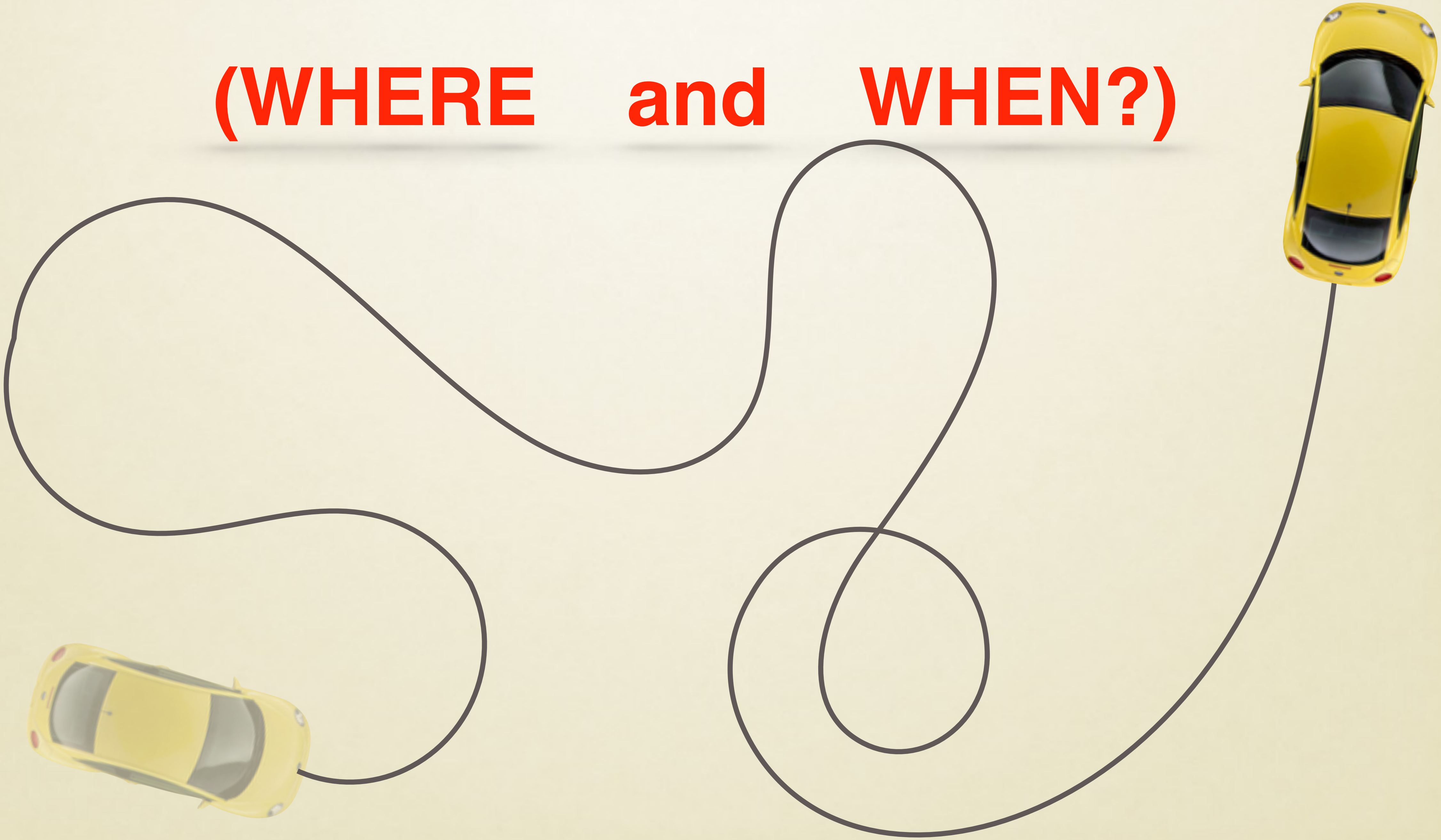
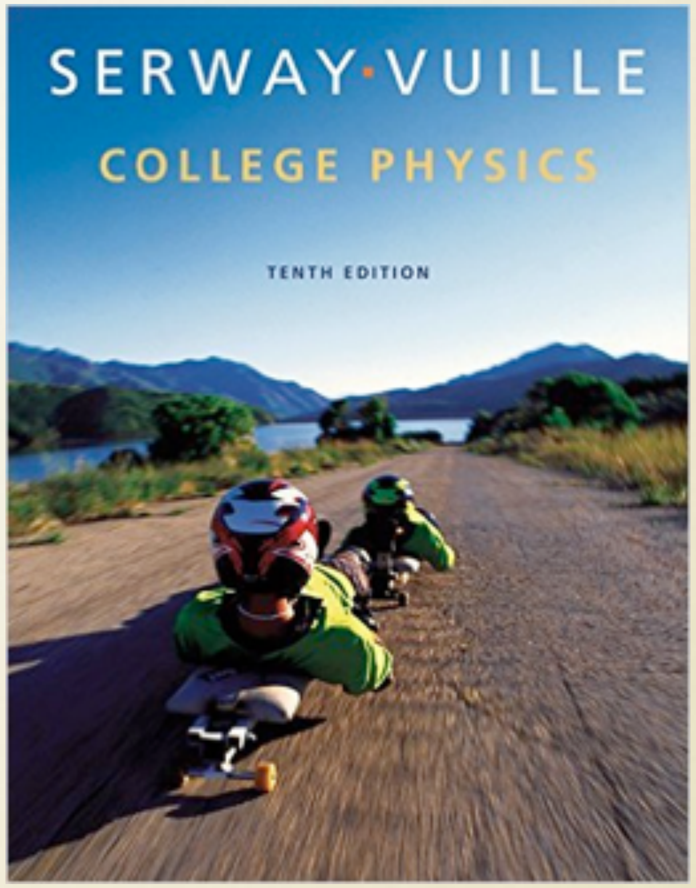
Displacement, Velocity, and Acceleration

(WHERE and WHEN?)



Math resources

- Appendix A in your book!
  - Symbols and meaning
  - Algebra
  - Geometry (volumes, etc.)
  - Trigonometry
  - Logarithms



Appendix A

Reminder

- You will do well in this class by PRACTICING!

Extra Practice Problems:
2.1, 2.3, 2.5, 2.21, 2.25, 2.27

Also: (Ungraded) homework warm-up problems

Reminders

Next class is next Wednesday.

Problem solving day: practicing for exam.

First clicker grade counted;
BRING YOUR CLICKERS!

Problem Solving Pro-tips

1. Draw a picture!

2. Use and label your reference frame.

3. List what you KNOW and DON'T KNOW in variable form.

4. Practice helps you pick best formulas!

Scalars and Vectors

- Scalar: just a number (magnitude).
- Vector: a number (magnitude) **with** a direction.

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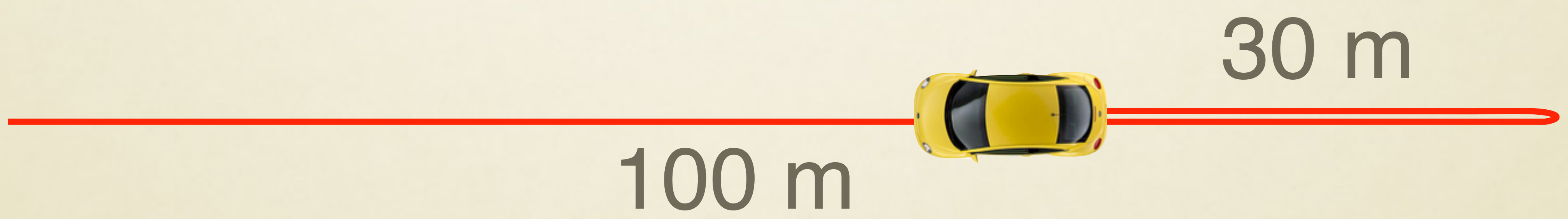

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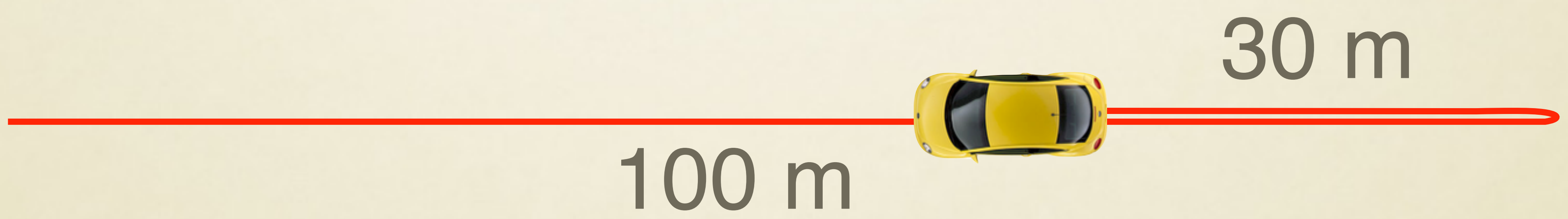

Distance (scalar): 100m + 30m = 130 meters

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Displacement, **x** (vector): 100 - 30 = +70 meters

Distance (scalar): 100m + 30m = 130 meters

Scalars and Vectors

Scalars:

Distance, x
Speed, v

Vectors:

Displacement, **x**
Velocity, **v**
Acceleration, **a**

Vectors are usually represented as BOLD
(or with an arrow hat).

