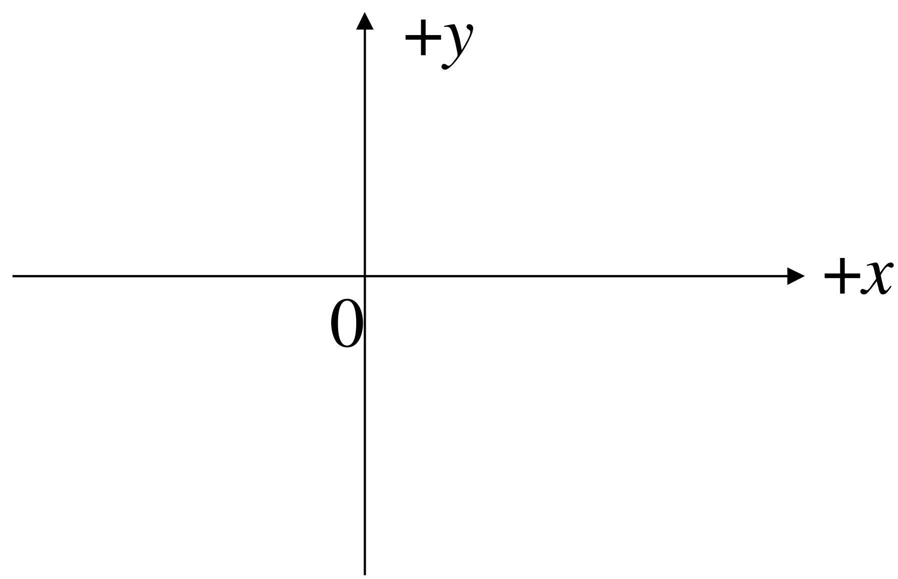
Pro Tip #1: Draw a picture



- In **ground** frame of reference one car moves at +55 km/hr while the other moves at +65 km/hr
- In reference frame of car on left, speed of car on right is +10 km/hr
- Generally assume the reference frame of the Earth (ground frame)
- Warning: weird things can happen if you take an accelerating frame

Pro Tip #2: Label Frame of Reference

- Frame of reference represented by a coordinate system



- The direction of these arrows is important for setting up problems and may affect the sign of your variables and/or answers (will see example soon)

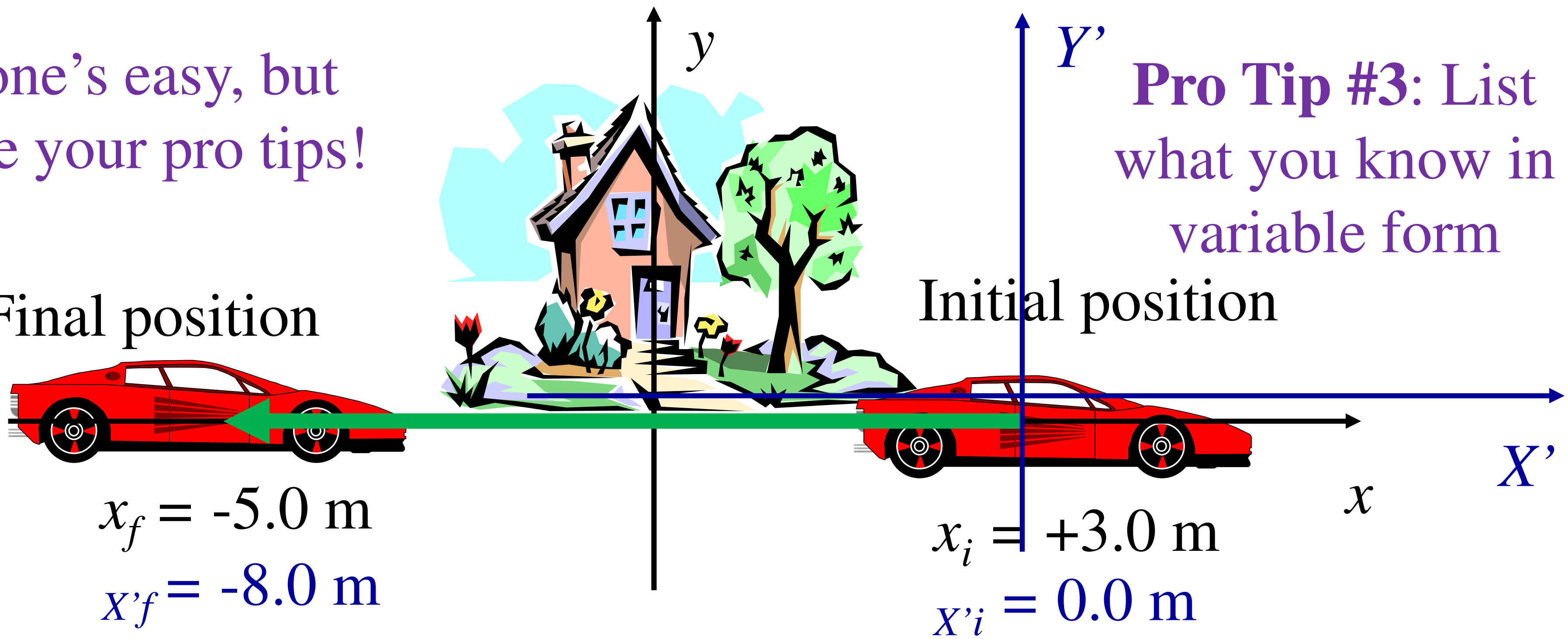
Displacement is a vector.

