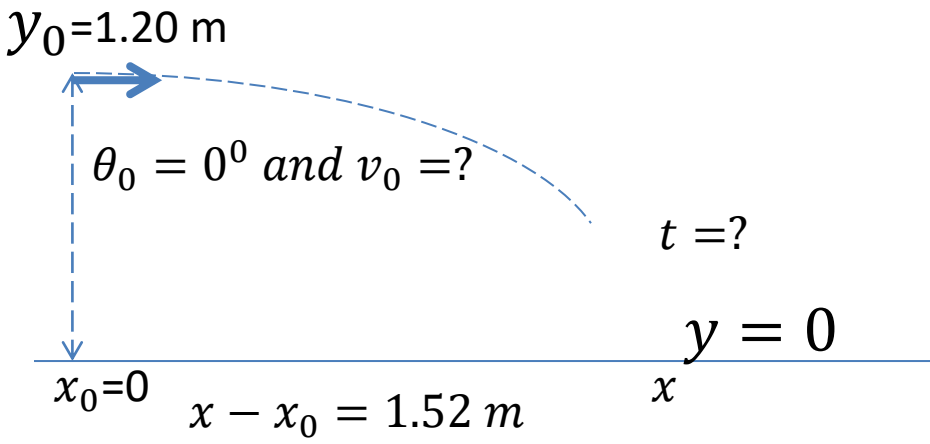
LECTURE 3

BOOK CHAPTER 4
(Projectile Motion)

Problem 22 (Book chapter 4):

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 from the table edge. (a) How long is the ball in the air? (b) What is its speed at the instant it leaves the table?



Answer: (a) We know

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

$$0 - 1.20 = (v_0\ sin\ 0^0)\ t - 4.9t^2$$

$$-1.20 = 0 - 4.9t^2$$

$$t = \sqrt{\frac{1.2}{4.9}}$$

t = 0.495 s

(b) We know

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

$$1.52 - 0 = (v_0 \cos 0^0)(\ 0.495)$$

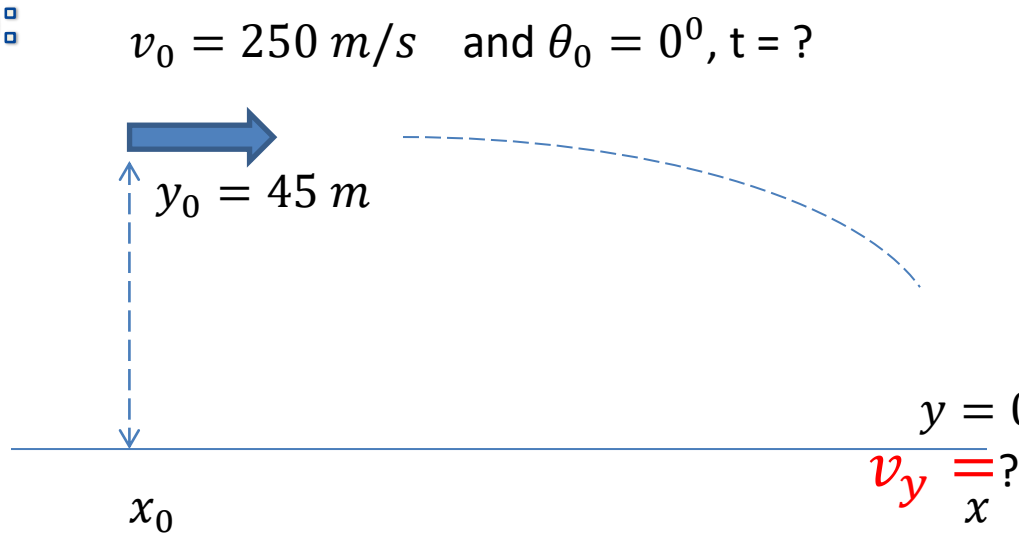
$$1.52 = (v_0 \cos 0^0)(\ 0.495)$$

$$1.52 = (v_0)(1)(0.495)$$

$$v_0 = \frac{1.52}{0.495} = 3.07\ m/s$$

Problem 23 (Book chapter 4):

A projectile is fired horizontally from a gun that is 45.0 m above flat ground, emerging from the gun with a speed of 250 m/s. (a) How long does the projectile remain in the air? (b) At what horizontal distance from the firing point does it strike the ground? (c) What is the magnitude of the vertical component of its velocity as it strikes the ground?