Frames of reference

Ground's reference frame

Driver's reference frame

Velocity, *v*

- In **ground** frame of reference, one car has v = +80 km/h while the other has v = +70 km/h
- In reference frame of driver, velocity of other car is v = +10 km/h

Reference frames on paper

- **PT #1: Draw a picture!**

"Jogger went 10m east, 10m north, sat on a stump a while, then walked 25m east."

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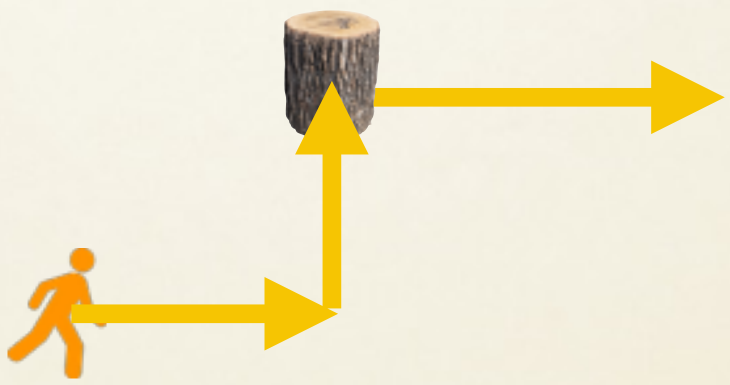

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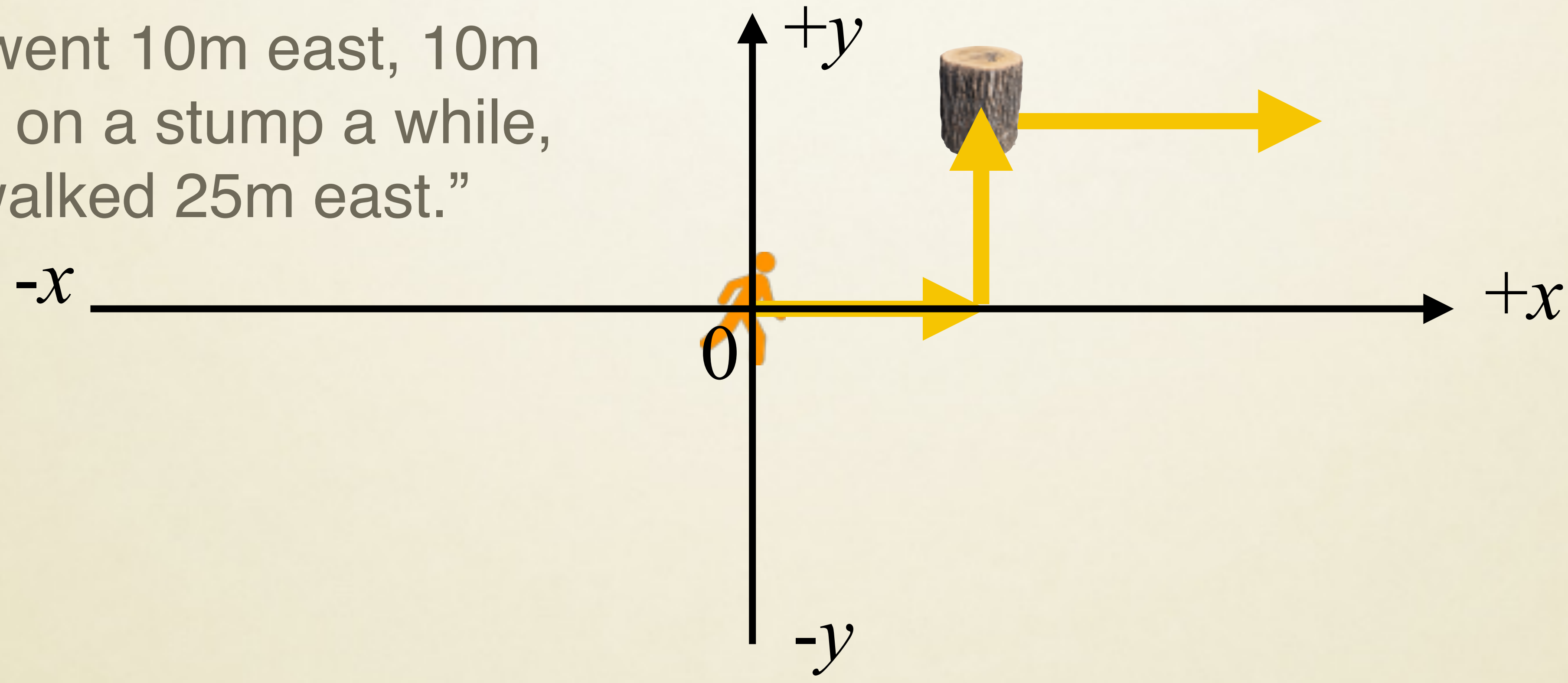

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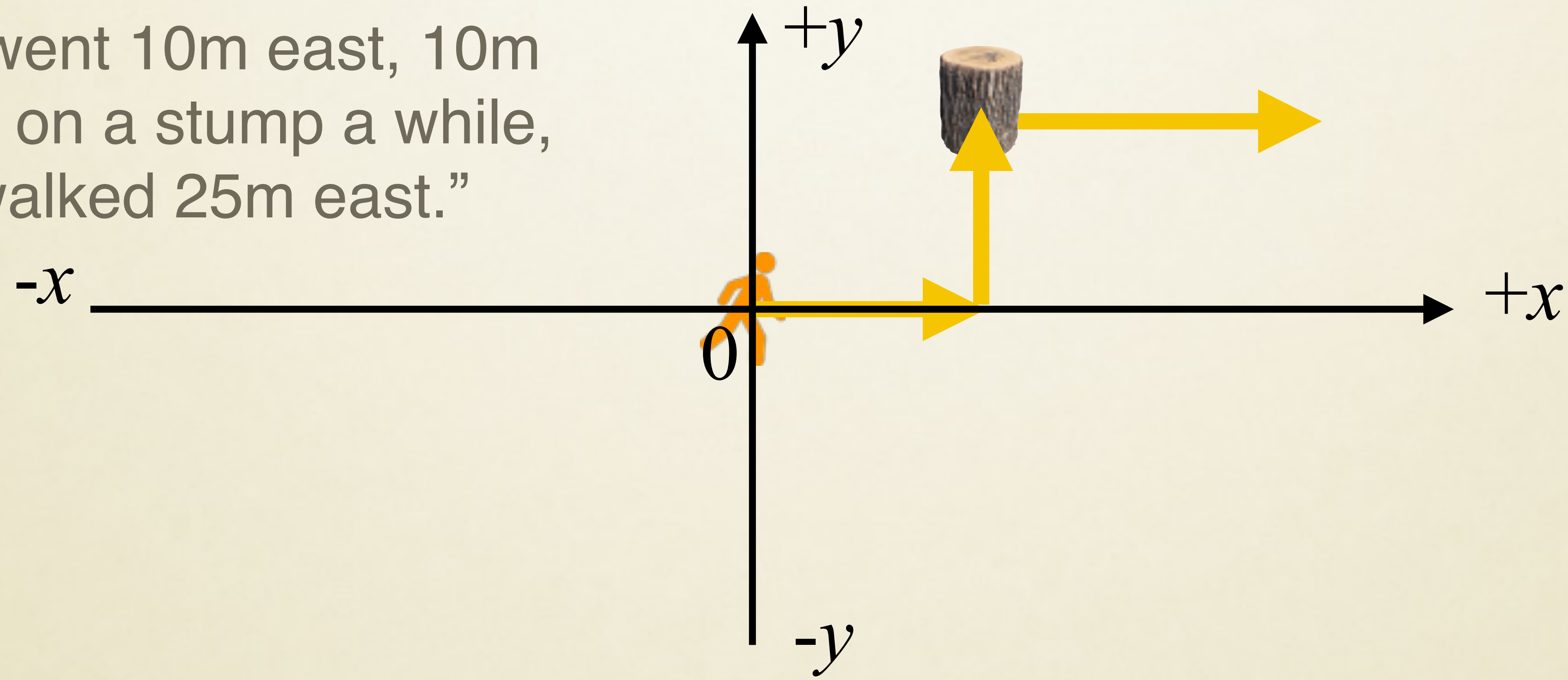

The direction of these arrows is important for setting up problems and **may** affect the sign of your variables and/or answers (will see example soon)

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Definition: change in the position of an object