Definition: change in the position of an object

Ex: Car initially parked 3.0 m to right of house, drives around the block, ends up 5.0 m to left of house. Find the displacement of the car.

This one's easy, but practice your pro tips!

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

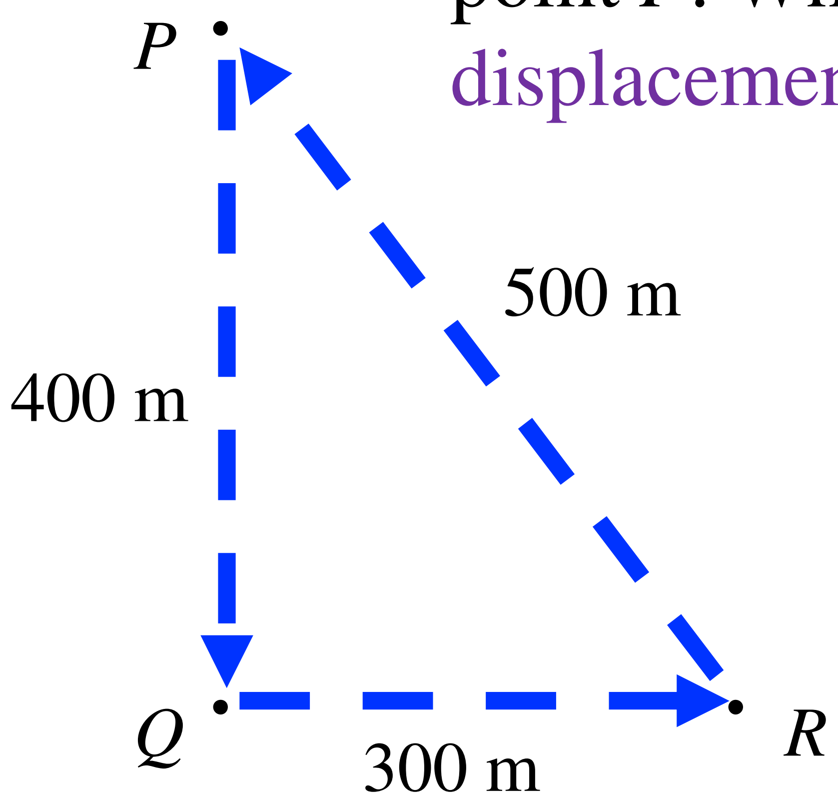


Displacement: $\Delta x = x_f - x_i$ $\qquad$ Δx = -5.0 m - (+3.0 m) = -8.0 m

Different reference frame $\qquad$ $\Delta x = x_f - x_i$ $\qquad$ Δx = -8.0 m – (0.0 m) = -8.0 m

Example Clicker Question (Ungraded) (Clickers Required Next Class)

A bicyclist starts at point *P* and travels around a triangular path that takes her through points *Q* and *R* before returning to point *P*. What is the magnitude of her net displacement for the entire round trip?



