Phys 2110-4 2/4/13

Note Title 2/4/2013

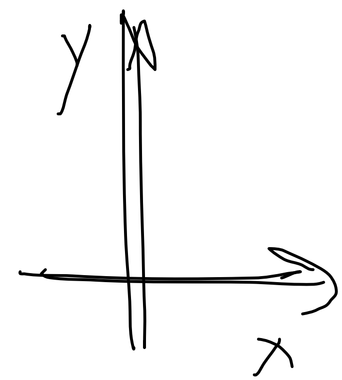
2D motion (ch 3)

Constant acceleration

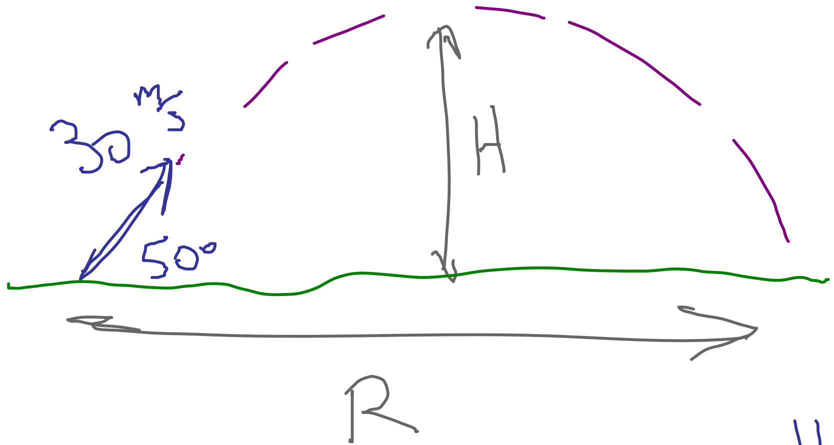
Projectile (free fall)

$a_x = 0 \quad a_y = -g$

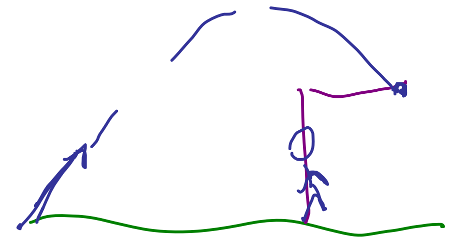
$g = 9.8 \frac{m}{s^2}$



# Example




Ground is flat



$$V_{x0} = 19.28\ \frac{m}{s}$$

$$V_{y0} = 22.98\ \frac{m}{s}$$

How long in flight?

when does $y = 0$

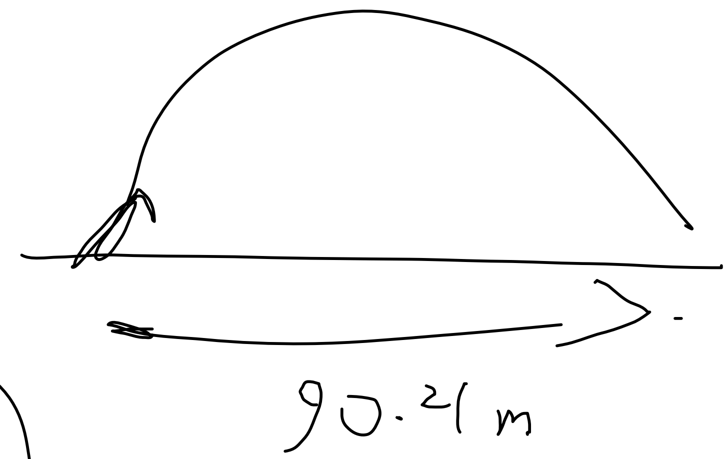
$$0 = (22.98\ \tfrac{m}{s})\,t - \frac{1}{2} g t^2$$

$$t = \begin{cases} 0\ s \\ 4.7\ s \end{cases}$$

what is x at this time

$x = (19.28)(4.7)$

$= 90.4\ m$




Find max ht.