Displacement: $\Delta x = x_f - x_i$

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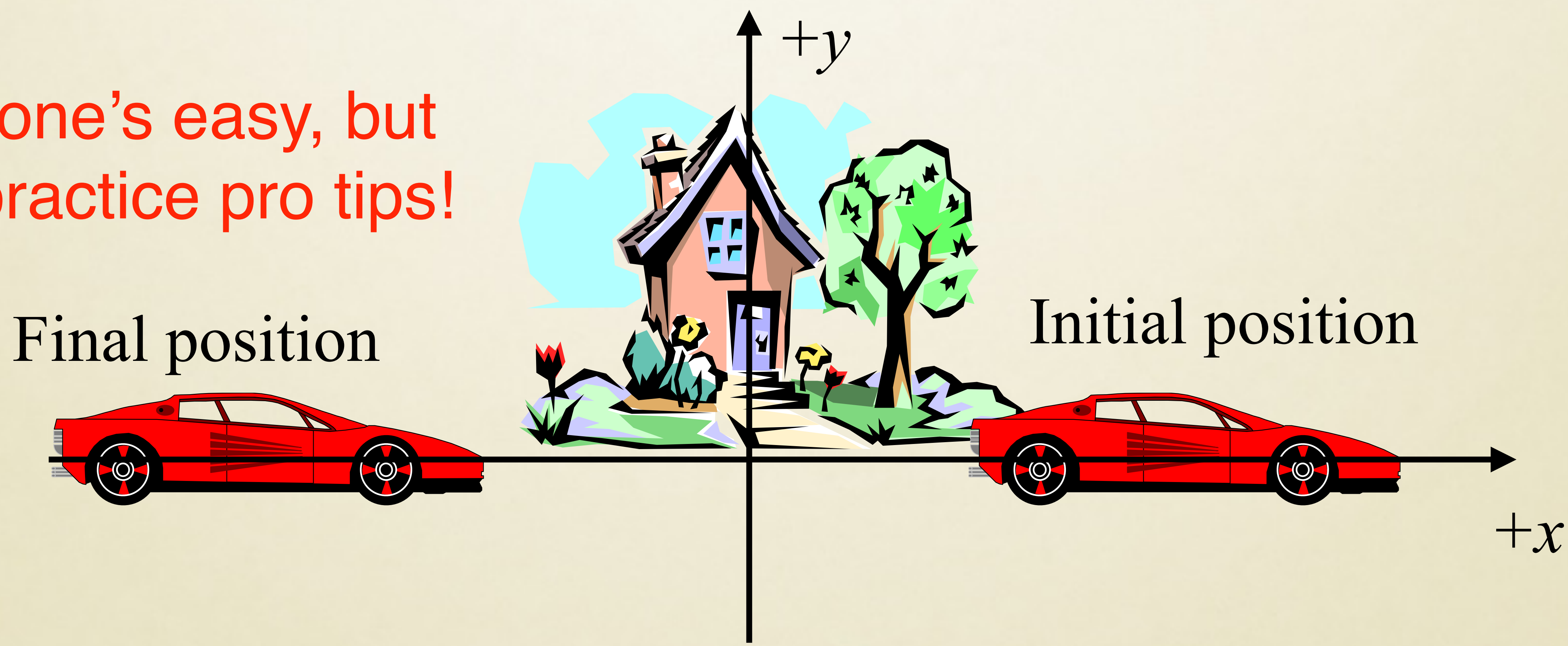

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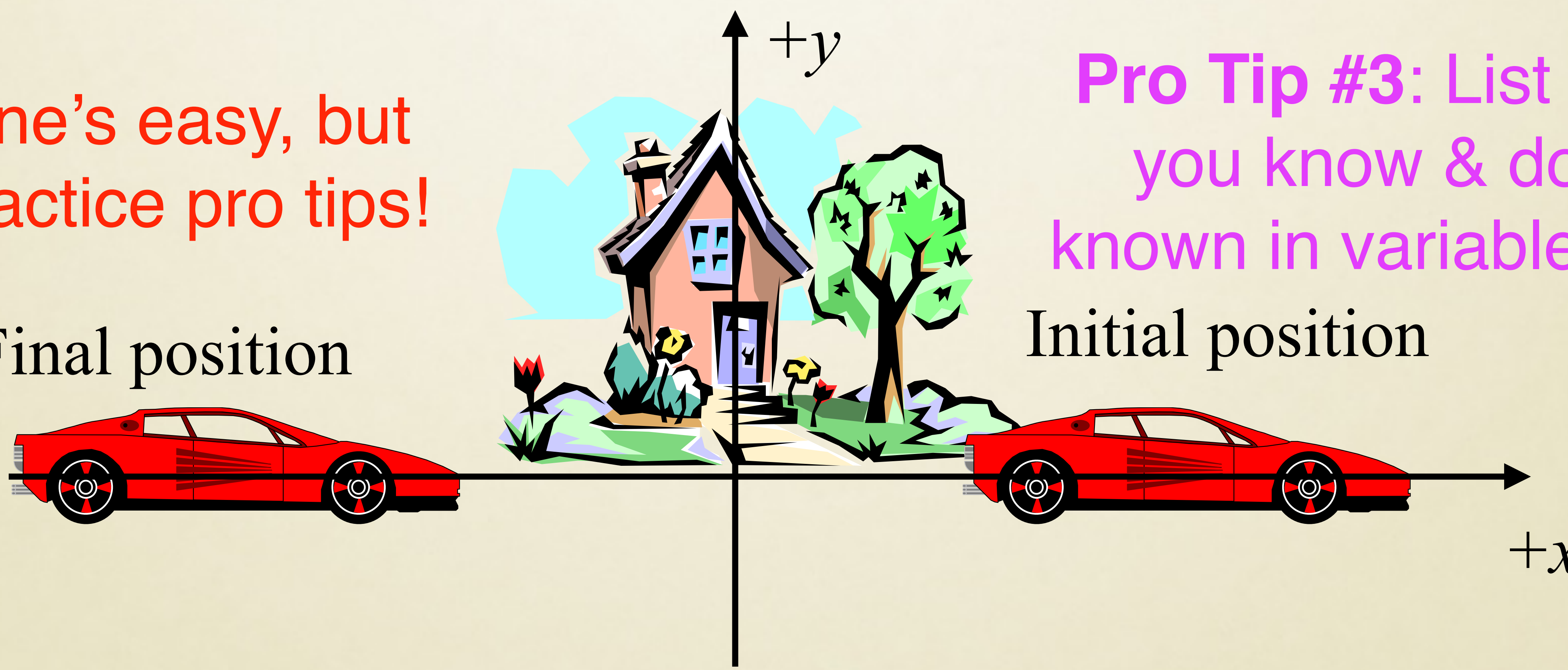

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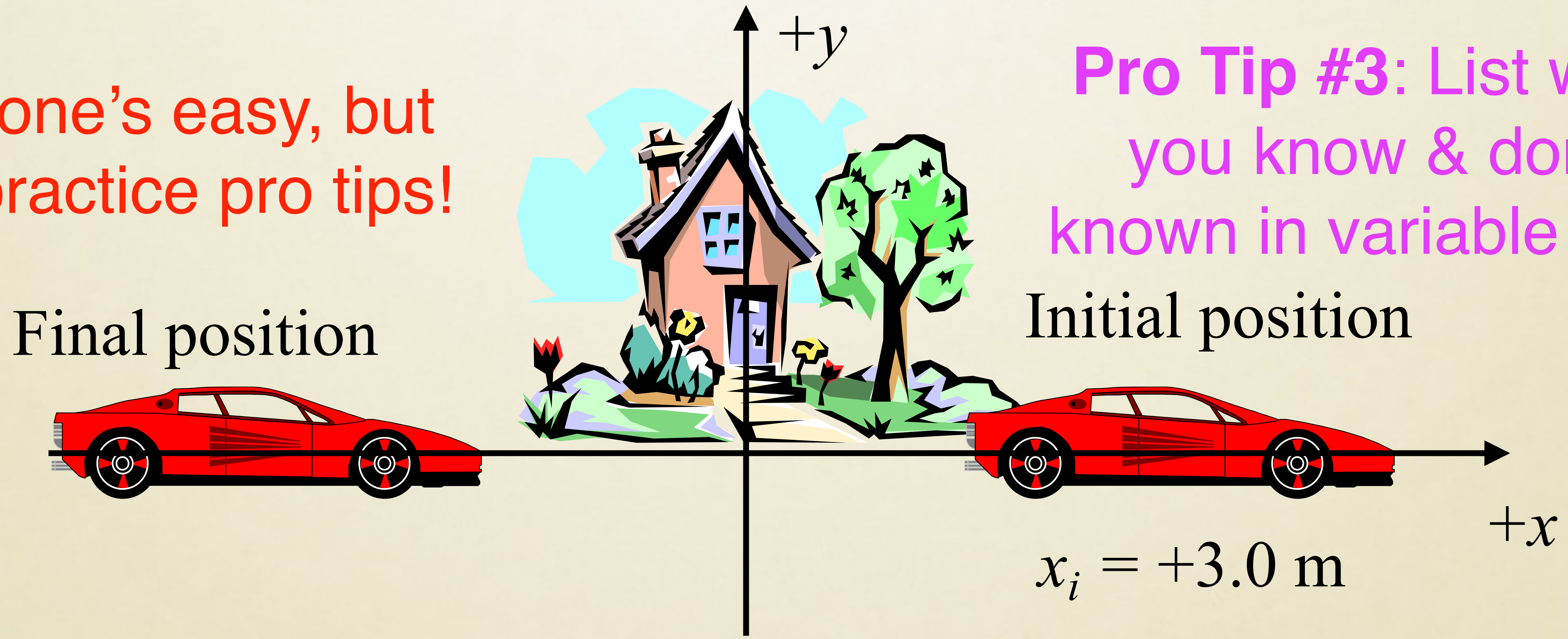

