Physics 101.

Lecture 5.

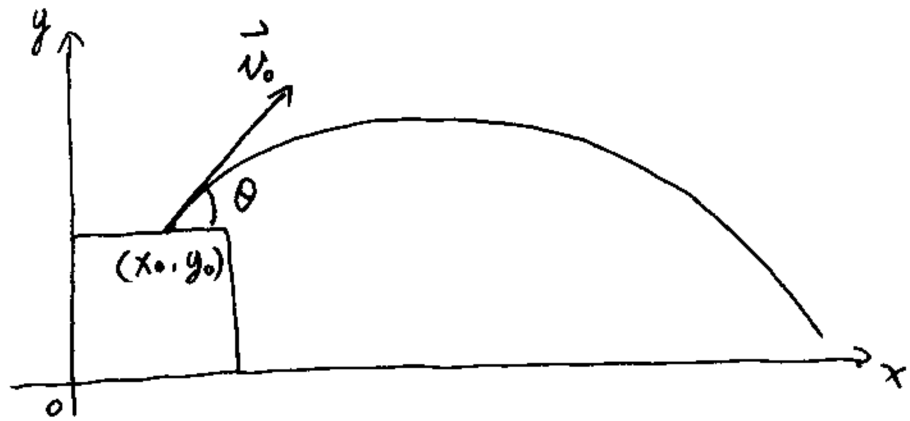
Mon. Jan. 13, 2003.

Topics Covered: Projectile Motion
Relative Motion
Newton's 2nd law of Motion

Ref: ch3. ch.4.

Demo: "Monkey"-Hunting experiment.

- Projectile Motion
  - Treat x- and y- components independently.



acceleration:

$a_x = 0 = \text{const.}$

$a_y = -g = \text{const.}$

velocity:

$v_x = v_{0x} = v_0 \cos\theta$

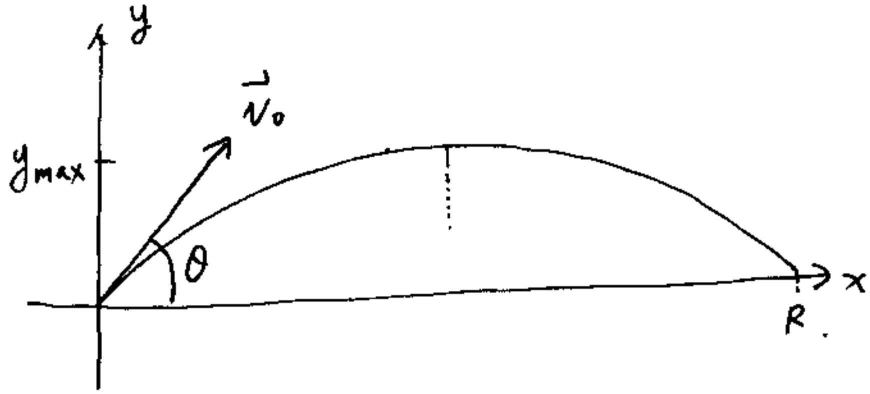
$v_y = v_{0y} + a_y t = v_0 \sin\theta - gt$

position:

$x = x_0 + v_0 \cos\theta \cdot t.$

$y = y_0 + v_0 \sin\theta \cdot t - \frac{1}{2} g t^2.$

- Special case — if we can choose $x_0 = 0$, $y_0 = 0$



$x = v_0 \cdot \cos\theta \cdot t$

$y = v_0 \sin\theta \cdot t - \frac{1}{2} g t^2$

$v_x = v_0 \cos\theta$

$v_y = v_0 \sin\theta - gt$.

Q1 : Find the Maximum height y_{max}.

when it reaches y_{max}, $v_y = 0$.

i.e. $v_0 \sin\theta - gt = 0$.

$$t = \frac{v_0 \sin\theta}{g}.$$

$$y_{max} = v_0 \sin\theta \cdot \frac{v_0 \sin\theta}{g} - \frac{1}{2} g \left(\frac{v_0 \sin\theta}{g}\right)^2.$$

$$= \frac{1}{2} \frac{(v_0 \sin\theta)^2}{g}$$

Q2. Find the range R.

when it hits the ground. $y = 0$.

i.e. $v_0 \sin\theta \cdot t - \frac{1}{2} g t^2 = 0$.

$$t = \frac{2 v_0 \sin\theta}{g}$$

$$x_{max} = R = v_0 \cdot \cos\theta \cdot \frac{2 \cdot v_0 \sin\theta}{g}.$$

$$= \frac{v_0^2}{g} 2 \cdot \sin\theta \cdot \cos\theta = \frac{v_0^2 \sin 2\theta}{g}.$$

Q3. What angle θ will yield the largest Range R?

