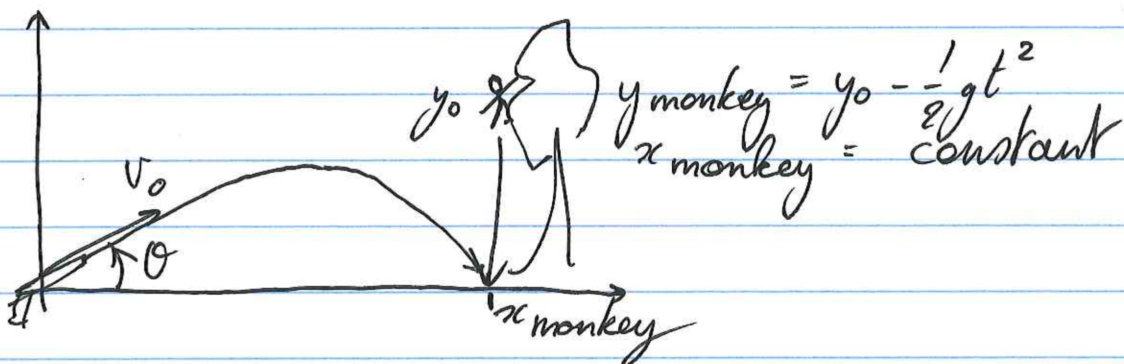
PHYS 107 - Week 3 - Wednesday

* Two objects in projectile motion

Q 2D Kin 2a

Let's look at a different problem:
where do I have to aim to hit the monkey?



Q Monkey dart

$$\begin{cases} x_{monkey} = \text{constant} \\ y_{monkey} = y_0 - \frac{1}{2}gt^2 \end{cases}$$

$$\begin{cases} x_{dart} = v_0 \cos\theta \cdot t \\ y_{dart} = v_0 \sin\theta \cdot t - \frac{1}{2}gt^2 \end{cases}$$

1) At what time does the dart reach x_{monkey}?

$$x_{dart} = x_{monkey} \text{ when } t = \frac{x_{monkey}}{v_0 \cos\theta}$$

2) What is the height of the dart then?

$$y_{dart} = x_{monkey}\frac{\sin\theta}{\cos\theta} - \frac{1}{2}gt^2$$

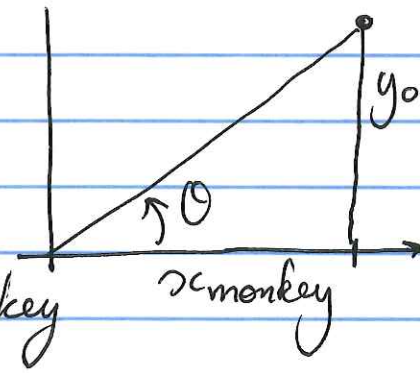
3) For the dart to hit the monkey, their vertical positions must be the same:

$$y_{dart} = y_{monkey}$$

$$x_{monkey} \frac{\sin\theta}{\cos\theta} \cancel{- \frac{1}{2}gt^2} = y_0 \cancel{- \frac{1}{2}gt^2}$$

$$x_{monkey} \tan\theta = y_0$$

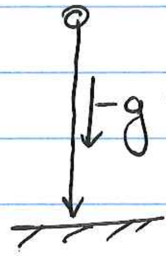
$$\tan\theta = \frac{y_0}{x_{monkey}}$$



→ aim directly <u>at</u> the monkey

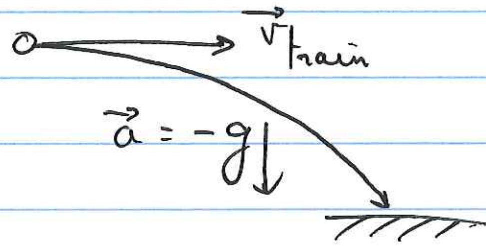
* Relative velocity : what happens when a coordinate system is moving ?

1) drop a ball :



$-g = \vec{a} \rightarrow y = y_0 - \frac{1}{2} g t^2$

2) in a train



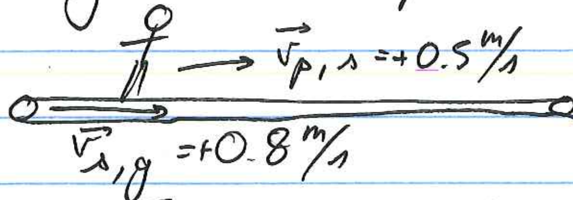
As long as $\vec{v}_{train}$ is constant, all physical laws inside the train are equal to those outside the train

↳ train is an <u>inertial</u> reference frame

$\vec{v}_{train}$ is constant when <u>both</u> magnitude <u>and</u> direction are <u>constant</u>!