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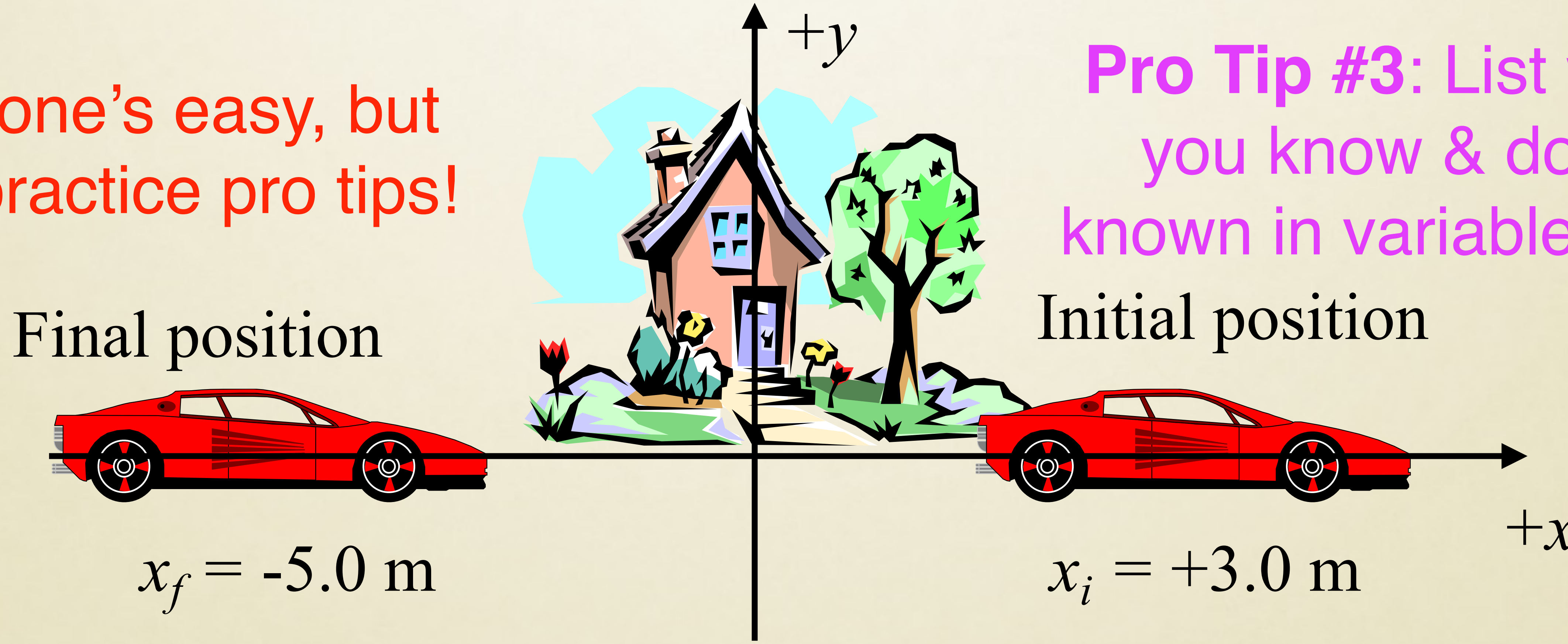

x_f = -5.0 m

x_i = +3.0 m

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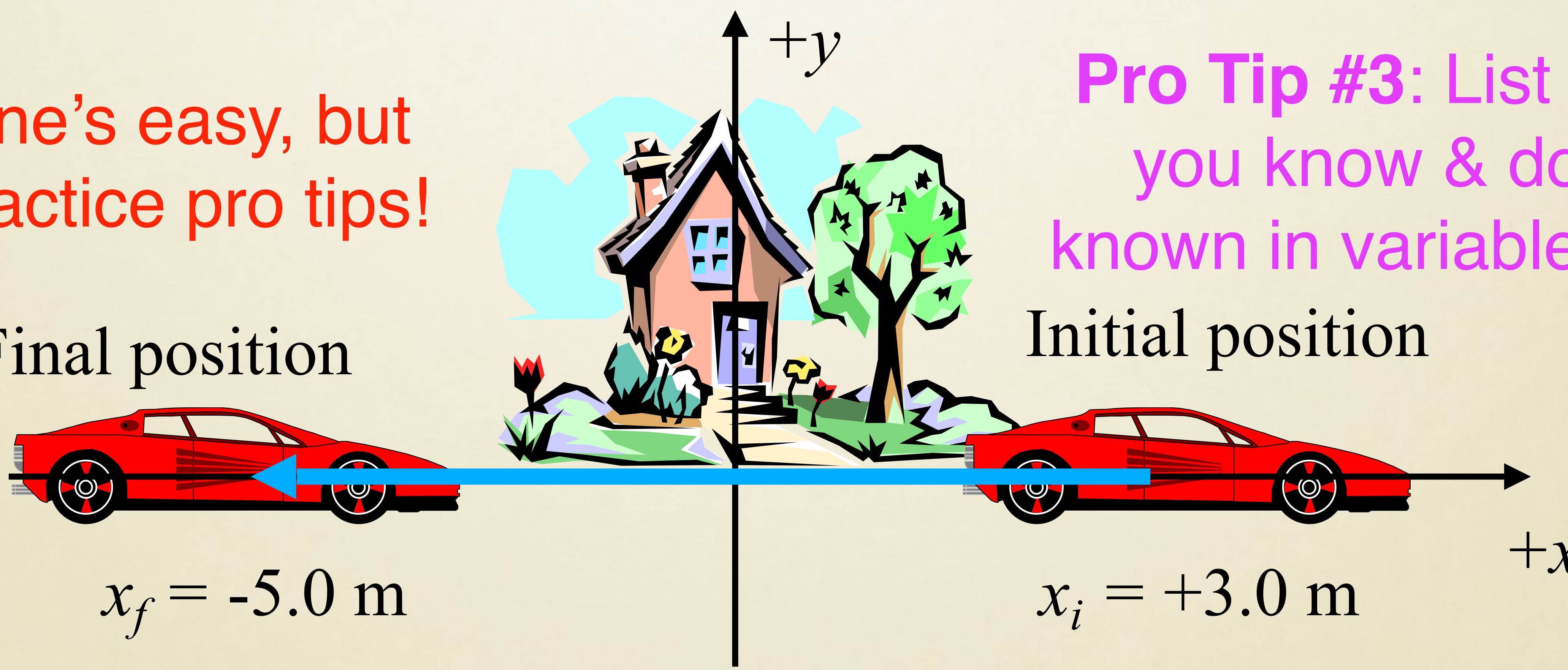

$\Delta x = ?$

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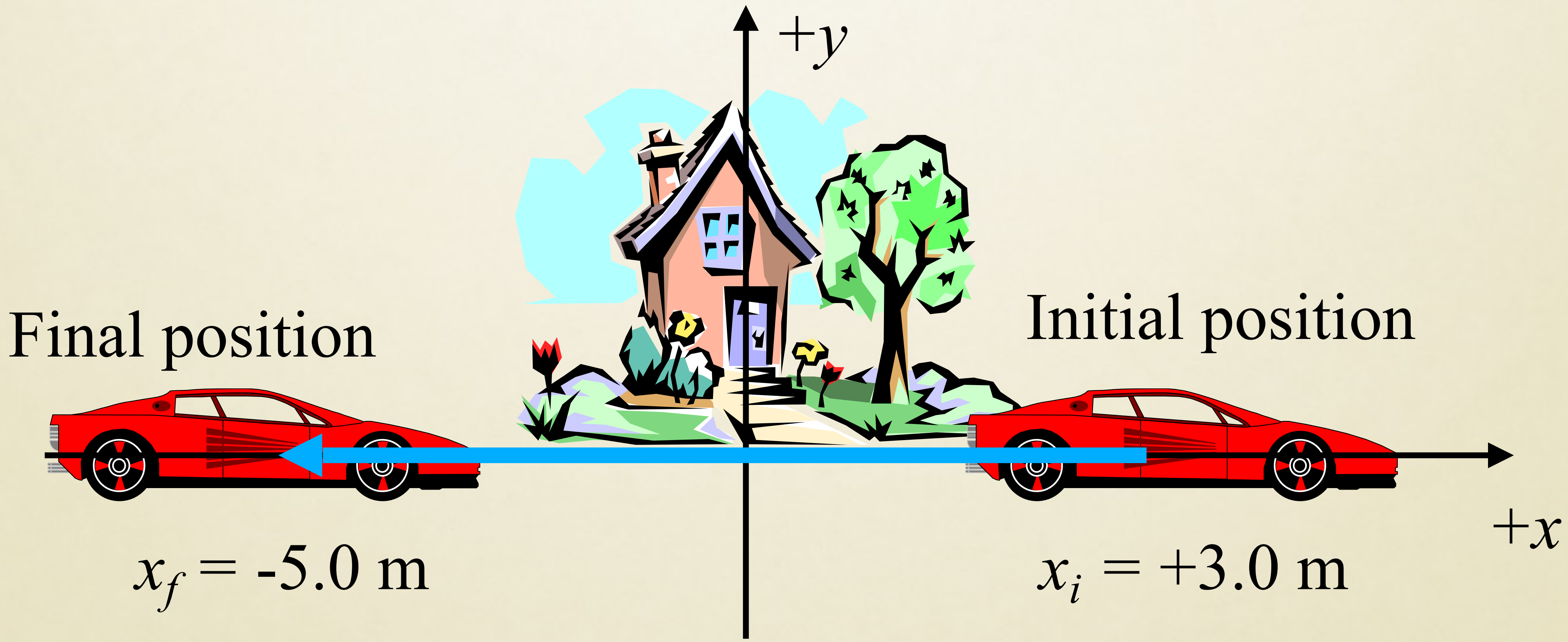

