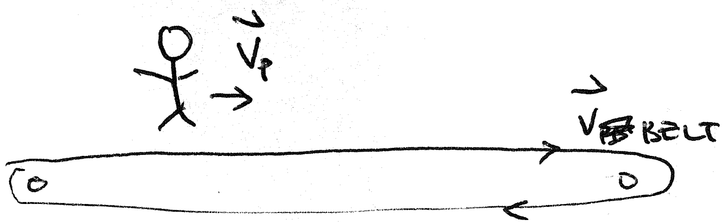
. LECTURE 6

PO

RELATIVE VELOCITY

PEOPLE MOVER

MCO ~~PEAPE PEAPL~~



WRT X

ABSOLUTE VELOCITY W.R.T TO REST FRAME

$$\vec{V}_A = \vec{V}_P + \vec{V}_{BELT}$$

$\boxed{\text{GALILEAN TRANSFORMATION}}$

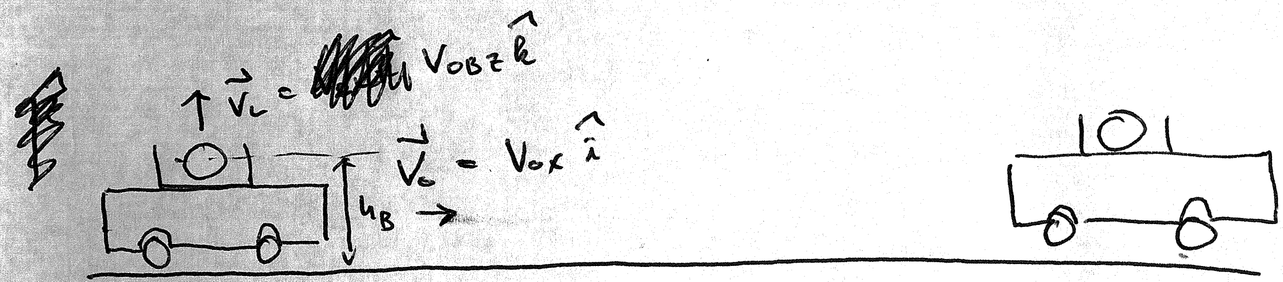
$\vec{V}_P$: VELOCITY OF THE PERSON W.R.T. BELT

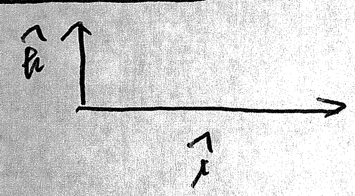
$\vec{V}_A$: VELOCITY OF THE PERSON W.R.T. REST FRAME

$$\vec{V}_A = \vec{V}_P + \vec{V}_{BELT}$$

LECTURE 6

DEMONSTRATION





BALL IS LAUNCHED VERTICALLY W.R.T.

THE VEHICLE TRAVELLING AT $\underline{V_{0x}\hat{i} = \vec{V}_0}$

★ MOTION OF THE CAR

$$\vec{a}_c(t) = \vec{0} = 0\hat{i} + 0\hat{j} + 0\hat{k}$$

$$\int \vec{a}_c(t)\,dt = \vec{V}_c(t) = V_{0x}\hat{i} + \underbrace{V_{0y}}_{0}\hat{j} + \underbrace{V_{0z}}_{0}\hat{k}$$

$$\int \vec{V}_c(t)\,dt = \vec{P}_c(t) = (V_{0x}t + \underbrace{x_0}_{0})\hat{i} + \underbrace{y_0}_{0}\hat{j} + \underbrace{z_0}_{0}\hat{k}$$

