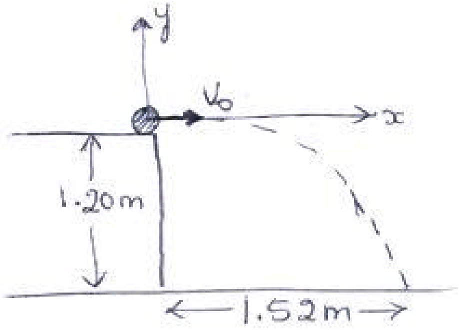
18E. A small ball rolls horizontally off the edge of a tabletop that is 1.20 m high. It strikes the floor at a point 1.52 m horizontally away from the edge of the table. (a) How long is the ball in the air? (b) What is its speed at the instant it leaves the table?



a) $y - y_0 = (v_0 \sin\theta_0)t - \frac{1}{2} g t^2$

but $\theta_0 = 0 \Rightarrow \sin\theta_0 = 0$

$\Rightarrow y - y_0 = -\frac{1}{2} g t^2$

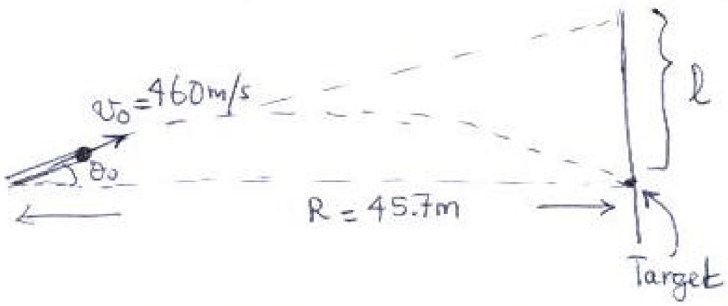
$-1.2 = -4.9 t^2 \Rightarrow \boxed{t = 0.50 \text{ sec}}$

b) $x - x_0 = (v_0 \cos\theta_0)t$

Since $\theta_0 = 0$ $\cos\theta_0 = 1$

$\Rightarrow x - x_0 = v_0 t \Rightarrow v_0 = \frac{x - x_0}{t} = \frac{1.52}{0.50} = \boxed{3.04 \text{ m/s}}$

25P. A rifle that shoots bullets at 460 m/s is to be aimed at a target 45.7 m away and level with the rifle. How high above the target must the rifle barrel be pointed so that the bullet hits the target? ssm



$$R = \frac{v_0^2 \sin 2\theta_0}{g} \Rightarrow \sin 2\theta_0 = \frac{gR}{v_0^2}$$

$$\Rightarrow 2\theta_0 = \sin^{-1}\left(\frac{gR}{v_0^2}\right) = \sin^{-1}\left(\frac{9.8 \times 45.7}{(460)^2}\right)$$

$$= 0.121^\circ$$

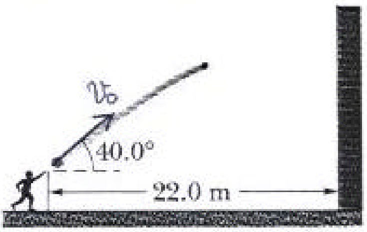
$$\Rightarrow \theta_0 = 0.0606^\circ$$

From the figure

$$\tan\theta_0 = \frac{\ell}{R} \Rightarrow \ell = R\tan\theta_0 = 45.7 \times \tan(0.606^\circ)$$

$$\ell = 0.048\,\text{m} = \boxed{4.8\ \text{cm}}$$

28P. You throw a ball toward a wall with a speed of 25.0 m/s and at an angle of 40.0° above the horizontal (Fig. 4-35). The wall is 22.0 m from the release point of the ball. (a) How far above the release point does the ball hit the wall? (b) What are the horizontal and vertical components of its velocity as it hits the wall? (c) When it hits, has it passed the highest point on its trajectory?