Δx = -5.0 m - (+3.0 m) = -8.0 m

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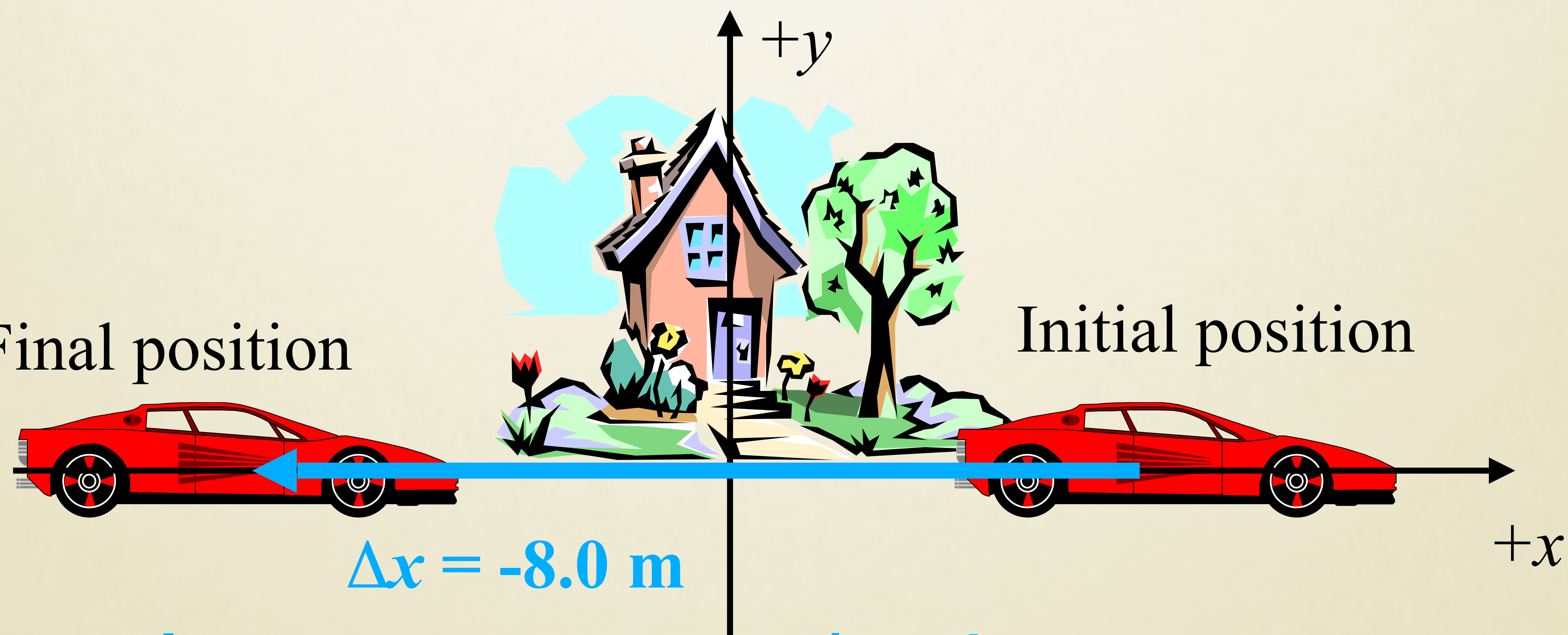

Arrow represents the Δx vector:

magnitude (8.0m) and **direction (-)** of displacement.

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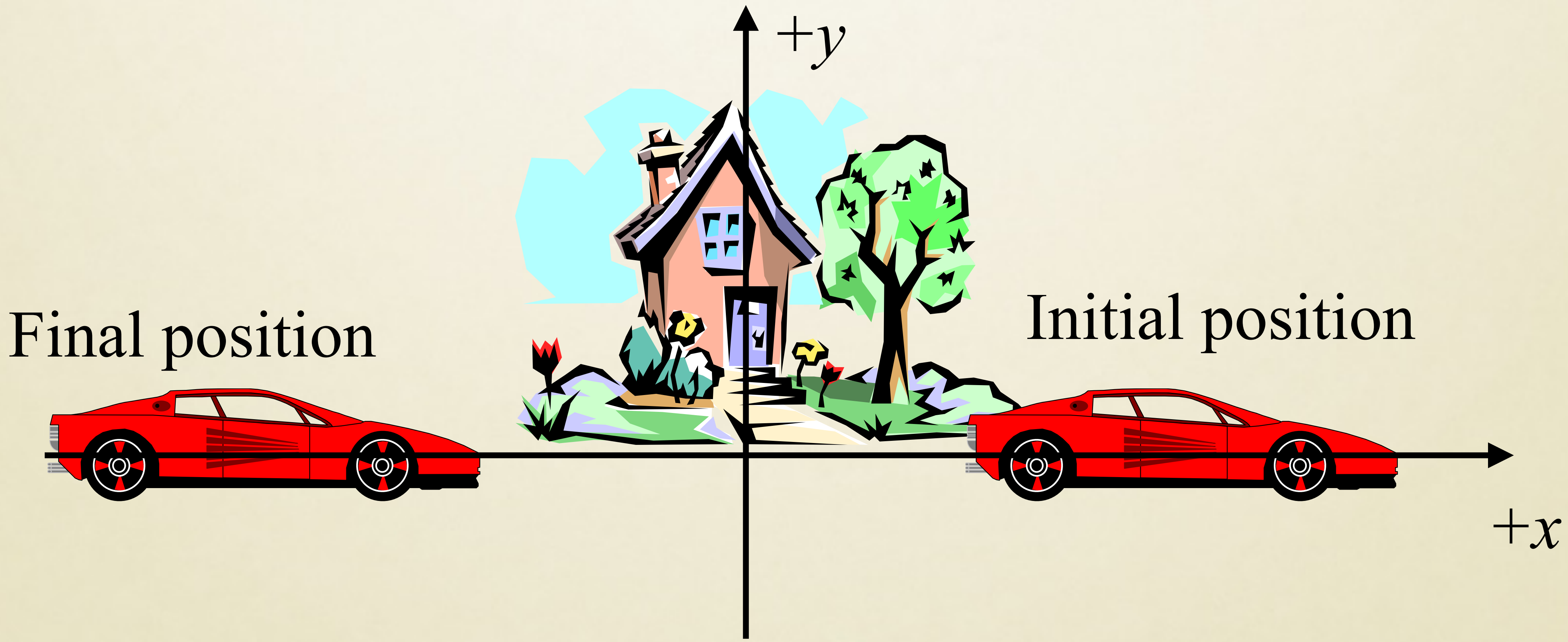

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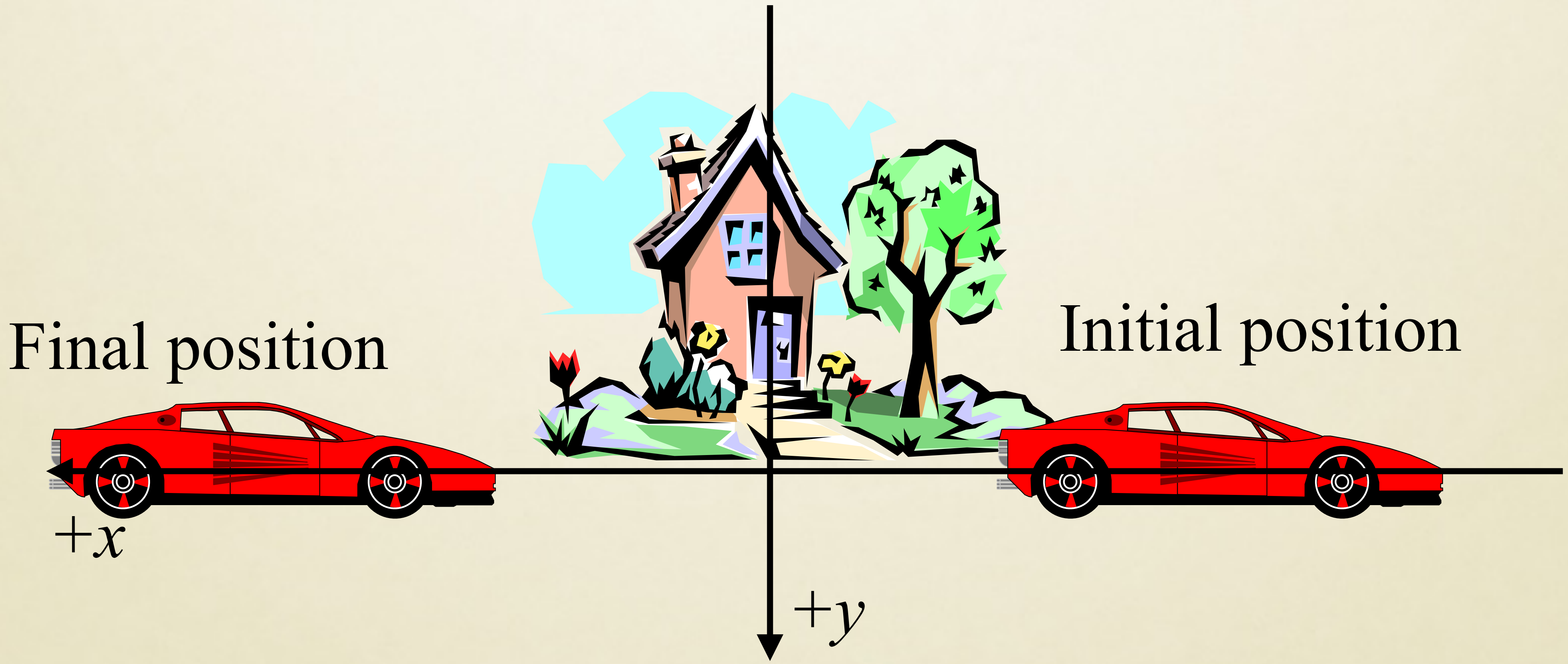

Write your knowns and unknowns!