$v_y = 0 \qquad (v_x = 19.28\ \frac{m}{s})$

$v_{y0} + a_y t$

$= (22.98\ \frac{m}{s}) - g t$

$t = 2.34\ s$

$(\frac{1}{2}$ total time of flight$)$

$$v_y^2 = v_{y0}^2 + 2a_y(y - y_0)$$

0 Know $-g$ $y$

What is value of $y$ at this time?

$y = (22.98\ \frac{m}{s})\, t - \frac{1}{2} g t^2$ plm $m$ $\longrightarrow$ $26.9\ m$

Do it again with $V_0$ at <u>angle</u> $\theta$

$$V_{x0} = V_0 \cos\theta$$

$$V_{y0} = V_0 \sin\theta$$


$$x = (V_0 \cos\theta)t$$

$$y = (V_0 \sin\theta)t - \frac{1}{2} g t^2$$

$$V_x = (V_0 \cos\theta)$$

$$V_y = (V_0 \sin\theta) - gt$$

Time of flight

when does $y = 0$

$$(V_0 \sin\theta)t - \frac{1}{2} g t^2 = 0$$

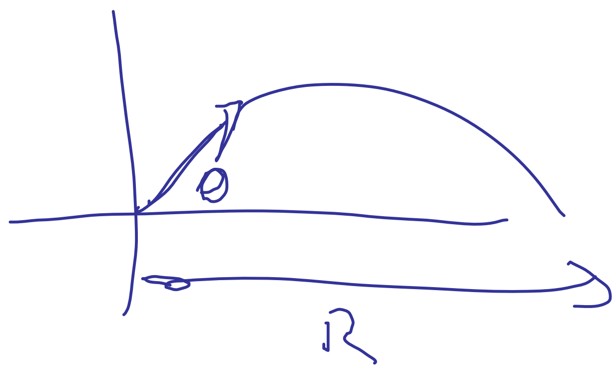
$$t\left[V_0 \sin\theta - \frac{1}{2} g t\right] = 0$$

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

what is x at this time?

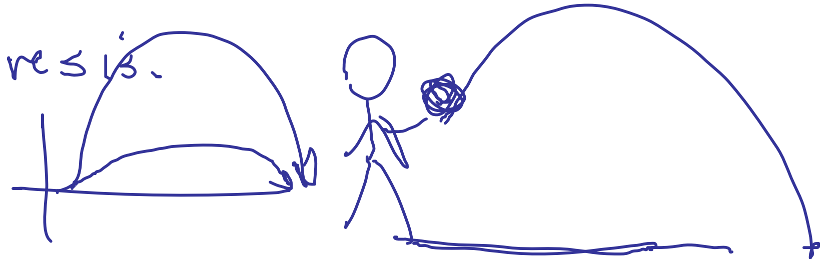
$$x = v_0 \cos\theta \, \frac{2 v_0 \sin\theta}{g}$$

$$x = R = \frac{2 v_0^2 \sin\theta \cos\theta}{g} = \frac{v_0^2 \sin 2\theta}{g}$$




$2\theta = 90$ $\quad \theta = 45$

No air resis.



$\sin 2\theta$ is same

0° 90°
30° 60°
40° 50°
20° 70°

Max ht, $v_y = 0 = v_0 \sin\theta - gt$

$v_y^2 = v_{0y}^2 + 2a(y - y_0)$ $\quad t = \dfrac{v_0 \sin\theta}{g}$ $\quad = \dfrac{1}{2}\dfrac{2v_0 \sin\theta}{g}$