a) $v_0 = 25$ m/s $\quad \theta_0 = 40^\circ \quad x - x_0 = 22$ m

$$y - y_0 = v_0 \sin\theta_0 \, t - \frac{1}{2} g t^2$$

use $x - x_0 = v_0 \cos\theta_0 \, t \Rightarrow t = \dfrac{x - x_0}{v_0 \cos\theta_0} = \dfrac{22}{25 \times \cos 40^\circ}$

$\Rightarrow t = 1.15$ sec

$\Rightarrow \quad y - y_0 = 25 \times \sin 40^\circ \times 1.15 - 4.9 \times (1.15)^2 = \boxed{12\text{ m}}$

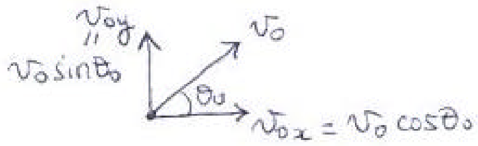
b) $v_x = v_0 \cos\theta_0 = \text{Const} = \boxed{19.2\text{ m/s}}$

$v_y = v_0 \sin\theta_0 - g t = 25 \times \sin 40^\circ - 9.8 \times 1.15 = \boxed{4.8\text{ m/s}}$

c) No, because v_y is still positive.
At the heighest point $v_y = 0$ and after that v_y becomes negative.

(30P) Two seconds after being projected from ground level, a projectile is displaced 40 m horizontally and 53 m vertically above its point of projection. What are the (a) horizontal and (b) vertical components of the initial velocity of the projectile? (c) At the instant the projectile achieves its maximum height above ground level, how far is it displaced horizontally from its point of projection?

at $t = 2s$ $\quad \begin{cases} x - x_0 = 40\,m \\ y - y_0 = 53\,m \end{cases}$



a) $x - x_0 = v_{0x}\, t$

$$40 = v_{0x}(2) \Rightarrow \boxed{v_{0x} = 20\ m/s}$$

b) $y - y_0 = v_{0y}\, t - \frac{1}{2} g t^2$

$$53 = v_{0y}(2) - 4.9 \times (2)^2 \Rightarrow \boxed{v_{0y} = 36\ m/s}$$

c) $x - x_0 = \frac{R}{2} = \frac{v_0^2 \sin 2\theta_0}{2g}$

$$v_0 = \sqrt{v_{0x}^2 + v_{0y}^2} = 41.4\ m/s$$

$$\theta_0 = \tan^{-1}\left(\frac{36}{20}\right) = 60.9°$$

$$\Rightarrow \quad x - x_0 = \frac{(41.4)^2 \times \sin(121.8°)}{2 \times 9.8} = \boxed{74.2\,m}$$

33P. A certain airplane has a speed of 290.0 km/h and is diving at an angle of 30.0° below the horizontal when the pilot releases a radar decoy (Fig. 4-36). The horizontal distance between the release point and the point where the decoy strikes the ground is 700 m. (a) How long is the decoy in the air? (b) How high was the released point? ilw

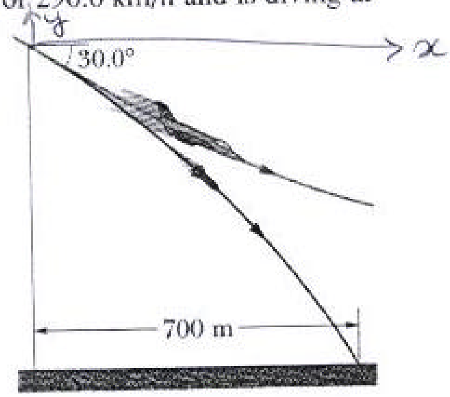
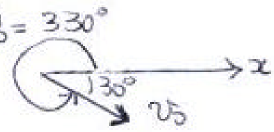


Fig. 4-36 Problem 33.