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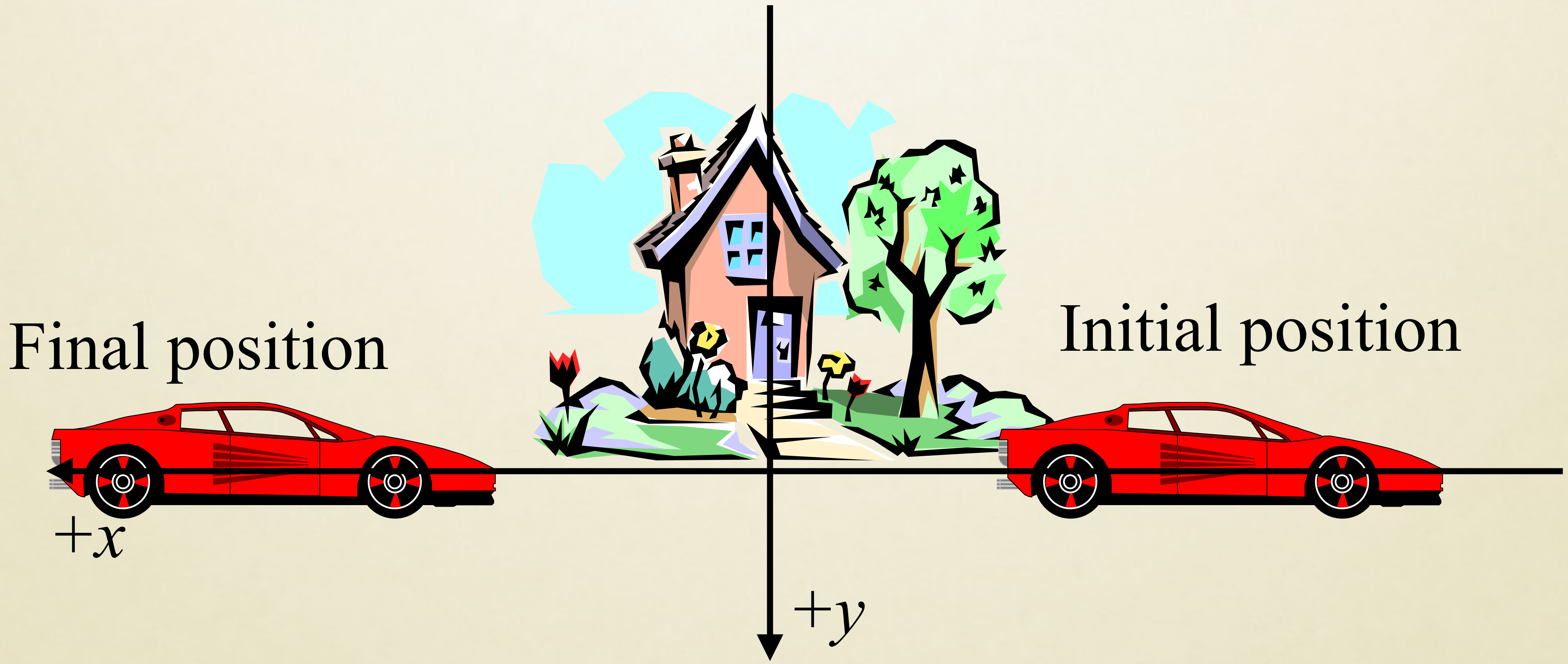

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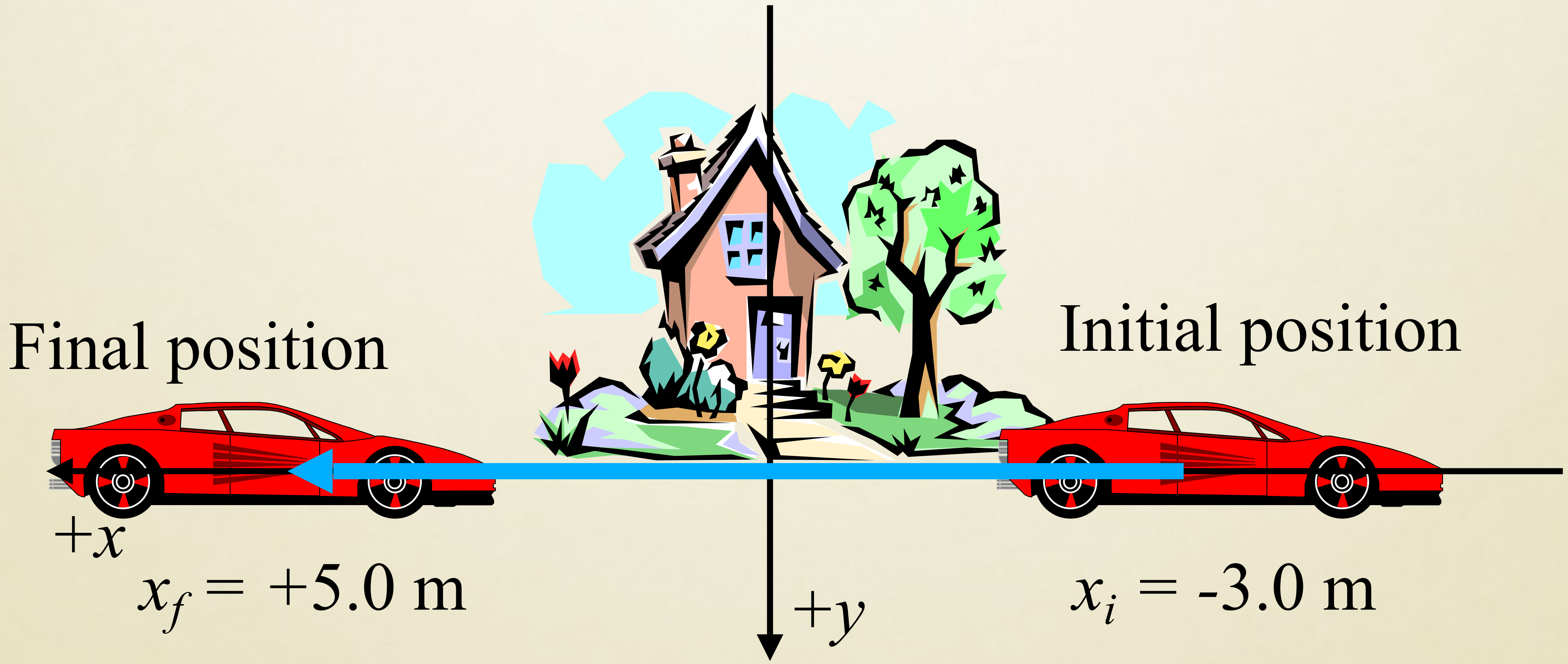

Δx = +5.0 m - (-3.0 m) = +8.0 m

Many people struggle with signs! Ask yourself after defining each variable:

Is the sign consistent with what direction I've called positive?

Up and right are usually positive! (particularly in WebAssign unless explicitly stated in the problem)

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

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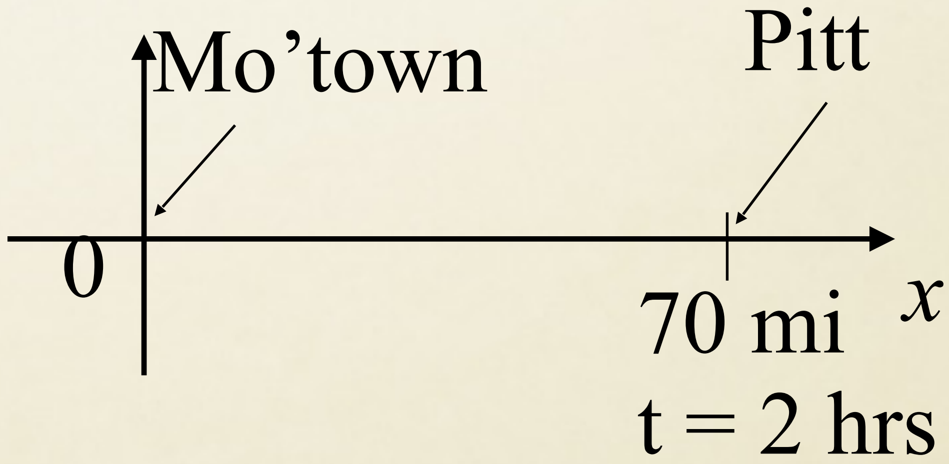

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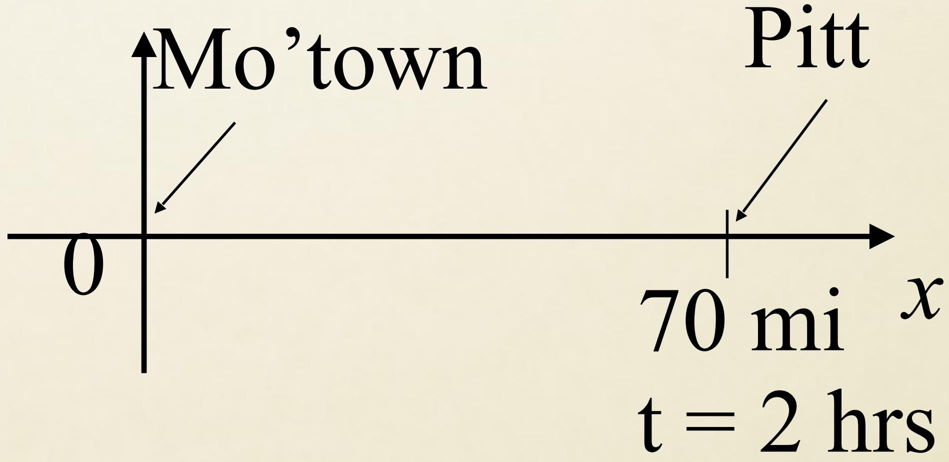