$0 = (v_0 \sin\theta)^2 - 2gH$

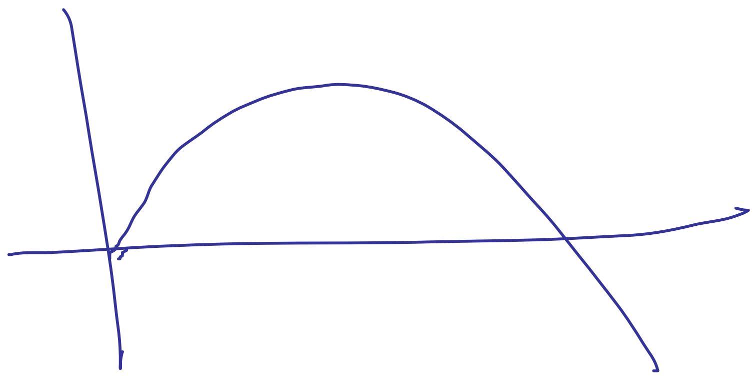
$H = \dfrac{v_0^2 \sin^2\theta}{2g}$

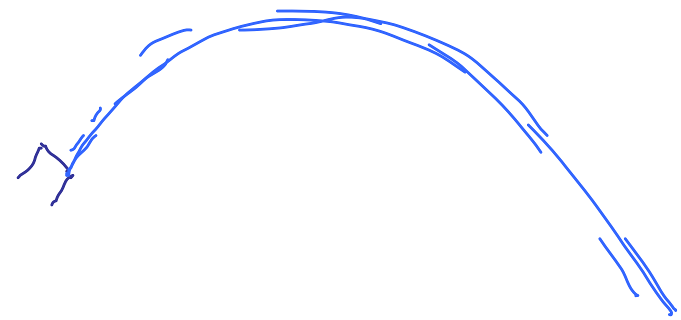
$x = v_0 \cos\theta\, t$ $\quad t = \dfrac{x}{v_0 \cos\theta}$ $\quad$ plug in $y(t)$ equation.

$y = \cancel{v_0} \sin\theta \left(\dfrac{x}{\cancel{v_0} \cos\theta}\right) - \frac{1}{2} g \left(\dfrac{x}{v_0 \cos\theta}\right)^2$

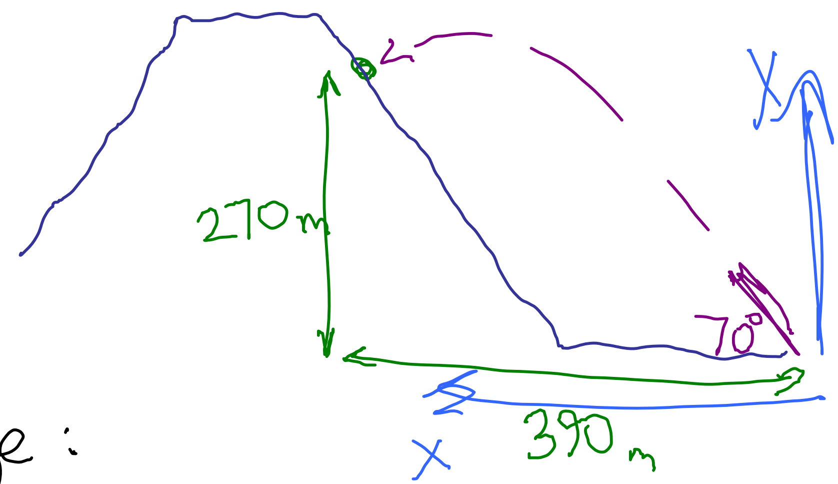
$$y = (\tan\theta)\, x - \frac{g\, x^2}{2 v_0^2 \cos^2\theta}$$

Shape of trajectory is parabola





3.70 Want to fire projectile so that it reaches given point.




Find $V_o$. From prev. page:

