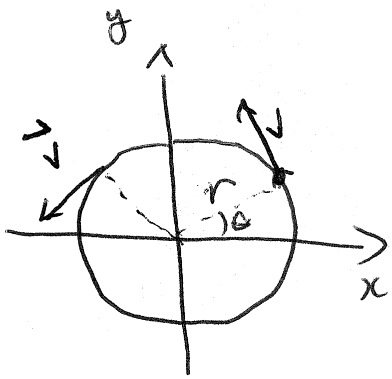
LECTURE 7

- NEED BOTTLE (PLASTIC) w/ WATER
- BALL ON A STRING
- PLUMB BOB

LAST TIME
- PROJECTILE MOTION
- UNIFORM CIRCULAR ~~PO~~ MOTION



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

UNIFORM MEANS $\theta = \omega t$

ω IS CONSTANT : ANGULAR VELOCITY

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

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

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

$$|\vec{v}(t)| = \sqrt{(-r\omega\sin\omega t)^2 + (r\omega\cos\omega t)^2}$$

$$= \sqrt{r^2\omega^2\sin^2(\omega t) + r^2\omega^2\cos^2(\omega t)}$$

$$= \sqrt{r^2\omega^2\left[\sin^2(\omega t) + \cos^2(\omega t)\right]}$$

$$= \sqrt{r^2\omega^2} = \omega r$$

$$|\vec{a}(t)| = \omega^2 r = \frac{v^2}{r}$$ = CENTRIPETAL ACCELERATION

$$|\vec{P}(t)| = r$$

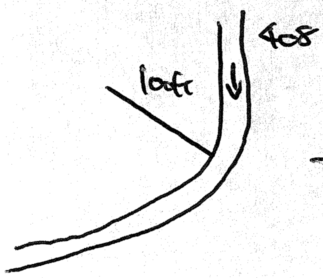
$$|\vec{v}(t)| = \omega r$$

$$|\vec{a}_c(t)| = a_c = \omega^2 r = \frac{v^2}{r}$$

HOW TO USE IT #1

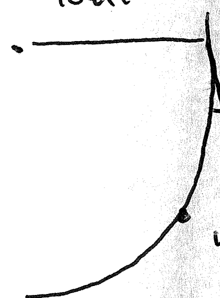
HIGHWAY TURN

$r = 1000$ ft



→ APPROXIMATION

$1000\text{ft} = 305\text{m} \sim 300\text{m}$



WHAT IS THE ACCELERATION HERE?

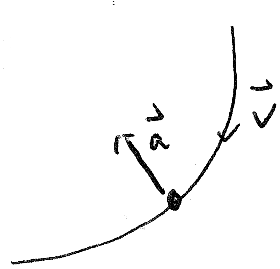
$$|\vec{a}| = \omega^2 r = \frac{v^2}{r}$$

BUT $v = \omega r$

VELOCITY IS 60 mph CONST $\Rightarrow$ $27.8\,\text{m/s} \sim 30\,\text{m/s}$

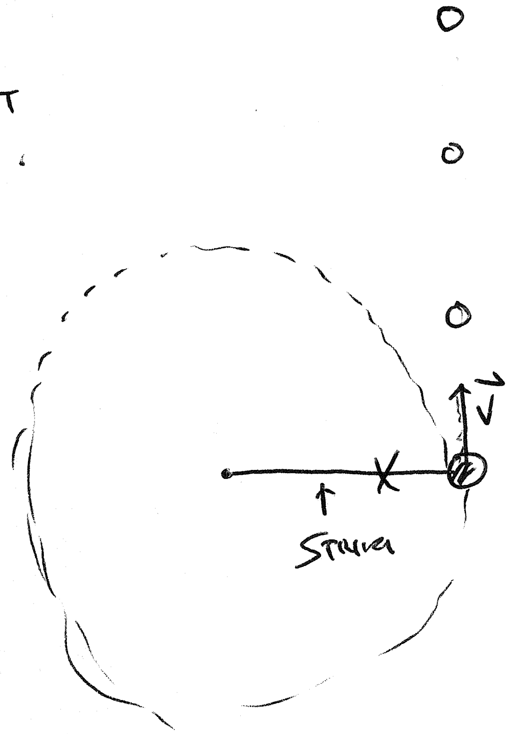
$$|\vec{a}| = \frac{v^2}{r} = \frac{(30\,\text{m/s})^2}{300\,\text{m}} = \frac{\overset{3}{\cancel{900}}\ \text{m}^2/\text{s}^2}{\cancel{300\,\text{m}}}$$