$v_0 = 290 \text{ Km/h} = 80.6 \text{ m/s}$

$\theta_0 = 330°$



$\theta_0 = 360° - 30° = 330°$

$x - x_0 = 700 \text{ m}$

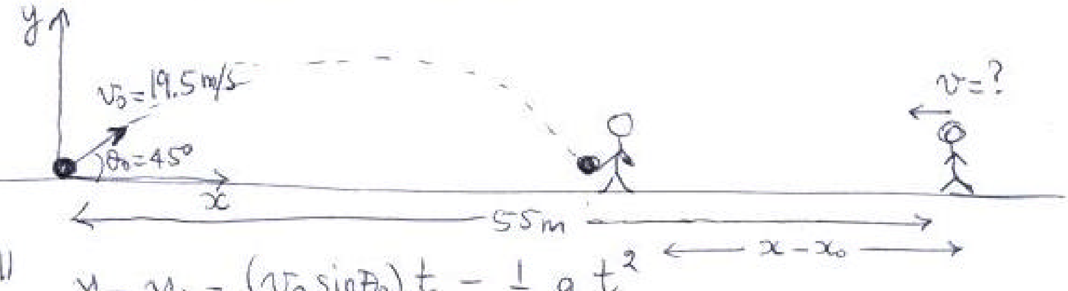
a) $x - x_0 = v_0 \cos\theta_0 \, t \Rightarrow t = \dfrac{x - x_0}{v_0 \cos\theta_0} = \dfrac{700}{80.6 \times \cos 330°} = \boxed{10. \text{ sec}}$

b) $y - y_0 = v_0 \sin\theta_0 \, t - \frac{1}{2} g t^2$

$= 80.6 \times \sin 330° \times 10 - 4.9 \times (10)^2 = \boxed{-893 \text{ m}}$

note thay $y - y_0$ is negative!

(36P.) A soccer ball is kicked from the ground with an initial speed of 19.5 m/s at an upward angle of 45°. A player 55 m away in the direction of the kick starts running to meet the ball at that instant. What must be his average speed if he is to meet the ball just before it hits the ground? Neglect air resistance.



The ball $\quad y - y_0 = (v_0 \sin\theta_0)t - \frac{1}{2}gt^2$

when the ball returns to the ground $y - y_0 = 0$

$$\Rightarrow \quad 0 = 19.5 \times \sin 45° \, t - 4.9t^2 = \underbrace{(19.5 \times \sin 45° - 4.9t)}_{=0}\, t$$

$$\Rightarrow \quad t = 2.81 \text{ sec}$$

The ball will land at

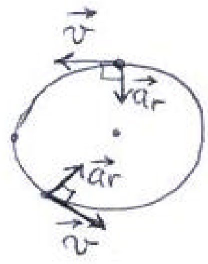
$$x - x_0 = (v_0 \cos\theta)t = 19.5 \times \cos 45° \times 2.81 = 38.7 \text{m}$$

The player has to run for a distance of $55 - 38.7 = 16.3$m

His average speed is $\quad \bar{v} = \frac{16.3}{2.81} = \boxed{5.8 \text{ m/s}}$

42E. What is the magnitude of the acceleration of a sprinter running at 10 m/s when rounding a turn with a radius of 25 m?

$$a_r = \frac{v^2}{r} = \frac{(10)^2}{25} = 4 \text{ m/s}^2$$



44E. A rotating fan completes 1200 revolutions every minute. Consider the tip of a blade, at a radius of 0.15 m. (a) Through what distance does the tip move in one revolution? What are (b) the tip's speed and (c) the magnitude of its acceleration? (d) What is the period of the motion?

The frequency $= f = 1200 \frac{\text{rev}}{\text{min}} = 1200 \frac{\text{rev}}{60 \text{ sec}} = 20 \frac{\text{rev}}{\text{sec}}$

