Homework Week #2

Ch. #3

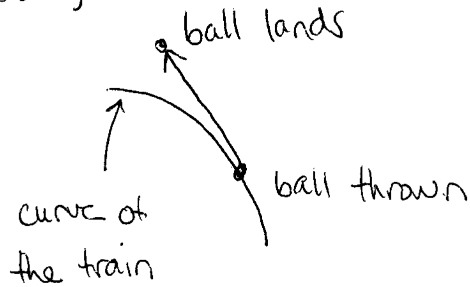
(Q22) The rain hits you because relative to you they have a component of their velocity in the horizontal direction. Another way to think about it is that when the umbrella moves forward (while you are running) there are some drops that have a height below the umbrella that don't get blocked and hit your leg

(Q24) a) The ball lands in her hand again. From the point of view of someone at rest with respect to the ground, the ball has some initial horizontal velocity equal to the velocity of the train, so the train is able to get underneath the ball so that the person sitting on the train doesn't notice any horizontal movement.

b) If the train accelerates, the ball will land behind the woman on the train.

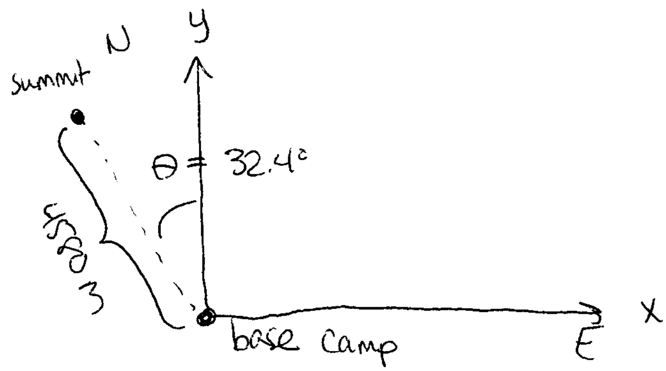
c) If the train decelerates, the ball will land in front of the woman on the train.

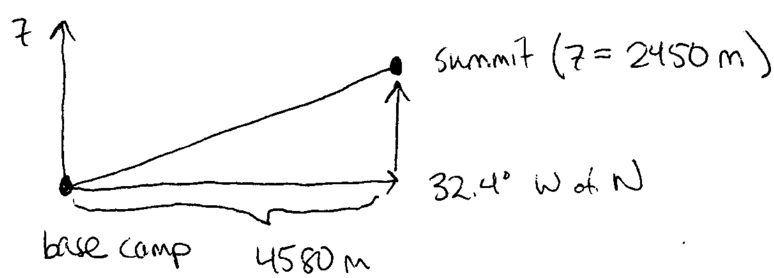
d) The ball will land in a place so that it falls on a line that is tangent to the curve at the location it was thrown upward (assuming that the train is moving at a constant speed)



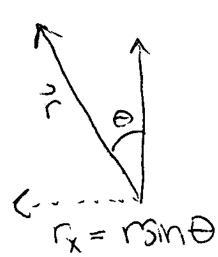
e) The air will exert a force on the ball, so the ball will accelerate backwards with respect to the train (this is like a horizontal version of a skydiver with a parachute)

(P16)





