••32 GO You throw a ball toward a wall at speed 25.0 m/s and at angle $\theta_0 = 40.0°$ above the horizontal (Fig. 4-35). The wall is distance $d = 22.0$ m from the release point of the ball. (a) How far above the release point does the ball hit the wall? What are the (b) horizontal and (c) vertical components of its velocity as it hits the wall? (d) When it hits, has it passed the highest point on its trajectory?

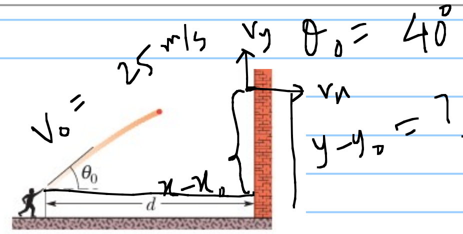
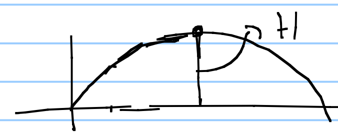
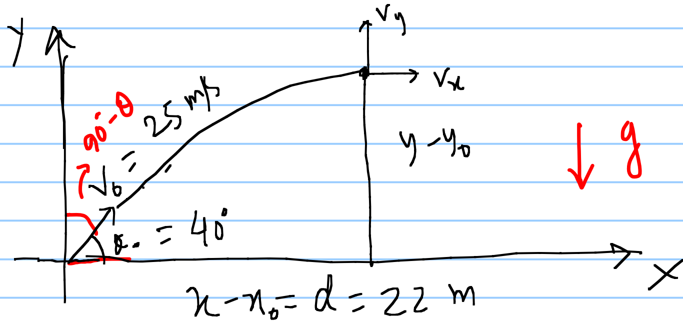


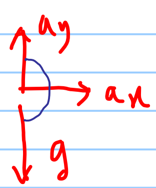
Figure 4-35 Problem 32.





$$\begin{cases} V_{0x} = V_0 \cos\theta_0 = 25 \times \cos(40°) = 19.15 \text{ m/s} \\ V_{0y} = V_0 \cos(90° - \theta_0) = V_0 \sin\theta_0 = 25 \times \sin(40°) \end{cases}$$

$$= 16.1 \text{ m/s}$$



$$\begin{cases} a_x = g \cos 90° = 0 \text{ m/s} \\ a_y = g \cos(180°) = -g \text{ m/s} = -9.8 \text{ m/s} \end{cases}$$

$y - y_0 = ?$

$$y - y_0 = V_{0y} t + \frac{1}{2} a_y t^2$$

$$y - y_0 = 16.1 \times t + \frac{1}{2} \times (-9.8) \times t^2 \quad -(1)$$

$$x - x_0 = v_{0x}\, t + \frac{1}{2} a_x t^2$$

$$\Rightarrow 22 = 19.15 \times t + \underbrace{\frac{1}{2} \times 0 \times t^2}_{0}$$

$$\Rightarrow t = \frac{22}{19.15}\ \text{s}$$

$$= 1.15\ \text{s}$$

In equation (1), $y - y_0 = [16.1 \times 1.15 - \frac{1}{2} \times 9.8 \times (1.15)^2]\ \text{m}$

$= \boxed{12.0\ \text{m}}$ (Ans a)

(b) $v_x = ?$

$$v_x = v_{0x} + a_x t$$

$$= 19.15\ \text{m/s} + 0 \times t$$

$$= 19.15\ \text{m/s}$$

(c) $v_y = ?$

$$v_y = v_{0y} + a_y t$$

$$= (16.1 - 9.8 \times 1.15)\ \text{m/s}$$

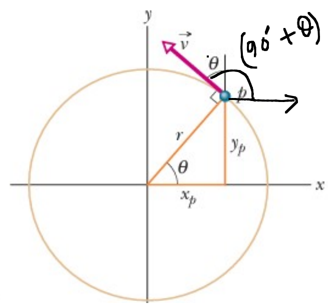
$$= 4.83\ \text{m/s}$$

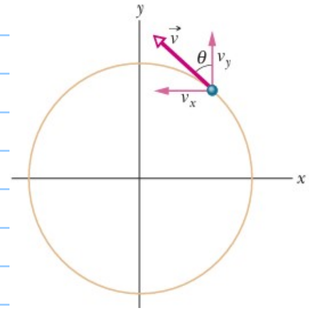
(d) $v_y \neq 0$,

$\boxed{4.04,\ 4.05}$

"Uniform circular Motion"

$|\vec{V}| = \boxed{\text{cont}}$





$\underbrace{\text{centripetal}}_{\text{center seeking}}$ acceleration

$$a = \frac{v^2}{r}$$

$$\vec{V} = v_x \hat{i} + v_y \hat{j}$$

$$V_x = V\cos(90^\circ+\theta) = \underline{-V\sin\theta}$$

$$V_y = V\sin(90^\circ+\theta) = \underline{V\cos\theta}$$

$$\vec{a} = \frac{d\vec{V}}{dt} \implies \vec{V} = -V\underline{\sin\theta}\,\hat{i} + V\underline{\cos\theta}\,\hat{j}$$

$$= -V\frac{y_p}{r}\hat{i} + V\frac{x_p}{r}\hat{j}$$

$$x_p = r\cos\theta$$

$$\implies \boxed{\cos\theta = \frac{x_p}{r}}$$

$$y_p = r\sin\theta$$

$$\implies \boxed{\sin\theta = \frac{y_p}{r}}$$

$$\vec{a} = \frac{d\vec{V}}{dt} = \frac{d}{dt}\left(-\frac{Vy_p}{r}\hat{i} + \frac{Vx_p}{r}\hat{j}\right)$$

$$= -\frac{d}{dt}\left(\frac{Vy_p}{r}\right)\hat{i} + \frac{d}{dt}\left(\frac{Vx_p}{r}\right)\hat{j}$$

$$= -\frac{V}{r}\frac{dy_p}{dt}\hat{i} + \frac{V}{r}\frac{dx_p}{dt}\hat{j}$$

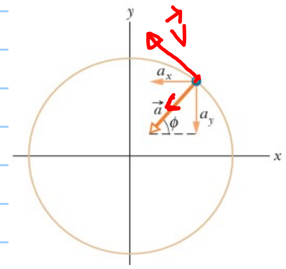
$$\frac{dx}{dt} = v_x \qquad \frac{dy}{dt} = v_y$$

$$= -\frac{V}{r}V_y\hat{i} + \frac{V}{r}v_x\hat{j}$$

$$= -\frac{V}{r}V\cos\theta\,\hat{i} + \frac{V}{r}(-V\sin\theta)\hat{j}$$

$$\boxed{\vec{a} = -\frac{v^2}{r}\cos\theta\,\hat{i} - \frac{v^2}{r}\sin\theta\,\hat{j}}$$

$$|\vec{a}| = \sqrt{\left(\frac{v^2}{r}\right)^2\left(\underbrace{\cos^2\theta + \sin^2\theta}_{1}\right)}$$



$$\boxed{a = \frac{v^2}{r}}$$

$$\varphi = \tan^{-1}\left(\frac{-\frac{v^2}{r}\sin\theta}{-\frac{v^2}{r}\cos\theta}\right)$$

$$= \pi + \tan^{-1}\tan\theta = \boxed{\pi + \theta}$$