Displacement, Velocity, and Acceleration
(WHERE and WHEN?)

Extra Practice Problems:
2.1, 2.3, 2.5, 2.21, 2.25, 2.27
(and how to solve problems effectively!)

https://sarahspolaor.faculty.wvu.edu/classes/physics-101-fall-2018

Math resources

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

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: "pop quiz"
(note: you will get an A on it)
and problem solving day.

Clickers first used;
BRING YOUR CLICKERS!
Problem Solving Pro-tips

1. Draw a picture!
2. Use and label your reference frame.
3. List “GIVENs” and “UNKNOWNs” in variable form.
4. Find the relevant formulas (and solve). Practice helps you pick the best ones!

Scalars and Vectors

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

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Initial positon  Final position
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>100 m</td>
<td>30 m</td>
</tr>
</tbody>
</table>
```

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

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

“How far am I from where I started, and in what direction?”

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).

What’s Your Reference Frame?

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

“Jogger went 10m east, 10m north, sat on a stump a while, then walked 25m east.”
What’s Your Reference Frame?

PT #1: Draw a picture!
PT #2: Use (and LABEL) a coordinate system.

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

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

Displacement (vector)
Definition: change in the position of an object
Displacement: \( \Delta x = x_f - x_i \)

A car is initially parked 3.0 m to the right of a house’s front door. It drives around the block, and ends up 5.0 m to left of the front door. Find the displacement of the car.

This one’s easy, but let’s practice pro tips!

Pro Tip #3: List what you know & don’t know in variable form

Displacement (vector)
Definition: change in the position of an object
Displacement: \( \Delta x = x_f - x_i \)

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.
**Displacement (vector)**
Definition: change in the position of an object

Displacement: \( \Delta x = x_f - x_i \)

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.

Write your knowns and unknowns!

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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)

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**Average Velocity**
Definition: velocity is displacement per unit time

\[ \bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i} \quad \text{[SI units: m/s]} \]

I’m going to Pittsburgh and back. The whole trip takes me a total of 3 hours, but it takes 2 hrs to drive to Pitt.

Average velocity going to Pitt?

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Average velocity coming back from Pitt?
Average velocity of round trip?

Note, average speed (scalar) of round trip: 140 miles / 3 h = 47 m/h!
**Acceleration**

[SI Units: m/s/s = m/s²]

- Average acceleration = change in velocity/time
  \[ a = \frac{v_f - v_i}{t_f - t_i} = \frac{\Delta v}{\Delta t} \]

- Instantaneous acceleration
  \[ a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} \]

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:
- \( t_0 \) = \( t_f \) = 0 “at time zero”
- \( x_0, x_f \) = “location at time zero”
- \( v_0, v_f \) = “velocity at time zero”

\[ a = \frac{v_f - v_i}{t_f - t_i} \]

\[ v = v_i + at \]

Similar derivations lead to more equations:

\[ v_{avg} = \frac{v_0 + v_f}{2} \]

\[ \Delta x = v_f t + \frac{1}{2} at^2 \]

\[ v^2 = v_0^2 + 2a\Delta x \]
Which formula to use?

Pay attention: key advice!

\[
\begin{align*}
 v &= v_0 + at \\
 v^2 &= v_0^2 + 2a\Delta x \\
 v_{\text{avg}} &= \frac{v + v_0}{2} \\
 \Delta x &= v_{\text{avg}} t + \frac{1}{2} at^2
\end{align*}
\]

- 1 equation with one unknown is solvable.
- 2 equations with two unknowns is solvable.

Pro Tip #3 Again: knowns and unknowns!
Pro Tip #4: Find the relevant formulae...
practice will help you pick!

Let’s Practice!

A nerve impulse in the human body travels at 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.