$\vec{r} = (r_x, r_y, r_z)$



$r_x = r\sin\theta$

$= (4580\,m)(\sin 32.4°)$

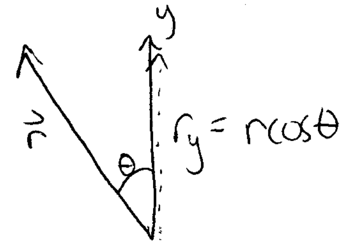
$= 2450\ m$

$r_y = r\cos\theta$

$= (4580\,m)\cos(32.4°)$

$r_y = 3870\,m$

$r_z = 2450\,m$



$\vec{r} = (2450\,m,\ 3870\,m,\ 2450\,m)$

$|\vec{r}| = \sqrt{(2450\,m)^2 + (3870\,m)^2 + (2450\,m)^2}$

$|\vec{r}| = 5190\,m$

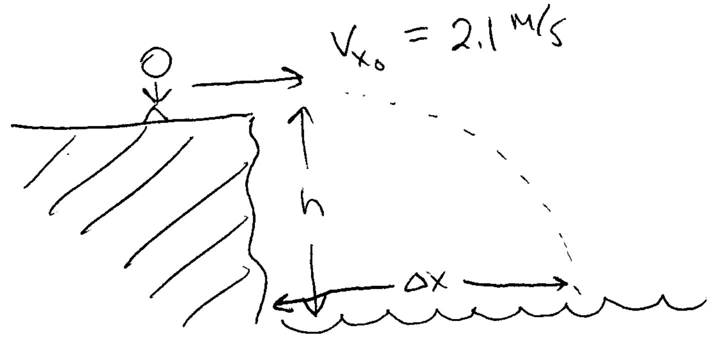
(P22) a) $a_y = a\sin\theta = (3.80\,m/s^2)\sin(30°)$

$a_y = 1.90\,m/s^2$

b) $\Delta y = \frac{1}{2}at^2$

$t = \sqrt{\frac{2\Delta y}{a}} = \sqrt{\frac{2(250\,m)}{1.90\,m/s^2}} = 16$ seconds

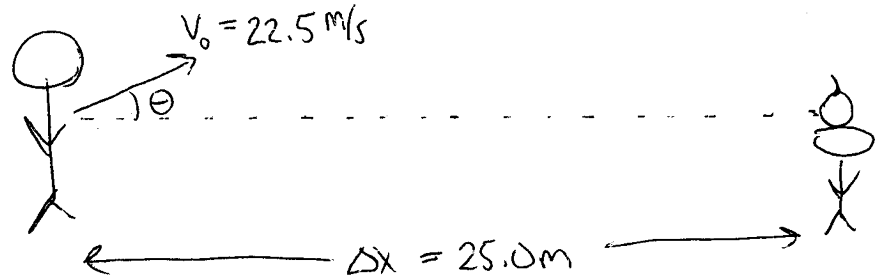
(P27)



$h = \frac{1}{2}at^2 = \frac{1}{2}(9.8\,m/s^2)(3.0\,s)^2 = 44\,m$

$\Delta x = V_{x_0}t = (2.1\,m/s)(3.0\,s) = 6.3\,m$

(P36)



Really this question is asking "What angle do you need so that the arrow is at its original height when its 25.0 m away?"

$$\Delta y = V_{y_0} t + \frac{1}{2} a t^2$$

$$\Delta x = V_{x_0} t \rightarrow t = \frac{\Delta x}{V_{x_0}}$$

$$\Delta y = V_{y_0}\left(\frac{\Delta x}{V_{x_0}}\right) + \frac{1}{2} a \left(\frac{\Delta x}{V_{x_0}}\right)^2$$

$$V_{y_0} = V\sin\theta \,, \quad V_{x_0} = V\cos\theta$$

$$\Delta y = \tan\theta \, \Delta x + \frac{1}{2} a \frac{\Delta x^2}{V^2 \cos^2\theta}$$

$$0 = \frac{\Delta x}{\cos^2\theta}\left(\sin\theta\cos\theta + \frac{1}{2}\frac{a\Delta x}{V^2}\right)$$

This expression is true when each term is zero, but $\frac{\Delta x V}{\cos^2\theta}$ is never zero because the largest $\cos^2\theta$ can be is 1.