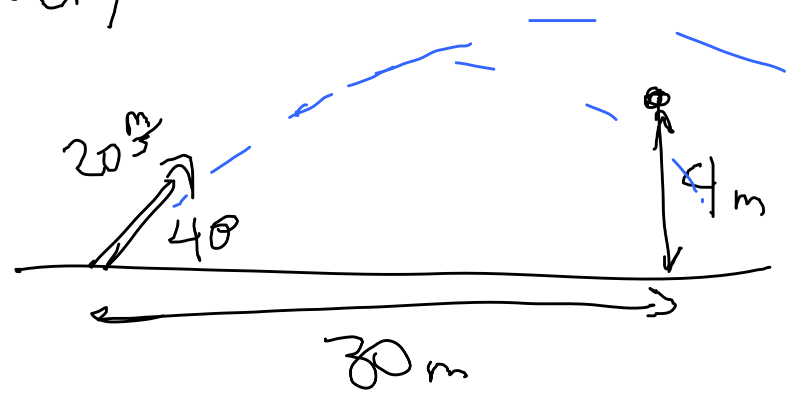
$$y = (\tan\theta)\,x - \frac{g x^2}{2 V_o^2 \cos^2\theta}$$

Given $y = 270\text{ m}$ $x = 390\text{ m}$ Solve for $V_o$

Do algebra $\Longrightarrow$ $V_o = 89.1 \frac{m}{s}$

# Example

Football thrown at $40^\circ$, $20\,\frac{m}{s}$ toward goal; goal is 30 m away 4 m high. Does ball go over/under goal?

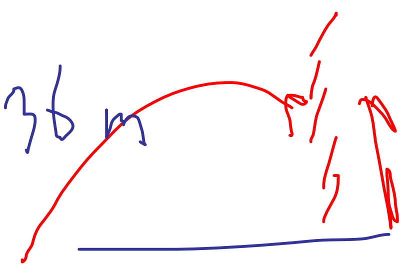



What is $y$ when $x = 30\,m$?

Solve for $t$ when $\underline{x = 30\,m}$ (solve $x(t)$)

Get $t = 1.96$

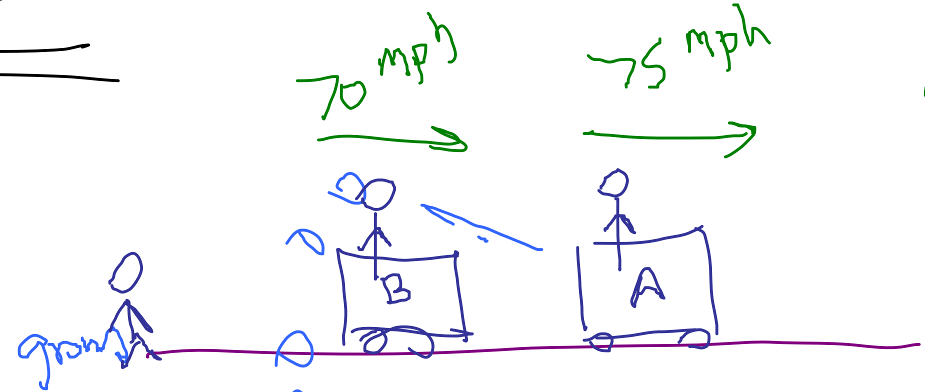
Put this $t$ into $y$ eqn $\longrightarrow$ $y = 6.36\,m$



# Relative motion

p. 34

Easy examples




According to guy on ground

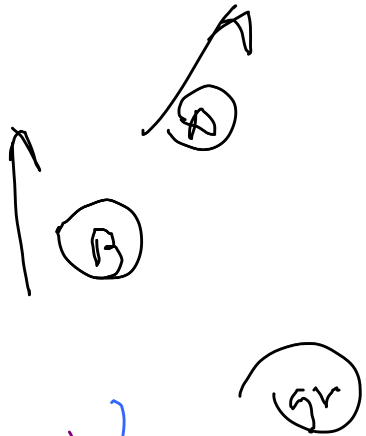
$5 \text{ mph} = V_{A \text{ rel to } B}$

