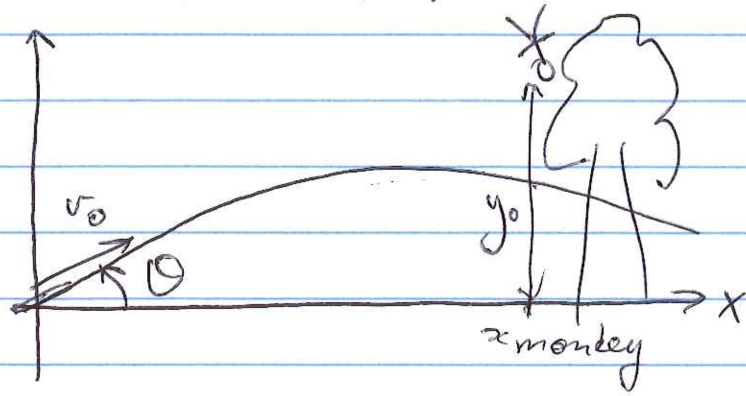
Two objects in projectile motion



x_{monkey} = constant

$y_{monkey} = y_0 - \frac{1}{2}gt^2$

$x_{dart} = v_{0,x}\, t$
$= v_0 \cos\theta \cdot t$

$y_{dart} = v_{0,y}\, t - \frac{1}{2}gt^2$
$= v_0 \sin\theta \cdot t - \frac{1}{2}gt^2$

1) determine t when $x_{dart} = x_{monkey}$
2) use t in $y_{dart} = y_{monkey}$

after 1 s : $-\frac{1}{2}gt^2 = -5\,m$
$-\frac{1}{2}(10\,m/s^2)(1s)^2$

1) $x_{dart} = \boxed{v_0 \cos\theta \cdot t = x_{monkey}}$

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

2) $y_{dart} = v_0 \sin\theta \cdot \underline{t} - \frac{1}{2}gt^2$

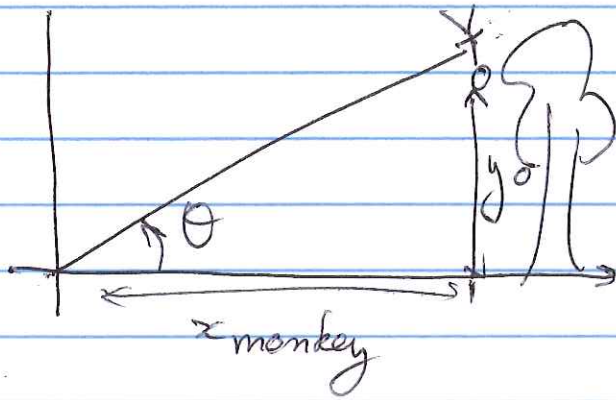
$y_{dart} = v_0 \sin\theta \left(\frac{x_{monkey}}{v_0 \cos\theta}\right) - \frac{1}{2}gt^2$

$y_{dart} = y_{monkey}$ if $\cancel{v_0} \sin\theta \left(\frac{x_{monkey}}{\cancel{v_0} \cos\theta}\right) \cancel{- \frac{1}{2}gt^2}$
$= y_0 \cancel{- \frac{1}{2}gt^2}$

what is θ ?

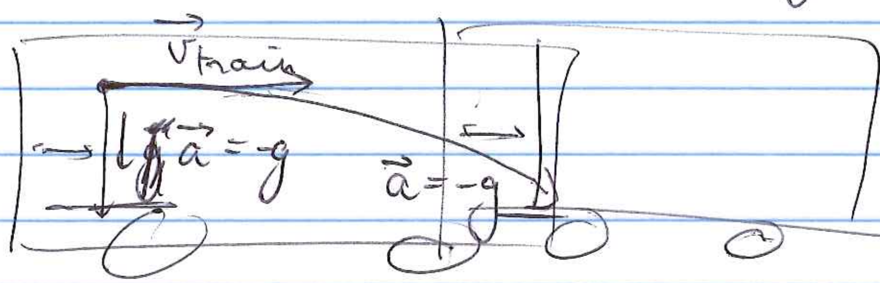
equation: $\tan\theta \; x_{monkey} = y_0$