★ MOTION OF THE BALL

$$\vec{a}_B(t) = -g\hat{k}$$

$$\vec{V}_B(t) = \underbrace{V_{0xB}}_{0}\hat{i} + \underbrace{V_{0yB}}_{0}\hat{j} + V_{0zB}\hat{k} - gt\hat{k}$$

$$= (V_{0zB} - gt)\hat{k}$$

$$\vec{P}_B(t) = \underbrace{x_0}_{0}\hat{i} + \underbrace{y_0}_{0}\hat{j} + \left(z_0 + V_{0zB}t - \frac{gt^2}{2}\right)\hat{k}$$

$$z_0 = h_B$$

- MOTION OF THE BALL

$$\vec{a}_B(t) = -g\hat{k}$$

$$\vec{V}_B(t) = V_{0x}\hat{i} + \cancel{V_{0y}\hat{j}}^{\,0} + (V_{0z} - gt)\hat{k}$$

$$= V_{0x}\hat{i} + (V_{0z} - gt)\hat{k}$$

$$\vec{P}_B(t) = \underline{V_{0x}t\hat{i}} + \left(z_0 + V_{0z}t - \frac{gt^2}{2}\right)\hat{k}$$

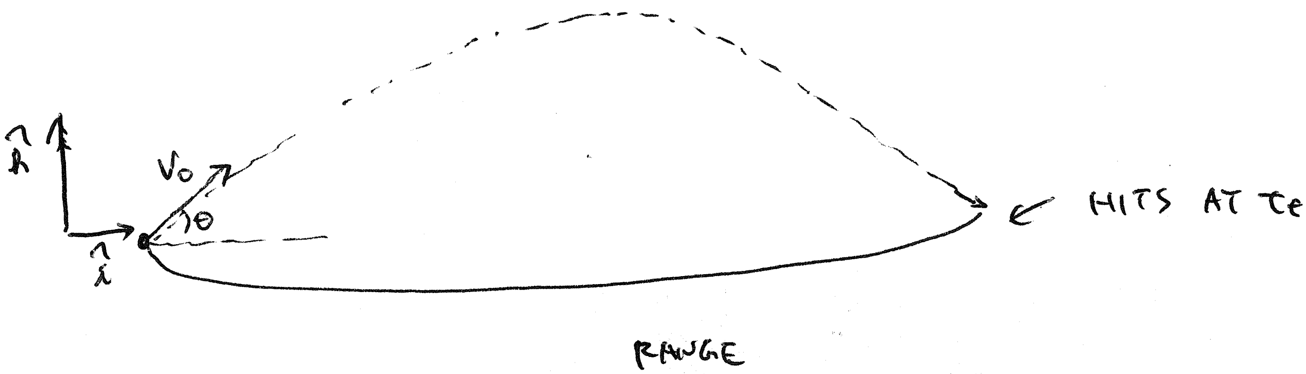
$$z_0 = h_B$$

$$\vec{P}_C(t) = \underline{V_{0x}t\hat{i}}$$

BALL + CAR ALWAYS AT THE SAME LOCATION IN X.

SO IT WORKS?!!

PROJECTILE MOTION (A CANNON)   NUCLEAR CANNON MAYBE



$\vec{a} = -g\hat{k}$

$$\int \vec{a}(t) = \vec{V}(t) = \vec{V}_0 + -gt\hat{k}$$

$$= V_0\cos\theta\,\hat{i} + V_0\sin\theta\,\hat{k} - gt\hat{k}$$

$$= V_0\cos\theta\,\hat{i} + (V_0\sin\theta - gt)\hat{k}$$

$$\vec{P}(t) = \underbrace{\cancel{\vec{P}_0}}_{0} + \vec{V}_0 t + -\frac{gt^2}{2}\hat{k}$$

$$= V_0\cos\theta\, t\,\hat{i} + \left(V_0\sin\theta\, t - \frac{gt^2}{2}\right)\hat{k}$$

$$V_0\sin\theta\, t_f - \frac{g t_f^2}{2} = 0$$

$$V_0 \sin\theta \, t_f - \frac{g t_f^2}{2} = t_f \left(V_0 \sin\theta - \frac{g t_f}{2} \right) = 0$$

$$t_f = \frac{2 V_0 \sin\theta}{g}$$

X POSITION ~~ATT~~ AT $T_F = \frac{2 V_0 \sin\theta}{g}$

$$R = V_0 \cos\theta \cdot \frac{2 V_0 \sin\theta}{g} = 2 \sin\theta \cos\theta \frac{V_0}{g}$$