So $$0 = \frac{1}{2}\sin 2\theta - \frac{g\Delta x}{2V^2}$$

$$\frac{1}{2}\sin 2\theta = \frac{g\Delta x}{2V^2}$$

$$\theta = \frac{1}{2}\sin^{-1}\left[\frac{g\Delta x}{V^2}\right]$$

$$\theta = \frac{1}{2}\sin^{-1}\left[\frac{(9.8\,m/s^2)(25.0\,m)}{(22.5\,m/s)^2}\right]$$

Remember to Check units!

$$\theta = 14.5°$$

(P40) a)

$$\Delta y = V_{oy}t + \frac{1}{2}at^2$$

$$h = \Delta y = (V_o \sin\theta)t + \frac{1}{2}at^2$$

$$-125\,m = (65.0\,m/s)\sin(37.0°)\,t - \frac{1}{2}(9.8\,m/s^2)t^2$$

$$0 = (-4.9\,m/s^2)t^2 + (39.1\,m/s)t + 125\,m$$

$$0 = (1\,s^{-2})t^2 - (7.98\,s^{-1})t + 25.5$$

$$t = \frac{7.98\,s^{-1} \pm \sqrt{(7.98\,s^{-1})^2 - 4(s^{-2})(25.5)}}{2\,s^{-2}}$$

$$t = 10.4\,s$$

b)

$$\Delta x = V_{x_o}t = V_o\cos\theta\,t = (65.0\,m/s)\cos(37°)(10.4\,s)$$

$$\Delta x = 540\,m$$

c) $V_f^2 = V_0^2 + 2a\Delta y$

$$V_y = \sqrt{(V_0 \sin\theta)^2 + 2(9.8\,m/s^2)(125\,m)}$$

$$= 63.0\,m/s$$

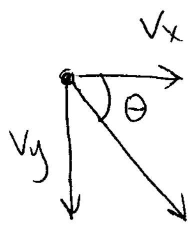
$$V_x = V_0 \cos\theta = (65.0\,m/s)(\cos 37°) = 51.9\,m/s$$

d) $$V = \sqrt{(51.9\,m/s)^2 + (63.0\,m/s)^2}$$

$$V = 81.6\,m/s$$

e) $$\tan\theta = \frac{V_y}{V_x} \rightarrow \theta = \tan^{-1}\left(\frac{V_y}{V_x}\right) = \tan^{-1}\left(\frac{63.0\,m/s}{51.9\,m/s}\right)$$

$$\theta = 50.5°$$



(P47) $$\theta = \tan^{-1}\left(\frac{V_y}{V_x}\right)$$ (see previous problem #40 e)

$$V_y = -gt + V_{y_0} = -gt + V_0 \sin\theta_0$$ thrown horizontally

$$V_x = V_{x_0} = V_0 \cos\theta_0 = V_0$$ thrown horizontally

$$\theta = \tan^{-1}\left(\frac{-gt + V_0 \sin\theta_0}{V_0 \cos\theta_0}\right)$$

$$\theta = \tan^{-1}\left(\frac{-gt}{V_0}\right)$$ with up as positive

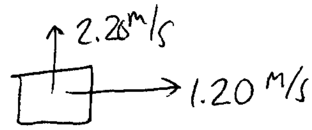
(P54) $v = \frac{d}{t} = \frac{45\pi D}{1\text{ min}\left(\frac{60\text{s}}{\text{min}}\right)} = \frac{45\pi D}{60}$

$a = \frac{v^2}{r} = \frac{\left(\frac{45\pi D}{60}\right)^2}{D/2} = \frac{2\left(\frac{45}{60}\pi D\right)^2}{D} = 2\left(\frac{45}{60\text{s}}\right)^2 \pi^2 D$

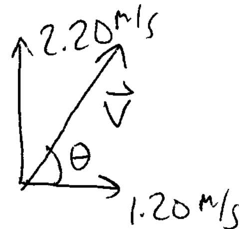
$a = 2\left(\frac{45}{60\text{s}}\right)^2 \pi^2 (.30\text{m}) = 3.3\ \text{m/s}^2$