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



$\tan\theta = \frac{\text{opposite}}{\text{adjacent}} = \frac{y_0}{x_{m\ldots}}$

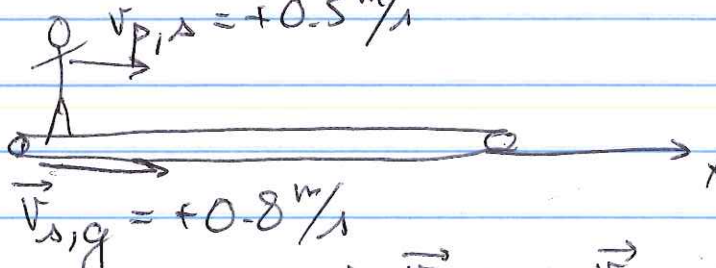
Relative velocity : what happens when your coordinate system is moving ?



As long as $\vec{v}_{train}$ is constant, all physical laws are valid inside the train just as they are outside.
inertial reference frames

magnitude and direction are constant

* Relative velocity in 1 dimension



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

Driving (taxi)

I-64 to Richmond

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

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

relative velocity of car 1 with respect to car 2 ?

$$\vec{v}_{1,2} = \vec{v}_{1,g} + \underbrace{\vec{v}_{g,2}}_{= -\vec{v}_{2,g}} = \vec{v}_{1,g} - \vec{v}_{2,g}$$

$$\vec{v}_{1,2} = 60 \text{ mph W} - 50 \text{ mph W} = 10 \text{ mph W}$$

$-5\,m/s = \vec{v}_{monkey,\,train}$

$\vec{v}_{train,\,monkey} = 5\,m/s$

$+15\,m/s = \vec{v}_{train,\,ground}$

$$\vec{v}_{ground,\,monkey} = -\vec{v}_{monkey,\,ground}$$

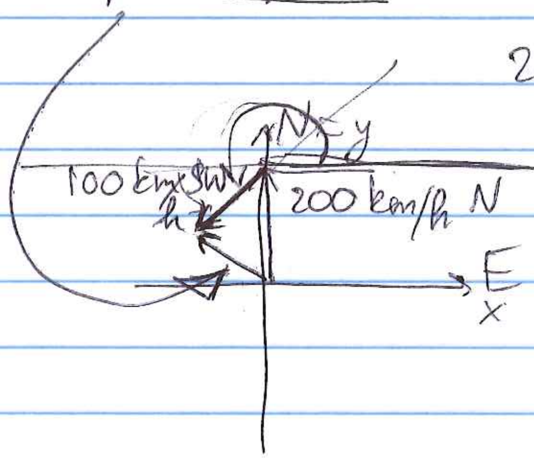
$$= -\left(\vec{v}_{monkey,\,train} + \vec{v}_{train,\,ground}\right)$$

$$= -\left(-5\,m/s + 15\,m/s\right) = -10\,m/s$$

2 dimensions:

Airplane heads north with air speed of $200\ \mathrm{km/h}$, but wind from NE at $100\ \mathrm{km/h}$. What is the velocity of the plane with respect to the ground?

$$\vec{v}_{plane,ground} = \underbrace{\vec{v}_{plane,air}}_{200\ \mathrm{km/h}\ N} + \underbrace{\vec{v}_{air,ground}}_{100\ \mathrm{km/h}\ SW}$$



x:

$$v_{plane,ground,x} = 0 + 100\ \mathrm{km/h}\cos(\underbrace{225^\circ}_{180^\circ+45^\circ}) = \underline{-70.7\ \mathrm{km/h}}$$

$$v_{plane,ground,y} = 200\ \mathrm{km/h} + 100\ \mathrm{km/h}\sin(225^\circ) = \underline{129.3\ \mathrm{km/h}}$$