$$= 3\,\text{m/s}^2$$



$\sim 0.3\,g$ POINTING TOWARDS CENTER

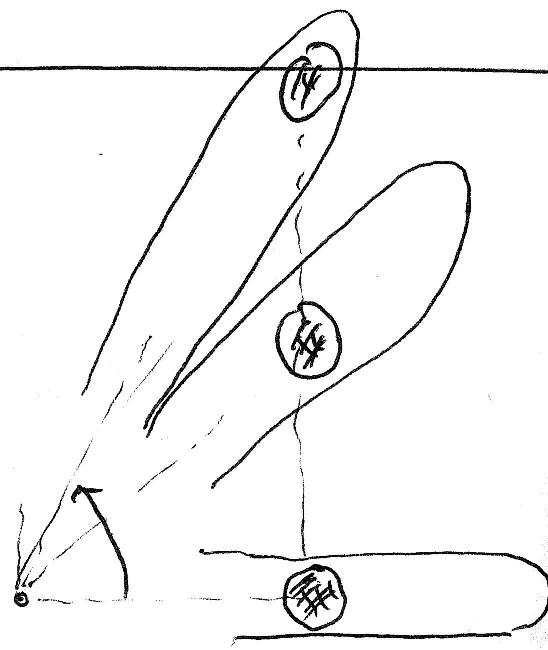
IMPORTANT POINT:



WHERE WILL THE BALL GO IF STRING IS CUT?

$\boxed{\text{SHOW VIDEO.}}$

GRAPHICAL WAY OF POINTING OUT



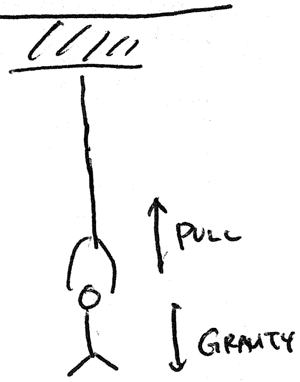
CONSIDER A GLASS TUBE.

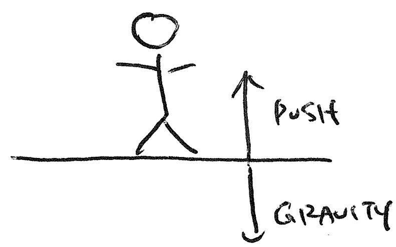
INTERESTING IT'S LIKE ACCELERATING IN OUTER DIRECTION

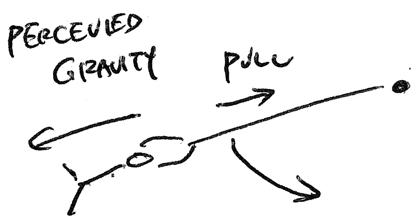
WATER BOTTLE TRICK.