$$V_{A/gr} = V_{A/B} + V_{B/gr}$$

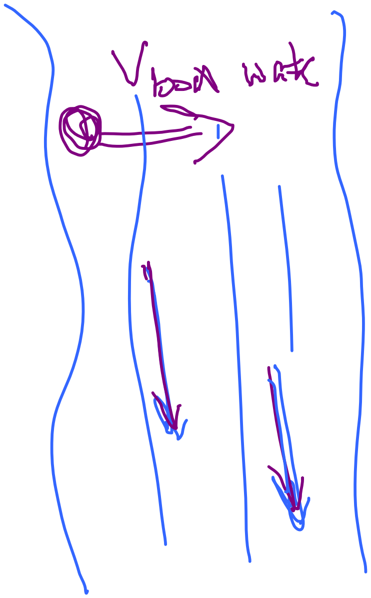
$$V_{A \text{ rel gr}} = V_{A \text{ rel to } B} = V_{B \text{ rel gr}}$$

$$75 = 5 \quad 70$$

Deal with 2 dim, vector equation



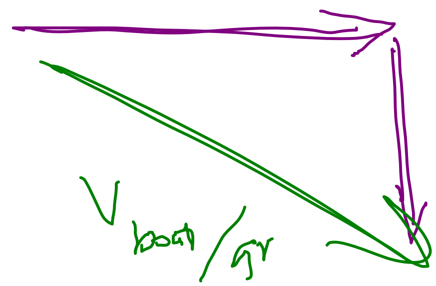

$$\vec{V}_{A/gr} = \vec{V}_{A/B} + \vec{V}_{B/gr}$$



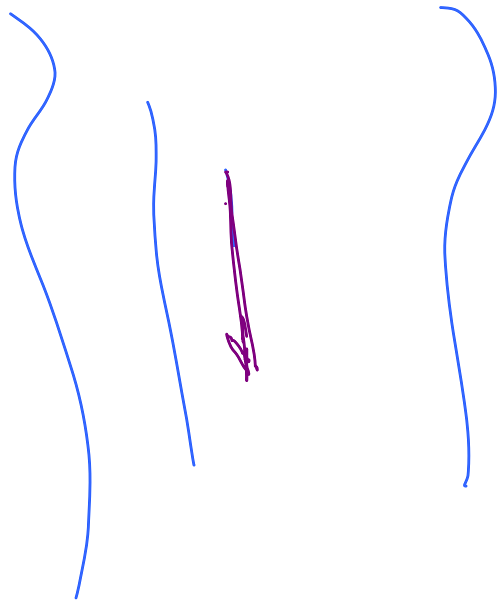

$$\vec{V}_{Boat/gr} = \vec{V}_{boat/water} + \vec{V}_{water/gr}$$

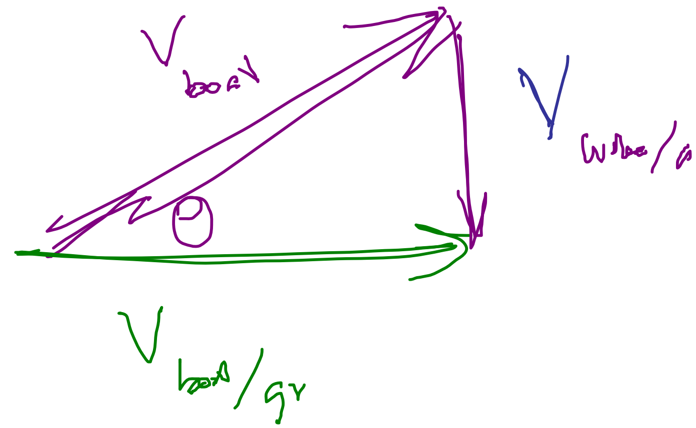
$V_{water} = 10 \frac{m}{s}$

$V_{water/ground}$



How can he end up opp the starting point?






Must row w/ upstream component.

3.27 You wish to row across stream. You row at $1.3 \frac{m}{s}$, river flows at $0.57 \frac{m}{s}$ ... angle.