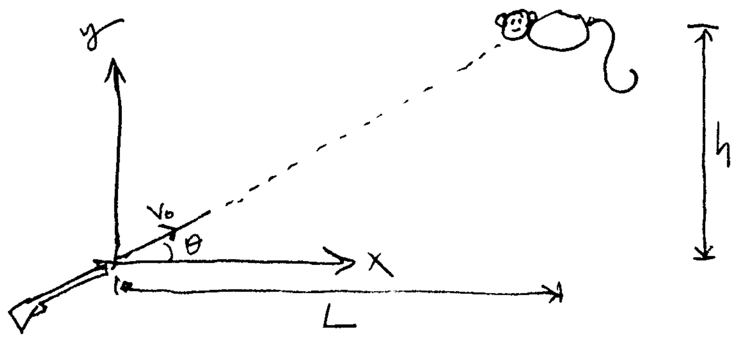
P2010 LECTURE 9

- Finishing up 2-D projectile problems: classic "shoot the monkey" experiment.

The basic problem: A hunter is aiming a rifle at a monkey in a tree. The monkey sees the shot fired, and drops out of the tree at the exact same time. Under what conditions does the shot hit the monkey?

- Start off in a zero-gravity environment:



Bullet goes straight (no accel.), and monkey doesn't move → monkey dies.

When does the monkey get hit?

$$x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2 = v_{0x}t$$

$$y = y_0 + v_{0y}t + \frac{1}{2}a_y t^2$$

Monkey has $x = L$, so it's hit at t when $v_{0x}t = L \Rightarrow t = \frac{L}{v_{0x}}$

- Now, turn on gravity.

Gravity doesn't affect x, so monkey & bullet still meet at $t = \frac{L}{V_{ox}} = \frac{L}{V_o \cos\theta}$ (if they meet atall).

But now $a_y \neq 0$ so equations of motion are:

Bullet

$y = \cancel{y_o} + V_{oy} t - \frac{1}{2} g t^2$, $y_o = 0$, $V_{oy} = V_o \sin\theta$

Monkey

$y_M = y_o - \frac{1}{2} g t^2$, $y_o = h$

Substitute in $t = \frac{L}{V_o \cos\theta}$.

$y_{bullet} = (\cancel{V_o} \sin\theta) \frac{L}{\cancel{V_o} \cos\theta} - \frac{1}{2} g \left(\frac{L}{V_o \cos\theta}\right)^2$

$= L \tan\theta - \frac{1}{2} g \left(\frac{L}{V_o \cos\theta}\right)^2$

$y_m = h - \frac{1}{2} g \left(\frac{L}{V_o \cos\theta}\right)^2$

$= h - \frac{1}{2} g \left(\frac{L}{V_o \cos\theta}\right)^2$

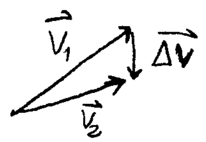
But look at triangle: $\tan\theta = \frac{h}{L}$

$y_{bullet} = \cancel{L} \frac{h}{\cancel{L}} - \frac{1}{2} g \left(\frac{L}{V_o \cos\theta}\right)^2$ $\quad y_m = h - \frac{1}{2} g \left(\frac{L}{V_o \cos\theta}\right)^2$

$y_{bullet} = y_{monkey}$ even with gravity $\Longrightarrow$ monkey still dies.

Review definition of acceleration: 1D $a = \frac{\Delta V}{\Delta t}$; 2D: $\vec{a} = \frac{\Delta \vec{V}}{\Delta t} = \frac{\vec{V}_2 - \vec{V}_1}{\Delta t}$

$\Delta \vec{V} = \vec{V}_2 - \vec{V}_1$: $\Delta \vec{V}$ is what you add to $\vec{V}_1$ to get $\vec{V}_2$.



$\vec{V}_1 + \Delta \vec{V} = \vec{V}_2$ or $\vec{V}_2 - \vec{V}_1 = \Delta \vec{V}$.