$$= \cancel{\sin} \sin 2\theta \frac{V_0}{g}$$

THIS IS MAXIMIZED WHEN $2\theta = 90°$

OR $\theta = 45°$

MATHEMATICALLY,

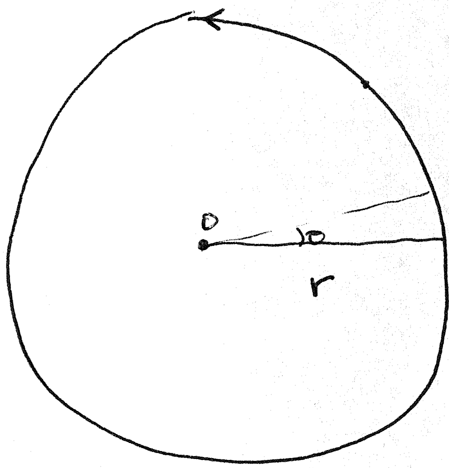
$$R = \frac{V_0}{g} \sin 2\theta$$

$$\frac{dR}{d\theta} = \frac{V_0}{g} 2 \cos 2\theta = 0$$

$$\frac{2V_0}{g} \cos 2\theta = 0 \qquad 2\theta = 90 \qquad \theta = 45°$$

UNIFORM

CIRCULAR MOTION



$$\vec{P}(t) = r\cos\theta\,\hat{i} + r\sin\theta\,\hat{j}$$

$$\theta = \omega t$$

$$\vec{P}(t) = r\cos\omega t\,\hat{i} + r\sin\omega t\,\hat{j}$$

2π ω : ANGULAR VELOCITY

$$\frac{2\pi}{\omega} = T \text{ [PERIOD]}$$

$$\vec{P}(t) = r\cos\omega t\,\hat{i} + r\sin\omega t\,\hat{j}$$

$$\frac{d\vec{P}}{dt} = \vec{V}(t) = -r\omega\sin\omega t\,\hat{i} + r\omega\cos\omega t\,\hat{j}$$

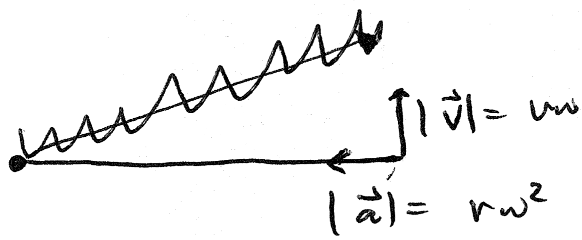
$$\frac{d\vec{v}}{dt} = \vec{a}(t) = -r\omega^2\cos\omega t\,\hat{i} + r\omega^2\sin\omega t\,\hat{j}$$

WHAT'S GOING ON AT $t = 0$ TIME = 0

$\vec{P}(t) = r\hat{i} + 0\hat{j}$ ✓

$\vec{V}(t) = 0\hat{i} + r\omega\hat{j}$

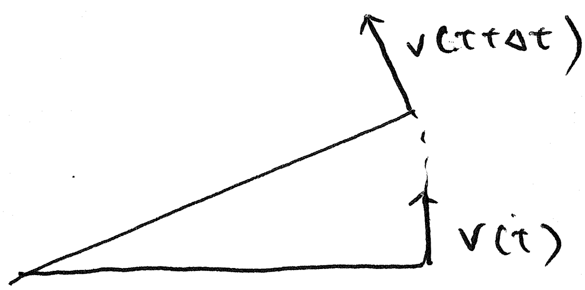
$\vec{a}(t) = -r\omega^2\hat{i} + 0\hat{j}$

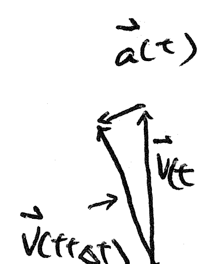


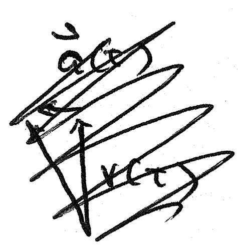
$$\therefore \quad \frac{|v|^2}{r} = \frac{r^2\omega^2}{r} = |a|$$

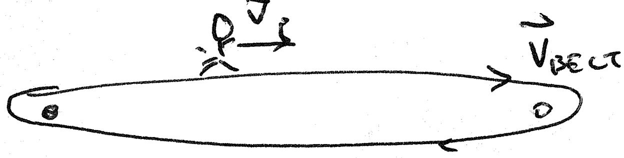
$$|a| = \frac{|v|^2}{r}$$

ACCELERATION POINTS IN W.T.F.