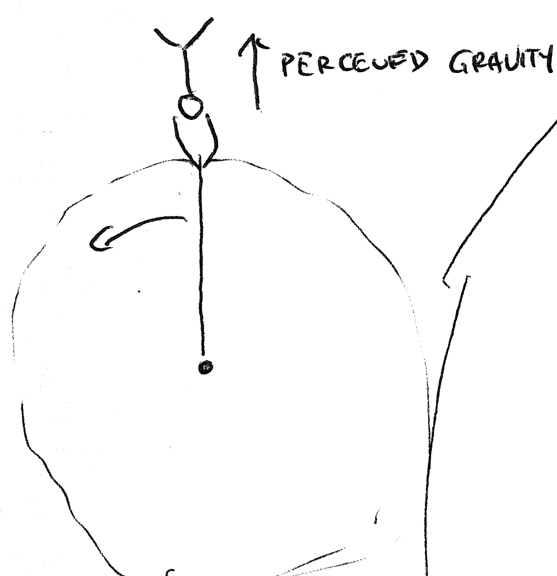
STRING DEMO

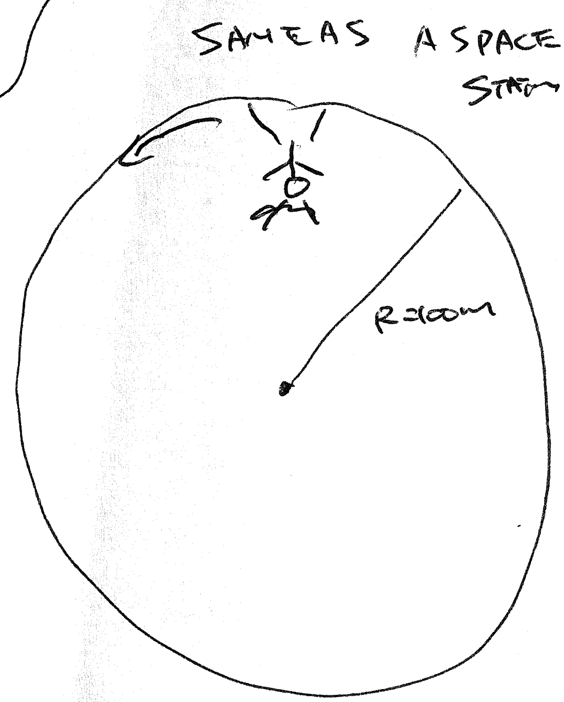
PERCEIVED GRAVITY











SPACESTATION R=100m

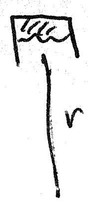
$\omega^2 R = 9.8\ m/s^2$ ← PERCEIVED GRAVITY

$\omega^2 \cong 0.1$

$\omega = 0.3\ rad/s$

$\omega r = v = 30\ m/s$

(~~[illegible]~~)
WATER DEMONSTRATON



$r = 50$ cm

~~ω =~~ $T \sim 1$ sec

$\omega = 2\pi$ ~~π~~ 6.36

$a = \omega^2 \cdot r = (2\pi)^2 \cdot 0.5$

$= 18\ m/s^2$

MISTAKE

(DEFINITION OF TANGENTIAL AND RADIAL ACCELERATION)

SKIP

• RELATIVE VELOCITY

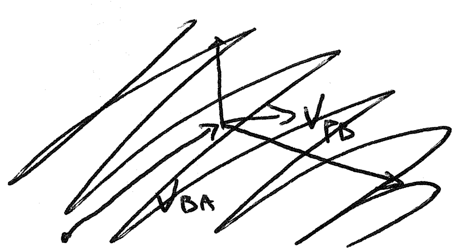
CONSIDER FRAME A ~~AND~~ AND B

FRAME A IS AT REST : ABSOLUTELY

FRAME B IS MOVING AT $\vec{V}_{BA}$

IN FRAME B, MASA MOVES WITH VELOCITY ~~...~~ $\vec{V}_{PB}$

WHAT IS THE VELOCITY OF MASA IN FRAME A

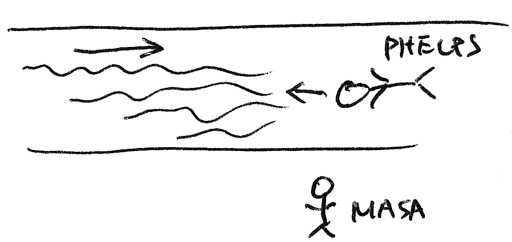


$$\boxed{\vec{V}_{PA} = \vec{V}_{PB} + \vec{V}_{BA}}$$

JUST A FANCY WAY OF SAYING WHAT WE SAYD.