The period $= T = \frac{1}{f} = \frac{1}{20} \frac{\text{sec}}{\text{rev}} = 0.05 \frac{\text{sec}}{\text{rev}}$

a) $\ell = 2\pi r = 2\pi (0.15) = \boxed{0.94 \text{ m}}$

b) $v = \frac{\ell}{T} = \frac{0.94}{0.05} = \boxed{18.8 \text{ m/s}}$

c) $a_r = \frac{v^2}{r} = \frac{(18.8)^2}{0.15} = \boxed{2356 \text{ m/s}^2}$

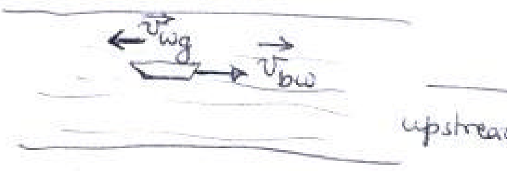
d) $\boxed{T = 0.05 \text{ sec}}$

54E. A boat is traveling upstream at 14 km/h with respect to the water of a river. The water is flowing at 9 km/h with respect to the ground. (a) What is the velocity of the boat with respect to the ground? (b) A child on the boat walks from front to rear at 6 km/h with respect to the boat. What is the child's velocity with respect to the ground?

$\vec{v}_{bw} = 14\hat{i}\ Km/h$

upstream = against the water flow

$\vec{v}_{wg} = -9\hat{i}\ Km/h$



a) $\vec{v}_{bg} = \vec{v}_{bw} + \vec{v}_{wg}$

$= 14\hat{i} - 9\hat{i} = 5\hat{i}\ Km/h$

b) $\vec{v}_{cb} = 6\hat{i}\ Km/h$

$\vec{v}_{cg} = \vec{v}_{cb} + \vec{v}_{bg}$

$= -6\hat{i} + 5\hat{i} = -1\hat{i}\ Km/h$

58E. Two highways intersect as shown in Fig. 4-38. At the instant shown, a police car P is 800 m from the intersection and moving at 80 km/h. Motorist M is 600 m from the intersection and moving at 60 km/h. (a) In unit-vector notation, what is the velocity of the motorist with respect to the police car? (b) For the instant shown in Fig. 4-38, how does the direction of the velocity found in (a) compare to the line of sight between the two cars? (c) If the cars maintain their velocities, do the answers to (a) and (b) change as the cars move nearer the intersection?

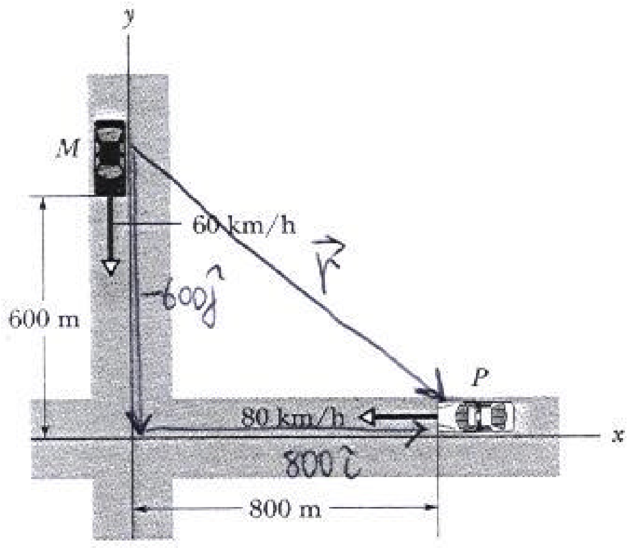
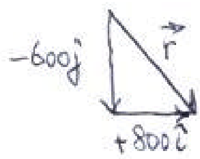


Fig. 4-38 Exercise 58.

$\vec{r} = -600\hat{j} + 800\hat{i}$



a) $\vec{v}_{MG} = -60\,\hat{j}$ (Km/h)

$\vec{v}_{PG} = -80\,\hat{i}$ (Km/h) $\qquad \vec{v}_{GP} = -\vec{v}_{PG} = +80\,\hat{i}$

$\vec{v}_{MP} = \vec{v}_{MG} + \vec{v}_{GP} = +80\hat{i} - 60\hat{j}$ (Km/h)

b) Line of sight is described by the vector $\vec{r}$

$\vec{r}_{MP} = +800\hat{i} - 600\hat{j}$ (see figure)

$\vec{v}_{MP}$ and $\vec{r}_{MP}$ have the same direction because

$\vec{r}_{MP} = 10\,\vec{v}_{MP}$