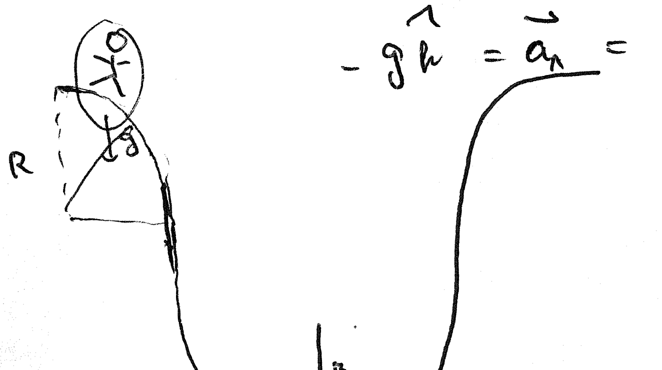
RELATIVE ACCELERATION

$$\vec{V}_A = \vec{V}_P + \vec{V}_{BELT}$$

$$\frac{d\vec{V}_A}{dt} = \frac{d\vec{V}_P}{dt} + \frac{dV_{BELT}}{dt}$$

$$\vec{a}_A = \frac{d\vec{V}_A}{dt} = \frac{dV_P}{dt} + \frac{dV_{BELT}}{dt}$$ = ABSOLUTE ACCELERATION MEASURED FROM REST

+

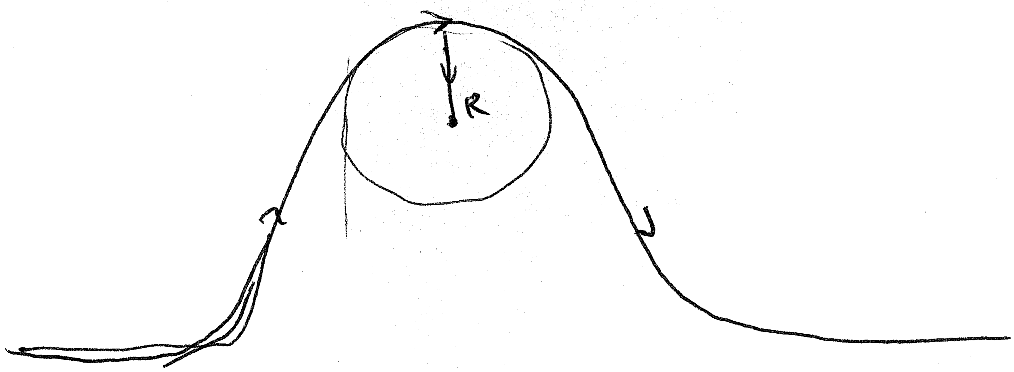


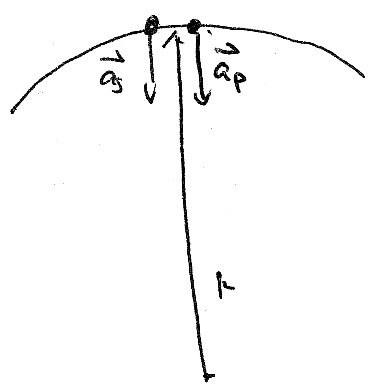
$-g\hat{h} = \vec{a}_A =$

dV_{PLANE}

$-g\vec{h} = P$

VOMIT COMET





$\therefore \quad \vec{a_s} = -g\hat{k} = \vec{a_r} - g\hat{k}$

$0 = \vec{a_r}$ of RELATIVE