Physics of Imagineering **In-class assignment #8**
November 3, 2015 **Trajectory**

Goals

1. To be practice using components.
2. To understand why we use components.
3. To draw a trajectory.
4. To practice algebra.

Equipment:

Notebook (draw diagrams directly inside)

Components

To make the mathematics easier, remember one thing. This may seem anti-intuitive, but repeated experiments have proven it to be true. **Directions can be separated.** What happens in the x-direction stays in the x-direction. What happens in the y-direction stays in the y-direction. Let's define the x-direction as parallel to the ground and the y-direction as perpendicular to the ground.

1. What forces act on a projectile in the x-direction? What do Newton's laws say about an object in this case?
2. What forces act on a projectile in the y-direction? What do Newton's laws say about an object in this case?
3. At the instant a cannon fires a cannonball horizontally over a level range, another cannonball held at the side of the cannon is released and drops to the ground. Which ball strikes the ground first?
4. Pick a partner; grab the apparatus from the instructor. What did you see?

Draw a Trajectory

5. Draw a trajectory in your notebook. What is this shape called? Draw a second with the same initial velocity and different launch angle. What is different? Why?

Range

When a projectile is fired, how far will it go?

6. Let's start with a prediction. As the projectile is fired faster, will it go farther or less far? On a planet with higher gravity, would the projectile go farther or less far?

We know that the x and y directions can be separated. The y-direction is affected by gravity while the velocity in the x-direction does not change. So, the distance traveled in the x-direction is given by $R = v_x t$, where R is the distance traveled, or the range, v_x is the x-component of velocity, and t is the time.

7. In terms of the magnitude of the initial velocity of the projectile, v, and the angle at which it is fired, θ, what is the x-component, v_x?

But, how long does the object remain in the air? For this, we turn to the y-component. In lab 4 we learned that acceleration is given by $a = \frac{v_f - v_i}{t}$. In the case of our projectile, we know the initial speed it was thrown at, v_i, and the speed when it reaches the top of its arc (just before it comes back down), $v_f = 0$. We also know the acceleration, so we can find the time it takes for the projectile to go up.

8. Write a formula for the time it takes for a projectile to go up, in terms of g, the acceleration due to gravity (9.8 m/s^2), and v_i, the initial y-component of velocity.

9. What is the initial y-component of velocity in terms of v and θ?
10. The time it takes for the projectile to hit the ground is twice what you found in #8. Plug 2 x your answer for #11 in for t in the first equation I gave you. You should now have a formula for range in terms of only v, g, and θ. Write that formula.
11. Your previous answer should have 2 trig functions. Look up a trig identity to turn this into a single trig function. You will need this formula for Monday's activity.
12. Does this equation make sense? Compare it to the predictions you made in #6.

Rides

- Toy Story Mania, Soarin' over California, Fireworks, California Screamin'