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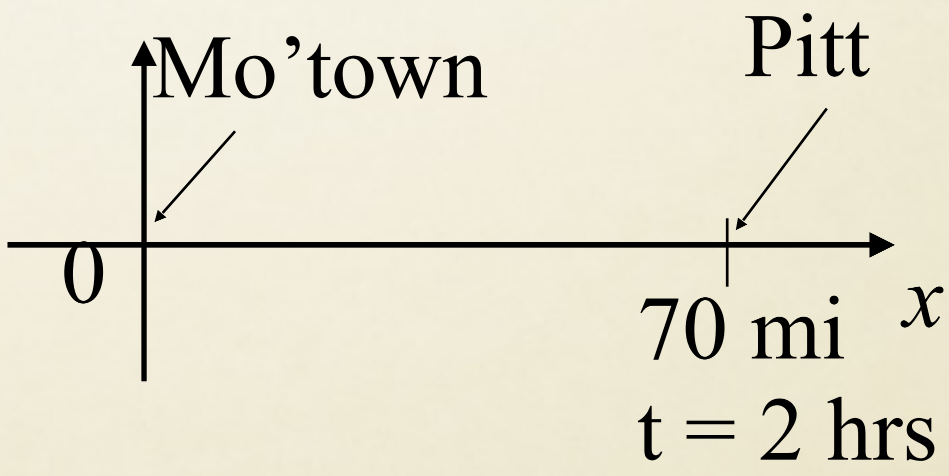
Ex: Go to Pittsburgh in 2 hrs, back in Morgantown 3 hrs after leaving

Average velocity going to Pitt:

$x_i = 0$ $\quad t_i = 0$

$x_f = +70$ mi $\quad t_f = 2$ hrs



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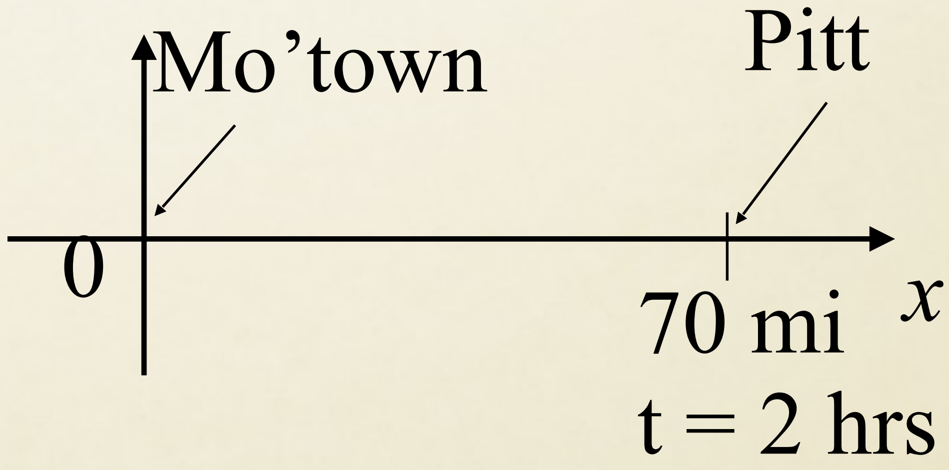

$$\bar{v} = \frac{70\text{ mi} - 0}{2\text{ hrs} - 0} = +35\text{ mi/hr}$$

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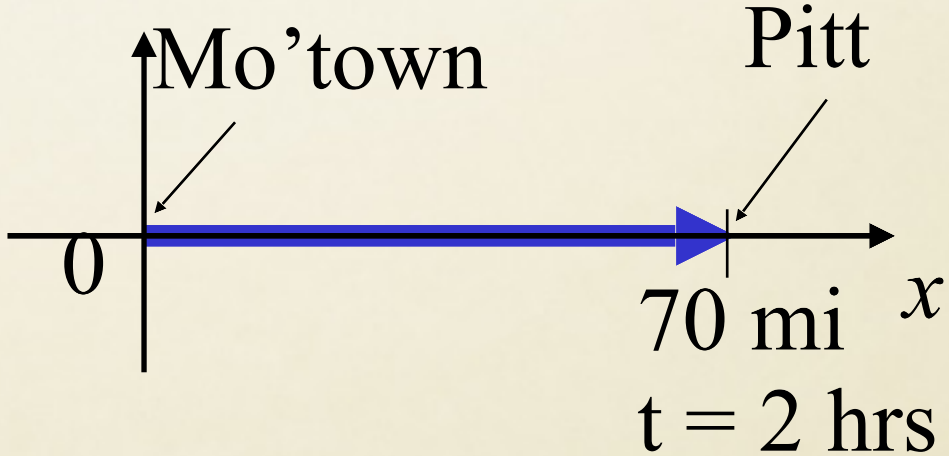

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Ex: Go to Pittsburgh in 2 hrs, back in Morgantown 3 hrs after leaving

Average velocity coming back from Pitt?

Average velocity of round trip?

If you finish those:
Average speed (scalar!) of round trip?

Average Velocity

Definition: velocity is displacement per unit time

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

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Speed: 140mi / 3h = 47 mi / h!

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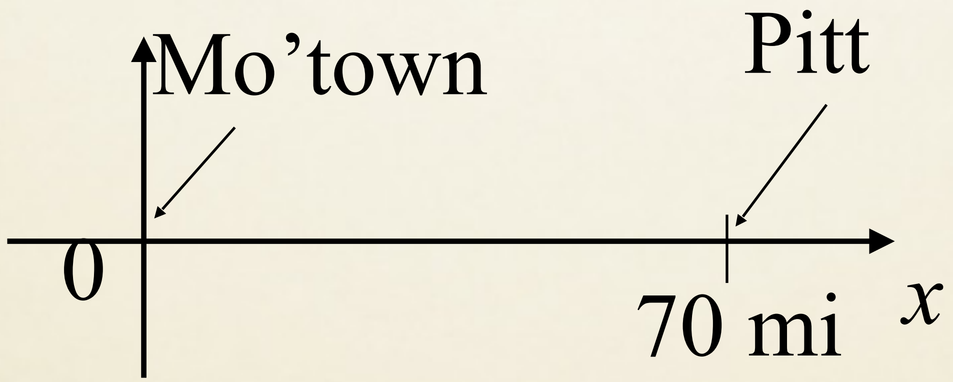

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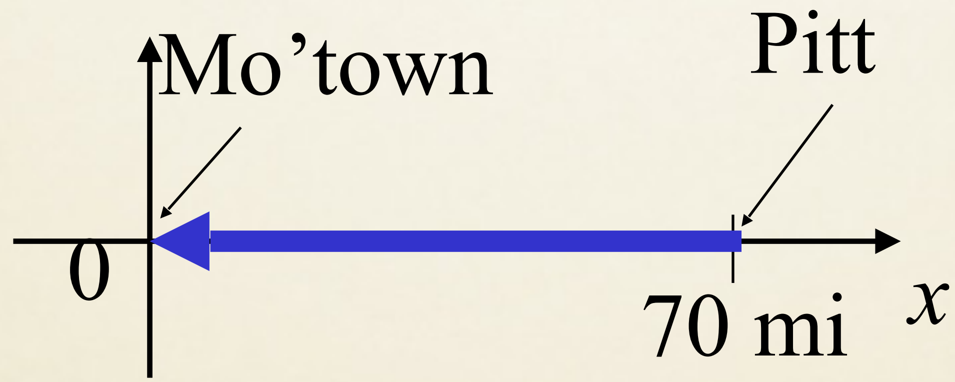

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Will discuss this difference more next lecture.