A. 100 m

B. 200 m

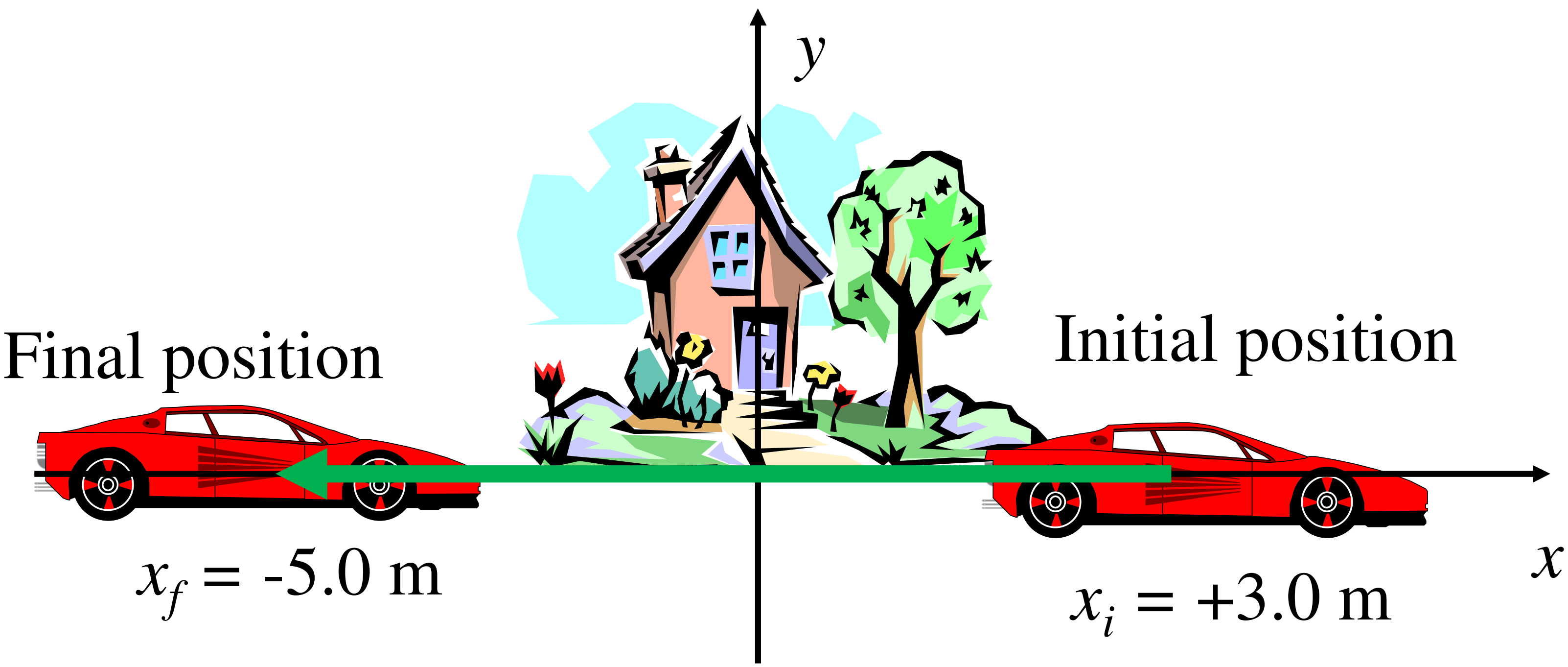
C. 600 m

D. 1200 m

E. zero

Q01

Vectors are typically represented as **bold.**



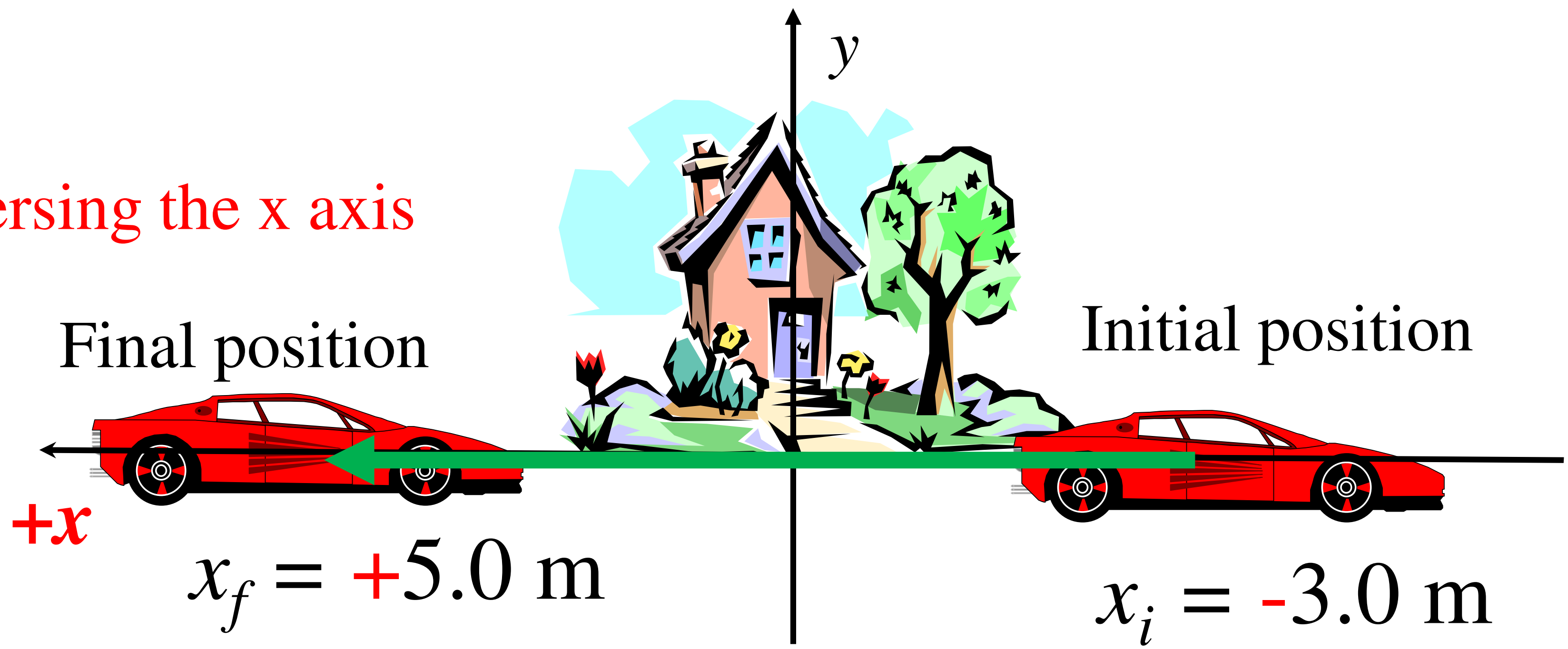
$\Delta x = x_f - x_i$ $\quad$ $\boldsymbol{\Delta x}$ = -5.0 m - (+3.0 m) = -8.0 m

Notes:

1. Distance is **not** displacement. In this case, distance traveled is distance driven around the block. Distance is always positive, does not indicate direction - example of a **scalar**
2. Green arrow from x_i to x_f indicates **direction** and **magnitude** of displacement - example of a **vector**
3. Sign of displacement indicates direction

Flipping the positive direction can change your answer!

Reversing the x axis



$$\Delta x = x_f - x_i$$

$\Delta x = +5.0 \text{ m} - (-3.0 \text{ m}) = +8.0 \text{ m}$

If we change which direction we call positive x, then the original and final positions change sign, which also changes the sign of the final displacement. Many people struggle with sign! Takes practice to master!

Why would we care about the sign?

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

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

If you need to use any of these variables in a formula, you will need to use the correct sign.

DANGER:

Many people struggle with signs! Ask yourself after defining each variable (tip 3) if sign is consistent with what direction you call positive.