<u>EXAMPLE</u> ~~A~~ PHELPS SWIMS UP RIVER AT 4 m/s.
BUT RIVER IS FLOWING AT 3 m/s

HOW FAST WILL HE BE MOVING TO A PERSON AT REST ?



$$\vec{V} = 4m - 3m/s = \boxed{1\,m/s}$$

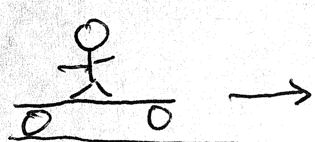
RELATIVE ACCELERATION

$$\vec{V}_{PA} = \vec{V}_{PB} + \vec{V}_{BA}$$

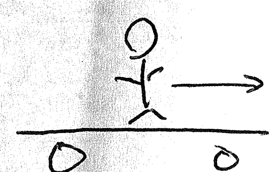
$$\frac{d\vec{V}_{PA}}{dt} = \frac{d\vec{V}_{PB}}{dt} + \frac{d\vec{V}_{BA}}{dt}$$

$$\vec{a}_{PA} = \vec{a}_{PB} + \vec{a}_{BA}$$

STOP EXAMPLE



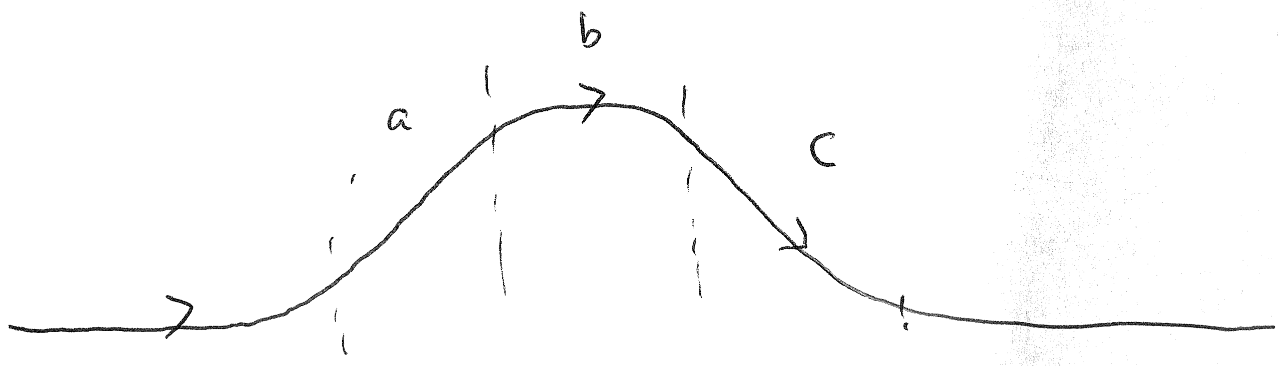
CAR STOPS



$$\vec{a}_{PA} = 0 = \vec{a}_{PB} + -g\,\hat{i}$$

$$\boxed{\vec{a}_{PB} = g\,\hat{i}}$$

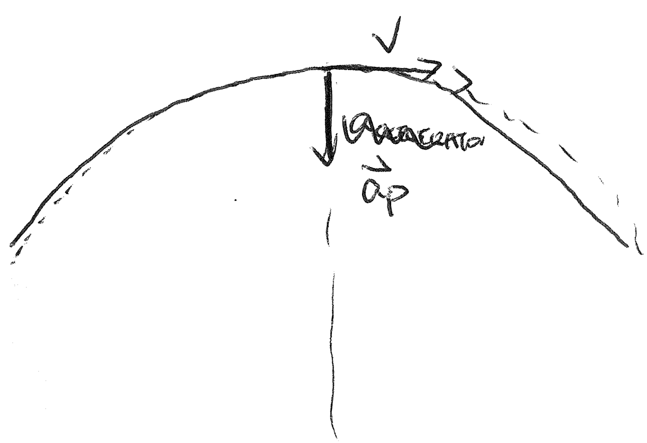
VOMIT COMET ; (NOT THE KIND OF BUS YOU NEED TO RIDE ON SATURDAYS)



QUESTION WHERE IS IT ZERO G ? VOTE

IT'S ACTUALLY b REGION

LET'S ANALYZE IT



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

$\vec{a}_{\text{OUTSIDE}} = -g\hat{k}$

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

$\vec{a}_R = \underline{\underline{0}}$ ZERO G

CHECK LOGIC