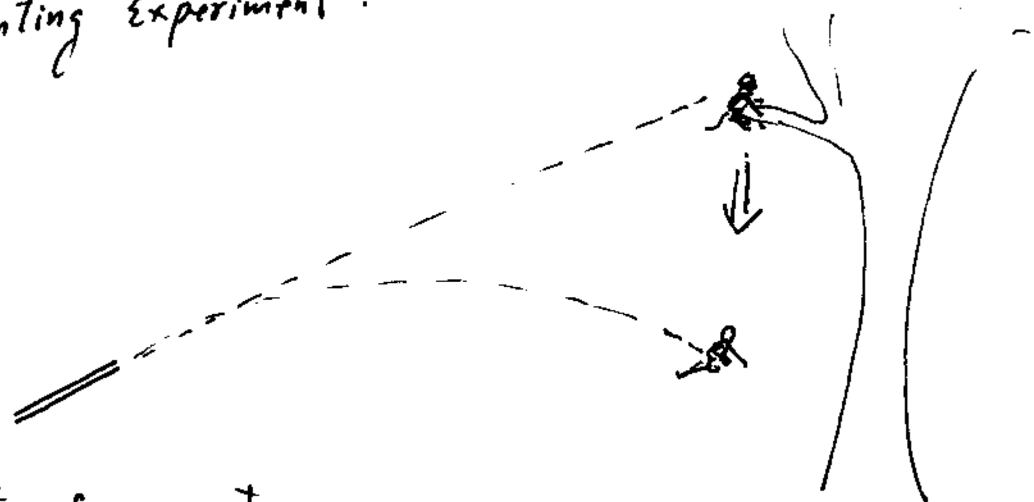
$$R = \frac{v_0^2}{g} \cdot \sin(2\theta).$$

when $2\theta = 90°$, $\sin(2\theta) = 1 = max$.

$\therefore$ $\theta = 45°$ will yield the largest range

$$R_{max} = \frac{v_0^2}{g}. \quad (\text{if } \theta = 45°)$$

"Monkey"- Hunting Experiment.



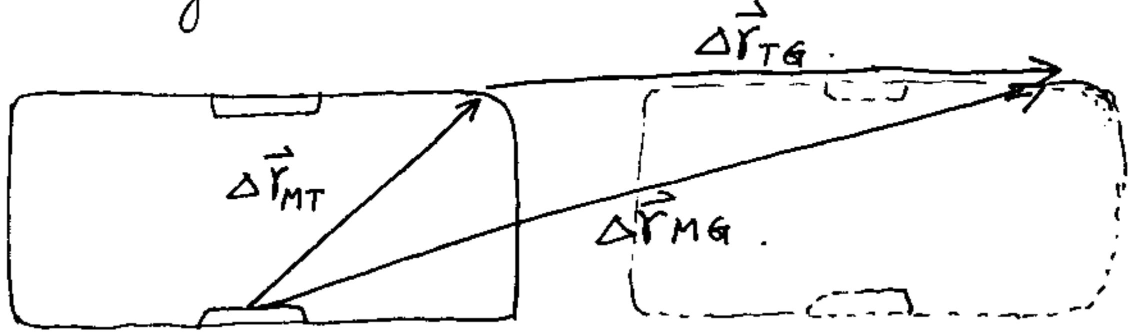
The effect of gravity on y: $\underbrace{-\frac{1}{2}gt^2}$.

is the same for the bullet and the monkey.

(even though they have different $\vec{v}_0$)

- Relative Motion.

e.g: Walking in a train. in time interval Δt.



$$\Delta\vec{r}_{MG} = \Delta\vec{r}_{MT} + \Delta\vec{r}_{TG}.$$

$$\lim_{\Delta t \to 0}\left(\frac{\Delta\vec{r}_{MG}}{\Delta t} = \frac{\Delta\vec{r}_{MT}}{\Delta t} + \frac{\Delta\vec{r}_{TG}}{\Delta t}\right)$$

$$\vec{v}_{MG} = \vec{v}_{MT} + \vec{v}_{TG}$$

Similarly.

$$\vec{a}_{MG} = \vec{a}_{MT} + \vec{a}_{TG}$$

In general, Bug – Man – Train – Ground.
would follow the same pattern:

e.g: $\vec{v}_{BG} = \vec{v}_{BM} + \vec{v}_{MT} + \vec{v}_{TG}$

- Newton's 2nd Law of Motion.

$$\vec{F} = m\vec{a}.$$

① $\vec{F}$ —— Net force. (Total force).

②. It's a vector equation.

$$F_x = ma_x$$
$$F_y = ma_y.$$
$$F_z = ma_z.$$

③. static : $\vec{a} = 0$.

$$\therefore \quad \vec{F} = 0.$$

④. when Net Force is zero : $\vec{F} = 0$.

$$\vec{a} = 0.$$

$\vec{v} = \text{const}.$ $\begin{cases} \text{at rest.} \\ \text{OR } \text{uniform motion along a straight line.} \end{cases}$

(That's Newton's 1st Law of Motion).