(P60) a) $|\vec{V}| = \sqrt{(2.20\text{ m/s})^2 + (1.20\text{ m/s})^2}$

$= 2.5\ \text{m/s}$



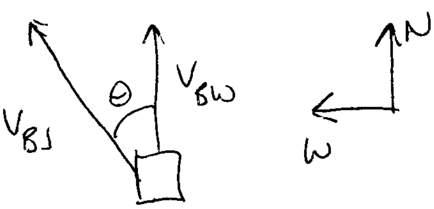
$\theta = \tan^{-1}\left(\frac{2.20\text{ m/s}}{1.20\text{ m/s}}\right) = 61.4°$



b) $\Delta r = V_{BS}\, t$

(changing picture → refer to 3-37)

$= (2.5\text{ m/s})(3.00\text{ s})$



$= 7.53\text{ m},\ 61.4°\ \text{N of W}$

$\vec{r} = (3.6\text{ m W},\ 6.6\text{ m N})$

(P64) $V_{PW_x} = V_{PB_x} + V_{BW_x} = (0.60\,m/s)(\cos 45^\circ) + 1.80\,m/s$

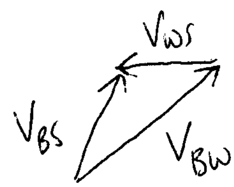
$V_{PWx} = 2.22\,m/s$

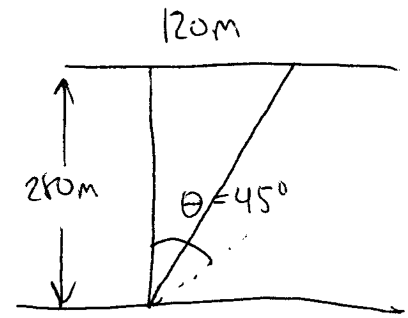
$V_{PWy} = (0.60\,m/s)(\sin 45^\circ) = 0.42\,m/s$

$V_{PW} = \sqrt{(2.22\,m/s)^2 + (0.42\,m/s)^2} = 2.26\,m/s$

$\theta = \tan^{-1}\left(\frac{V_y}{V_x}\right) = \tan^{-1}\left(\frac{0.42\,m/s}{2.22\,m/s}\right) = 10.7^\circ$ above the water.

(P66) What is the boats velocity with respect ~~respect~~ to the shore





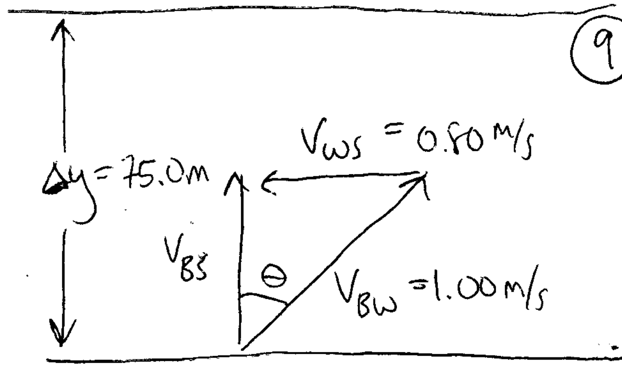
$t_{cross} = \frac{\Delta y}{V_y} = \frac{280\,m}{(2.40\,m/s)(\cos 45^\circ)}$

$= 165\,s$

$V_{BS_x} = \frac{120\,m}{165\,s} = 0.72\,m/s$

$V_{WS} = V_{BW_x} - V_{BS_x} = (2.40\,m/s)(\sin 45^\circ) - 0.72\,m/s$

$V_{WS} = 0.98\,m/s$



(P68) So we want

$$V_{BW_x} = V_{WS}$$

$$V_{BW} \sin\theta = V_{WS}$$

$$\theta = \sin^{-1}\left(\frac{V_{WS}}{V_{BW}}\right) = \sin^{-1}\left(\frac{0.80\,m/s}{1.00\,m/s}\right) = 53^{\circ}$$