Average Velocity

Definition: velocity is displacement per unit time

$$\bar{v} \equiv \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$$

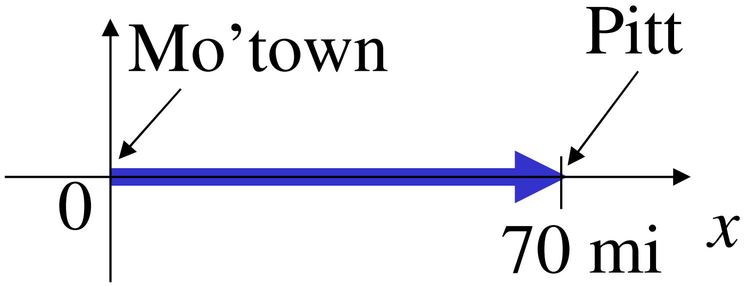
SI units: m/s

Ex: Go to Pittsburgh in 2 hrs, back in Morgantown 3 hrs after leaving

Average velocity going to Pitt:

$x_i = 0 \quad t_i = 0$

$x_f = +70 \text{ mi} \quad t_f = 2 \text{ hrs}$

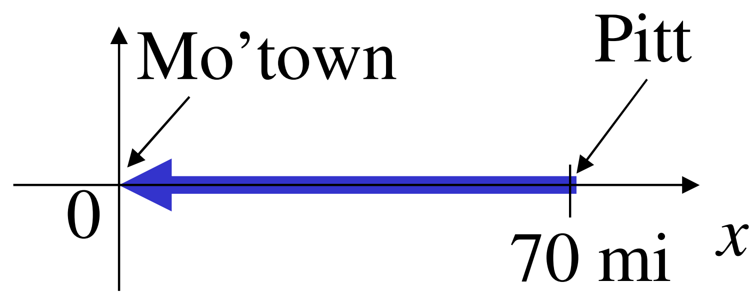


$$\bar{v} = \frac{70 \text{ mi} - 0}{2 \text{ hrs} - 0} = +35 \text{ mi/hr}$$

Average Velocity

Average velocity coming back from Pitt:

$$x_i = +70 \text{ mi} \quad t_i = 2 \text{ hrs}$$
$$x_f = 0 \text{ mi} \quad t_f = 3 \text{ hrs}$$



$$\bar{v} \equiv \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$$

$$\bar{v} = \frac{0 - 70 \text{ mi}}{3 \text{ hrs} - 2 \text{ hrs}} = -70 \text{ mi/hr}$$

Velocity is a vector. The sign of velocity indicates if it is travelling along the positive x axis or in the opposite direction.

Part 1:

$$\bar{v} = \frac{70\text{ mi} - 0}{2\text{ hrs} - 0} = +35\text{ mi/hr}$$

Part 2:

$$\bar{v} = \frac{0 - 70\text{ mi}}{3\text{ hrs} - 2\text{ hrs}} = -70\text{ mi/hr}$$

What was the average velocity round trip?

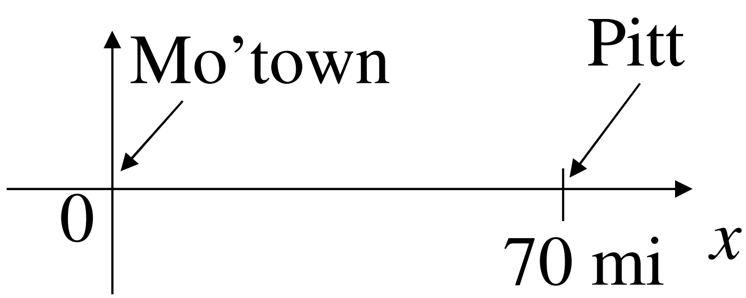
A. 52.5 mph

B. 46.7 mph

C. 35 mph

D. -17.5 mph

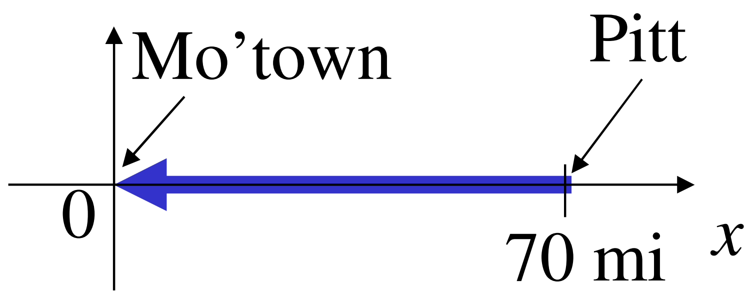
E. 0.0 mph



3 hour trip

Q02

Average Velocity



Part 1:

$$\bar{v} = \frac{70\text{ mi} - 0}{2\text{ hrs} - 0} = +35\text{ mi/hr}$$

Part 2:

$$\bar{v} = \frac{0 - 70\text{ mi}}{3\text{ hrs} - 2\text{ hrs}} = -70\text{ mi/hr}$$

$$\bar{v} \equiv \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$$

Average velocity round trip?

