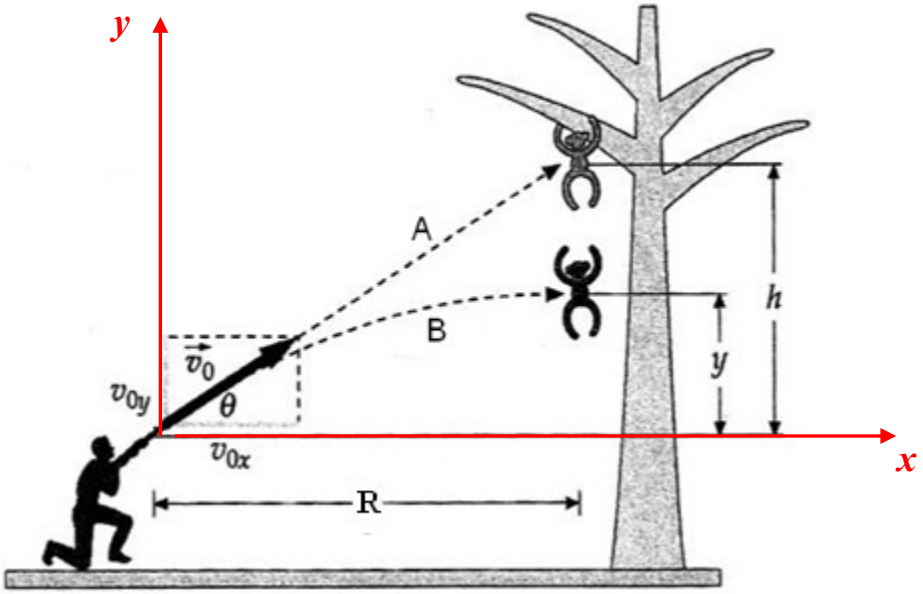
Phys101 Tutorial Worksheet 1

Name:_____

Computing ID:_____

The Monkey and the Hunter Problem



A student fires a dart at a stuff monkey held by an electromagnet a distance **h** vertically above the dart gun and a distance **R** horizontally away from the dart gun. The student aims directly at the monkey and fires, but as the student fires, the power of the electromagnet is turned off causing the monkey to drop simultaneously. Will the dart miss the monkey?

Method 1: Calculation

Idea: Both the dart and the monkey are in a projectile motion. We can find their positions at anytime and see if they will be at the same location at the same time.

Method 2: Investigation

Idea: What could cause the dart to miss the monkey? How does it work?

Method 1: Calculation

First, set up a coordinate system.

Question 1: Why do we need to set up a coordinate system early on?

Your answer: The formulas and variables would not mean anything if we don't have a coordinate system .

Question 2: How do you choose your coordinate system (origin, direction of x- and y-axes)? Draw your coordinate system in the figure.
There are many possible choices. See the figure.

Question 3: How do you approach the problem? Given h, R, v_0, and θ.

A summary of your approach:
1. Find the time it takes (t) for the dart to travel a horizontal distance R.
2. Find the y-position of the dart as well as the monkey at time t, y_d and y_m.
3. If $y_d = y_m$ at time t, then the dart hits the monkey. If not, or if it's hard to tell, then we could find the difference $y_d - y_m$, which would tell us by how much the dart would miss the monkey.

Your calculation and result:

It takes time t the dart to travel a horizontal distance R: $t = \dfrac{R}{v_0 \cos\theta}$

At time t: $y_d = v_0 \sin\theta\, t - \frac{1}{2} g t^2$; $y_m = h - \frac{1}{2} g t^2$

The difference in y-position at time t:

$$\begin{aligned} y_d - y_m &= v_0 \sin\theta\, t - \frac{1}{2} g t^2 - \left(h - \frac{1}{2} g t^2 \right) \\ &= v_0 \sin\theta\, t - h \\ &= v_0 \sin\theta \frac{R}{v_0 \cos\theta} - h \\ &= R \tan\theta - h \\ &= R \frac{h}{R} - h \\ &= 0 \end{aligned}$$

Therefore, the dart will hit the monkey.

Method 2: Investigation

Question 4: What could possibly cause the dart to miss the monkey?

Obviously the dart might miss the monkey because the monkey drops. The real question is that when we analyze the monkey's motion, what are the relevant quantities. Can you think of a physical quantity that represents or characterizes this falling motion?

g - the gravitational acceleration due to the earth

Question 5: Does the quantity characterizing the monkey's falling motion affect the motion of the dart? If it does, compare its effects on the monkey and the dart. Then we know whether or not the dart will miss the monkey, or how much it will miss the monkey. You need to do this analysis quantitatively.

The motion of monkey: $x_m = R, \quad y_m = h - \frac{1}{2} g t^2$

The motion of dart: $x_d = v_0 \cos\theta\, t, \quad y_d = v_0 \sin\theta\, t - \frac{1}{2} g t^2$

The effect of gravity on the monkey is exactly the same as that on the dart, i.e., it changes the y-position by $-gt^2/2$.
Therefore, the gravity should make no difference in the result of shooting.

In other words, if there were no gravity, the monkey wouldn't drop, the dart would hit the monkey because the shooter aims directly at the monkey. Now, since the gravity has the same effect on the monkey and the dart, "turning on" the gravity makes no difference in the result.