* Relative ~~velo~~ velocity in 1 dimension :

Moving on an airport moving walk :



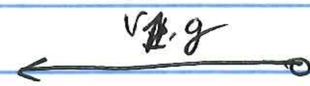
$\vec{v}_{p,s}$ = person relative to sidewalk

$\vec{v}_{s,g}$ = sidewalk relative to ground

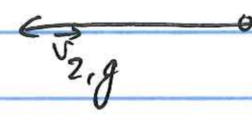
↳ $\vec{v}_{p,g} = \vec{v}_{p,s} + \vec{v}_{s,g} = +1.3\ m/s$

Driving on I-64 to Richmond

$\vec{v}_{1,g} = 60\,\text{mph W}$



$\vec{v}_{2,g} = 50\,\text{mph W}$



relative velocity is $\vec{v}_{1,2}$ (1 relative to 2)

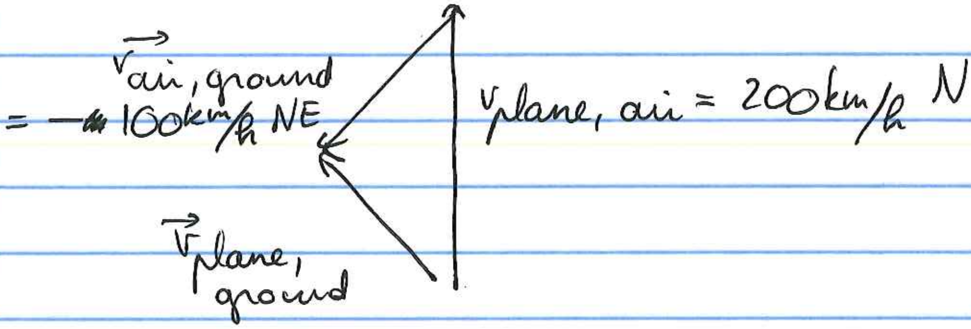
$$\vec{v}_{1,2} = \vec{v}_{1,g} + \vec{v}_{g,2} = \vec{v}_{1,g} - \vec{v}_{2,g} = \underline{10\,\text{mph W}}$$

$$\vec{v}_{2,1} = \vec{v}_{2,g} + \vec{v}_{g,1} = \vec{v}_{2,g} - \vec{v}_{1,g} = \underline{-10\,\text{mph W}}$$

* Relative velocity in 2 dimensions:

Airplane heads <u>north</u> with air speed 200 km/h but wind from <u>northeast</u> at 100 km/h. What is the speed and direction with respect to ground?

$$\vec{v}_{plane,ground} = \vec{v}_{plane,air} + \vec{v}_{air,ground}$$



In components: x: $v_{plane,\,ground,\,x} =$

$$= 0\,km/h + 100\,km/h\,\cos(225^\circ)$$
$$= -70.7\,km/h$$

y: $v_{plane,\,ground,\,y} =$

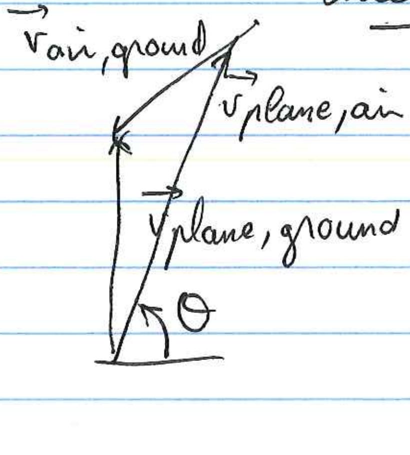
$$= 200\,km/h + 100\,km/h\,\sin(225^\circ)$$
$$= +129.3\,km/h$$

$\hookrightarrow$ $|\vec{v}_{plane,\,ground}| = \sqrt{(-70.7\,km/h)^2 + (+129.3\,km/h)^2}$
$= 147\,km/h$

$$\tan\theta = \frac{129.3}{-70.7} \rightarrow \theta = -61.3^\circ$$

But that angle is not only solution
$\rightarrow \theta = 118.67^\circ$

~~Example~~: Other question: in what direction must the plane fly to have a ground speed that is due north?



$|\vec{v}_{plane,\,ground}|$ ~~as~~ $= 200\,km/h$
but direction unknown

$$\vec{v}_{plane,air} = \vec{v}_{plane,ground} - \vec{v}_{air,ground}$$

x: $v_{plane,air,x} = 0 - 100\,km/h\,\cos(225°)$
$= +70.7\,km/h$

since $|\vec{v}_{plane,air}| = 200\,km/h$

$\hookrightarrow \cos\theta = \dfrac{v_{plane,air,x}}{|\vec{v}_{plane,air}|}$

$\theta = 69.3° \rightarrow 20.7°$ E of N