$x_i = 0$ mi $t_i = 0$ hrs
$x_f = 0$ mi $t_f = 3$ hrs

$$\bar{v} = \frac{0 - 0}{3\text{ hrs} - 0} = 0$$

Note: **Avg. Speed =** distance/time is not the same as velocity.
If no direction change, it is the magnitude of velocity.

Average speed round trip = distance traveled/time: 140 mi/3 hrs = 47 mi/hr

Instantaneous Velocity

- Only use the average velocity when asked for "average."
- Instantaneous velocity is velocity at a particular instant.

Will discuss this difference more in the graphing section of Ch.2.

Acceleration

- Average acceleration = change in velocity/time

$$\bar{a} \equiv \frac{v_f - v_i}{t_f - t_i} = \frac{\Delta v}{\Delta t}$$

- Instantaneous acceleration

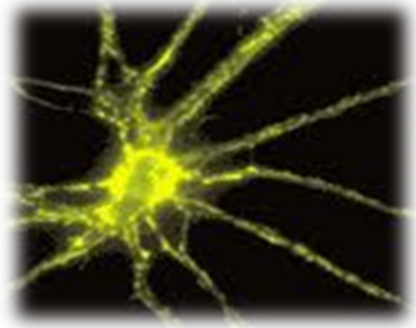
$$a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t}$$

Units: m/s/s = m/s^2

- Like velocity and displacement, acceleration is a vector (has direction and magnitude).

The sign of acceleration indicates which direction its velocity changes. Positive acceleration means speeding up when moving in the positive x direction **OR** slowing down when moving in the negative x direction.

Let's Practice



The speed of a nerve impulse in the human body is about 100 m/s. If you accidentally stub your toe in the dark, **estimate** the time it takes the nerve impulse to travel to your brain.

Draw a picture and list knowns and unknowns

Average velocity = 100 m/s = displacement / time

Change in time = $\Delta t = \Delta x/v$ = ~2 m / 100 m/s = 0.02 s or 20 milliseconds

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:

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

Which formula to use?

$$v = v_o + at$$

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

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

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

Pro Tip #3: List what you know <u>and need to know</u> 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!

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?

Draw a picture and list knowns and unknowns

Want: Δt Know: v_o, v_f, a

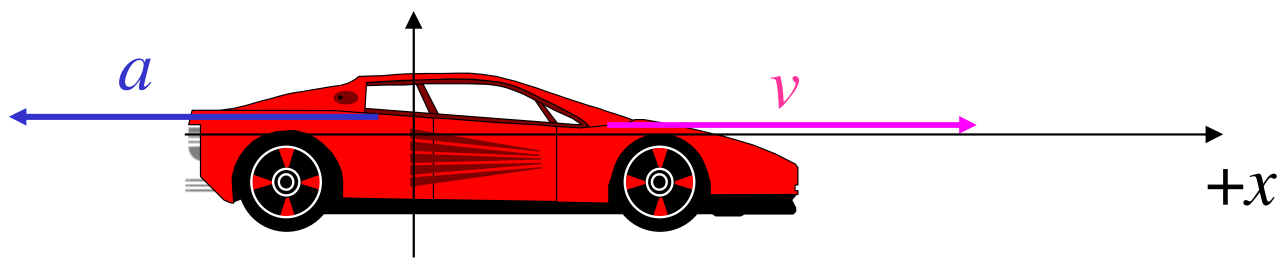
$v = v_o + a\,\Delta t$ rearrange: $\Delta t = (v - v_o)/a$

Will need to convert mi/h to what?

Clarifying the Signs

Can someone give me an example when an object's instantaneous velocity and instantaneous acceleration to be of opposite sign at some instant of time?

Ex: car moving in $+x$ direction but slowing down



Acceleration (Ungraded)

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**

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 $t = 3.5s$.

Clicker Answers

Chapter/Section: Clicker #=Answer

Ch.2A: 1=E, 2=E