Physics 101 Lecture 3
Kinematics: Vectors and Motion in 1 Dimension

What concepts did you find most difficult, or what would you like to be sure we discuss in lecture?

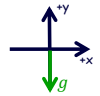
- Acceleration vectors.
- Will you go over the third checkpoint
- Do harder problems in class
- I've never been more confused in my life
- Nothing!
- Trigonometric review, sines and cosines

Review! Kinematics: Free Fall, A Special Case

- Free Fall: An object's motion is caused by *gravity alone*
  - $a = g$, the *acceleration of gravity*
  - $g = 9.8\ \mathrm{m/s^2}$
  - Important Kinematic Expressions
    - $y = y_0 + v_{0_y}t - \frac{1}{2}gt^2$
    - $v_y = v_{0_y} - gt$
    - ${v_y}^2 = v_{0_y}^2 - 2g(y - y_0)$

Review! A Few Facts About *g*

- For Gravity:
  - Acceleration is $g = 9.8\ \mathrm{m/s^2}$ near the surface of the earth.
  - g **always** points downward
  - Position may be positive, zero or negative
  - Velocity may be positive, zero or negative



- To Calculate position or velocity as a function of *time*:
  - Position: $y = y_0 + v_{0y}t - \frac{1}{2}gt^2$
  - Velocity: $v_y = v_{0y} - gt$
- To calculate velocity as a function of *position*:
  - $v_y^2 = v_{0y}^2 - 2g(y - y_0)$

Tip for applying kinematic equations

- Always pick a point in the trajectory and apply kinematic equation(s) for that point
- A lot of times you will have two unknowns after writing kinematic equations (e.g., maximum height reached by a ball and time it took to get there).
- Have faith in the process and use algebra to solve for unknowns. (Recall that you need 2 eqns to solve for 2 unknowns)

Free Fall Demo: Two Dropped Objects

Which will hit the ground first, the feather or the coin?

A) coin B) Same C) Feather

Note: Free fall only works when air resistance is negligible!

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Fred's Free Fall Calculations

Fred throws a ball 30 m/s vertically upward.

What is the maximum height the ball reaches?

What is the speed at max height? $v = 0\ m/s$ at the maximum height.

- $v^2 = v_o{}^2 - 2g\Delta y$
- $\Delta y = (v^2 - v_o^2)/(-2g)$
- $= \dfrac{-30^2\ \frac{m^2}{s^2}}{-2\times 9.8\ \frac{m}{s^2}}$
- $= 46$ m.

Or, use: $v_{top} = v_o - gt$ to get t

Then $y = y_o + v_o t - (1/2)gt^2$

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Fred's Free Fall Calculations

Fred throws a ball 30 m/s vertically upward.

How long does it take to reach its maximum height?

- ✓ $v = v_0 - gt$
- ✓ $t = \dfrac{v - v_0}{a}$
- ✓ $= \dfrac{0 - 30\ \frac{m}{s}}{-9.8\ \frac{m}{s^2}}$
- ✓ $= 3.1$ seconds

How long does it take the ball to make the complete round trip?

Free Fall Facts:

- ✓ Remember: $a = -g$.
- ✓ Velocity becomes more and more negative if object is dropped from rest.
- ✓ If $v > 0$, speed decreases.
- ✓ If $v <= 0$ speed increases.

Vectors

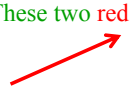
- Vector:
  A quantity that has:
  - size (called magnitude)
  - direction
- In physics lots of quantities are vectors such as:
  - velocity
  - acceleration
  - forces

Vectors

- We represent vectors with arrows.
  - The length of the arrow is the magnitude of the vector
  - The direction is shown by which way the arrow points

A Vector 

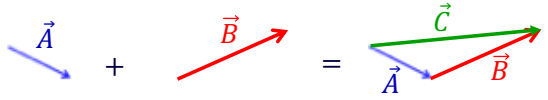
- Rules for dealing with vectors:
  - You can move a vector in space and it is the same vector, as long as you do not change:
    - » the magnitude (length of the arrow)
    - » the direction
  - These two red vectors are the same.

Adding and subtracting vectors

- To add two vectors, put the tail of the second vector at the tip of the first vector, and draw the sum from the tail of the first vector to the tip of the second.

- Let's perform $\vec{A} + \vec{B} = \vec{C}$:



Subtracting Vectors

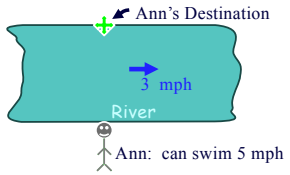
- To subtract vectors:
  - add the negative of the vector you are subtracting.
  - The negative of a vector has the same length but points in the opposite direction.

Swimmer Example: Velocity is a Vector

Ann needs to swim across a river.
Ann can swim 5 mph with *respect to the water*.
The river flows 3 mph East (i.e. from Ann's left to Ann's right).
At what angle should Ann swim to end directly to the other side of the river?

Clicker Q: Step 1: Should Ann swim:

a) toward her left?
b) toward her right?
c) straight across?



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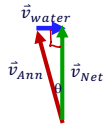
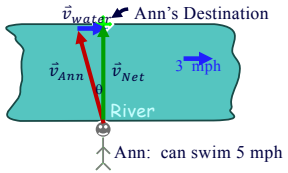
Step 2: The vector diagram for Ann's swim will look like this:





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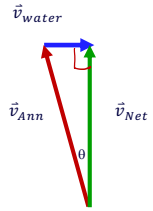
Step 3: Find θ:

From the triangle, we know: $\sin\theta = v_{water}/v_{Ann} = 3/5$

So solve for θ: $\theta = \arcsin(3/5) = 36.9^o$

How would you go about finding the green vector, which is Ann's velocity relative to the ground?



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