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

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

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

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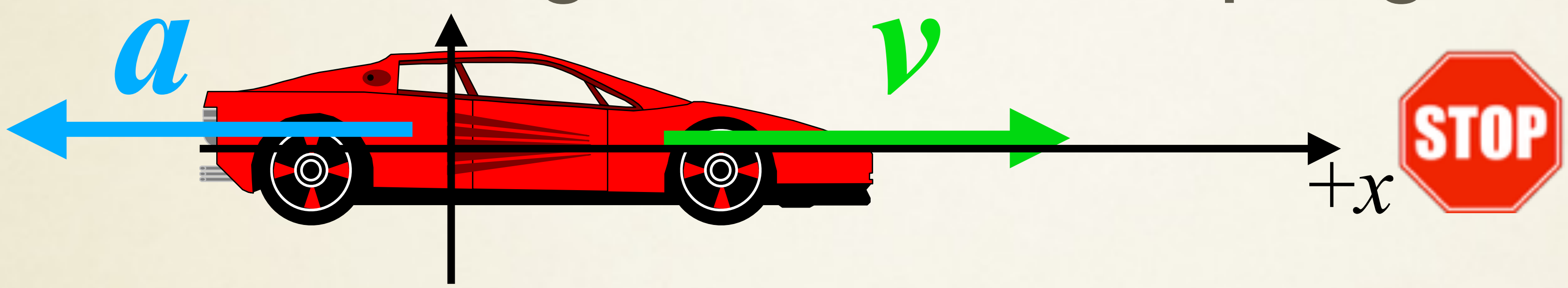
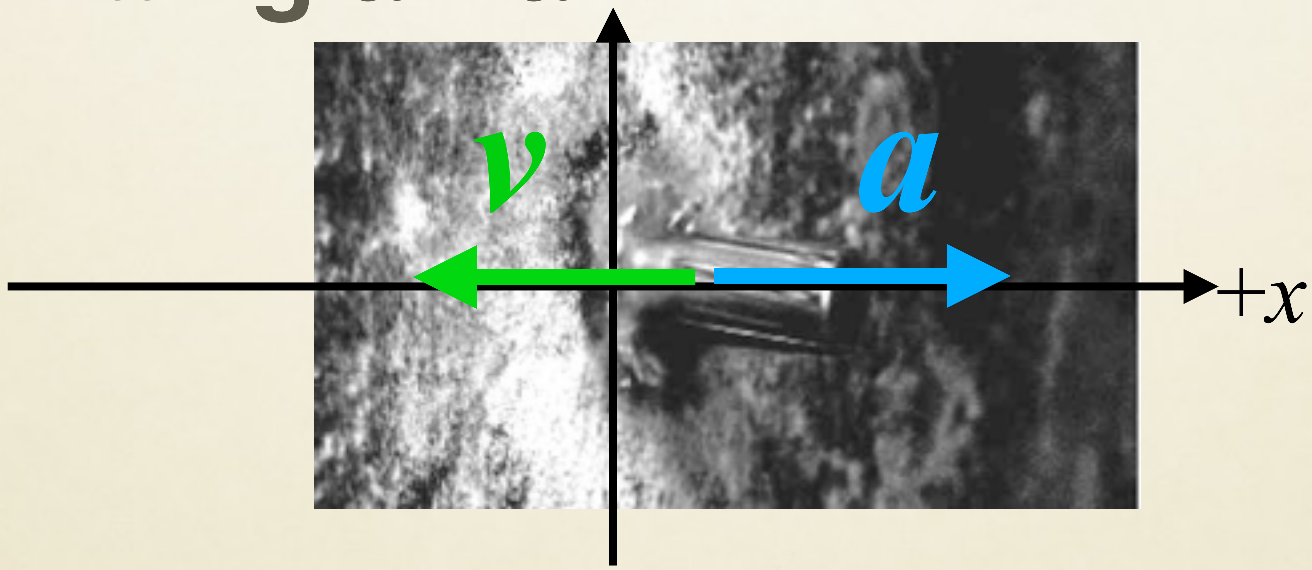
The sign of acceleration indicates **which direction its velocity changes**. Positive acceleration means speeding up when moving in the positive x direction **OR** slowing down when moving in the negative x direction.

Signs of acceleration

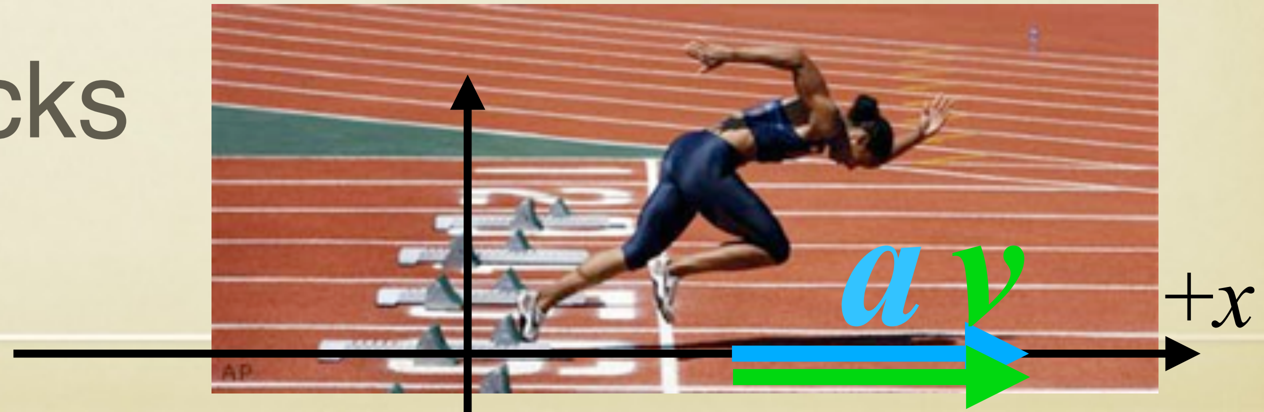
- A car slowing down at a stop sign



- A bullet hitting a wall



- Sprinter out of the blocks



Motion at Constant Acceleration

Special case when *a* does not change with time

Notation:

$t_f = t \quad t_i = 0$ "t at time zero"

$x_f = x \quad x_i = x_o$ "location at time zero"

$v_f = v \quad v_i = v_o$ "velocity at time zero"

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

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

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

$$v_{avg} = \frac{x_f - x_i}{t_f - t_i}$$

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

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Motion at Constant Acceleration

Special case when *a* does not change with time

Notation:

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Pro Tip # 4: Practice helps you pick best formulas!

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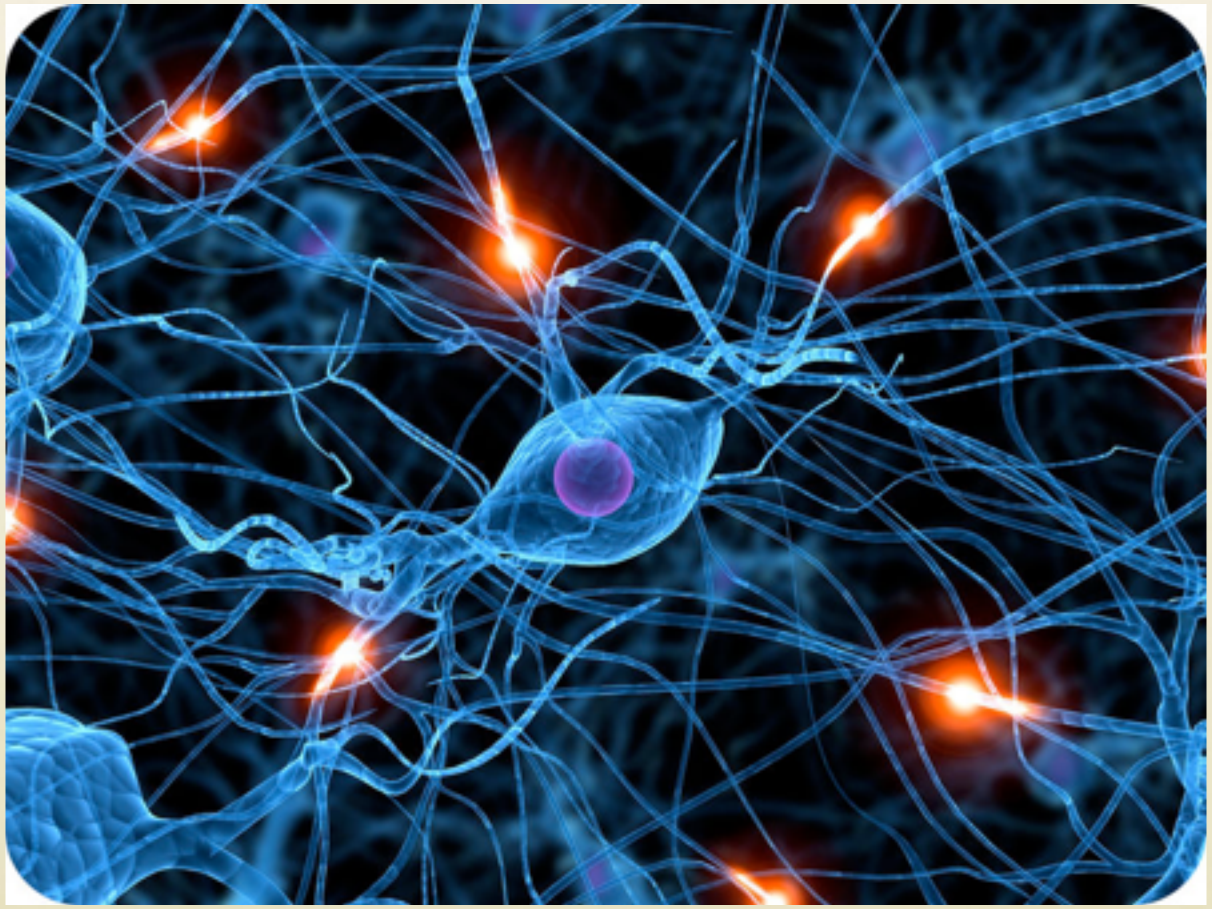
The speed of a nerve impulse in the human body is about 100 m/s. If you accidentally stub your toe in the dark, **estimate** the time it takes the nerve impulse to travel to your brain.



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= 0.02 s or 20 milliseconds

Problems inside problems

Might need to break down problem into smaller pieces! Solve in sequence.

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1 mile = 1609 m

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Will need to convert mi/h to what?

1 mile = 1609 m

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 $t = 3.5s$.

Problem Solving Pro-tips

1. Draw a picture!

2. Use and label your reference frame.

3. List what you KNOW and DON'T KNOW in variable form.

4. Practice helps you pick best formulas!