Answer: (a) We know

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

$$0 - 45 = (v_0\ sin\ 0^0)\ t - 4.9t^2$$

$$-45 = 0 - 4.9t^2$$

$$t = \sqrt{\frac{45}{4.9}} = 3.03\ s$$

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

$$x - x_0 = (250)(\cos 0^0)\ (3.03)$$

$$x - x_0 = (250)(1)(3.03)$$

$$x - x_0 = 757.50\ m$$

(c) We know $v_y = v_0 \sin\theta_0 - gt$ $[v = u + at]$

$$v_y = 250(\sin 0^0) - (9.8)\,(3.03)$$

$$v_y = 0 - (9.8)\,(3.03)$$

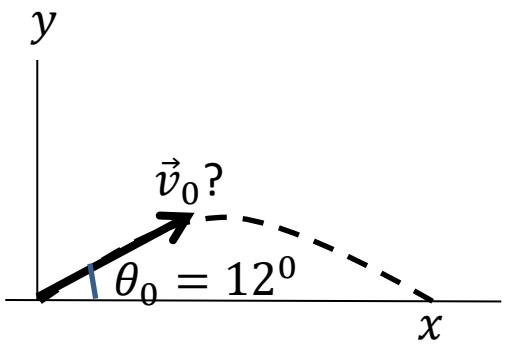
$v_y = -29.69$ m/s The magnitude of v_y is 29.69 m/s

Problem 25 (Book chapter 4):

The current world-record motorcycle jump is 77.0 m, set by Jason Renie. Assume that he left the take-off ramp at 12.0º to the horizontal and that the take-off and landing heights are the same. Neglecting air drag, determine his take-off speed.

Answer:

Since the take-off and landing heights are the same, that is $y - y_0 = 0$, we can use the formula



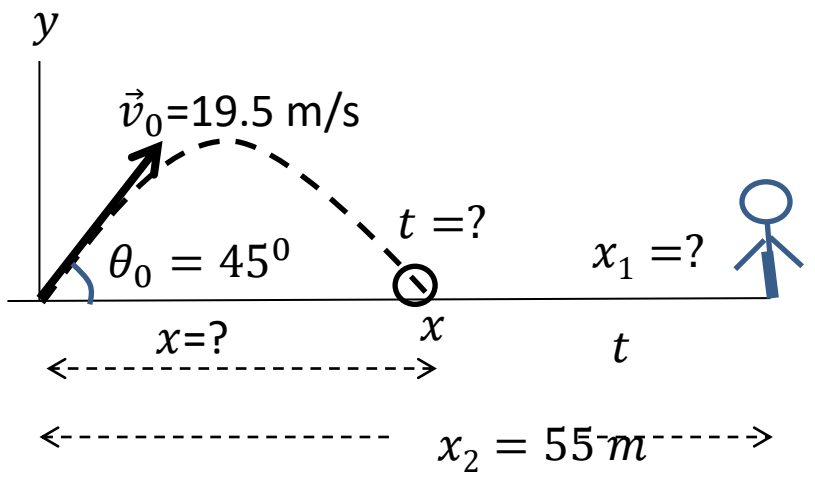
$R = x - x_0 = 77\ m$

$$R = \frac{v_0^2 \sin 2\theta_0}{g} \quad or \quad v_0 = \sqrt{\frac{Rg}{\sin 2\theta_0}}$$

$$or\ \ v_0 = \sqrt{\frac{(77)(9.8)}{\sin 24^0}} \qquad v_0 = \sqrt{\frac{754.6}{0.4067}} = 43.07\ m/s$$

Problem 30 (Book chapter 4):

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?



Answer: Here, $y - y_0 = 0$

We use the following formula to find the time of flight of the ball.

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

$$0 = (19.5)\ (\sin\ 45^0)\ t - 4.9\ t^2$$

$$(19.5)(0.707)\ t = 4.9\ t^2$$

$$t = \frac{13.787}{4.9} = 2.81\ s$$

The player must take the time 2.81 s to meet the ball.

We need to find $x - x_0$ *to obtain the distance travled by the player.*

$$x - x_0 = (v_0 \cos\theta_0)\ t = (19.5)(\cos 45^0)(2.81)$$

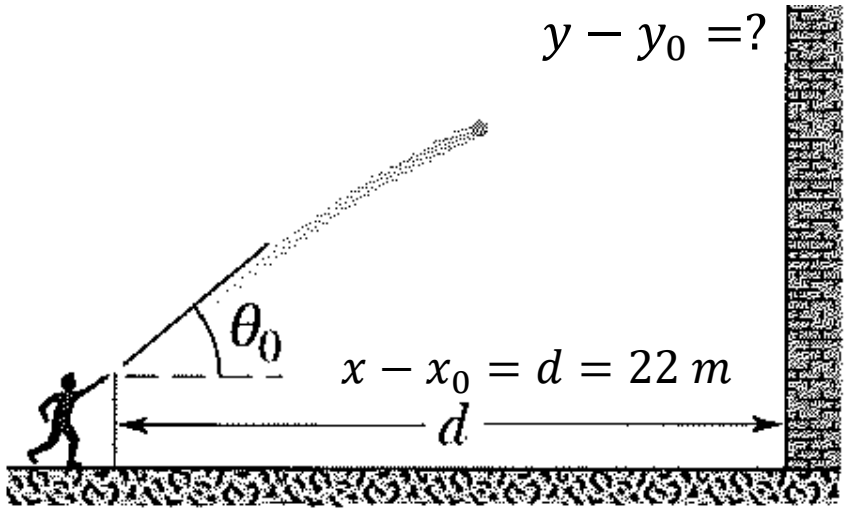
$$x - 0 = 38.74\ m$$

$$x = 38.74\ m$$

$$\textit{Average speed of the player} = \frac{\textit{Distance traveled by the player, x1}}{\textit{Time taken by the player, t}} = \frac{55 - 38.74}{2.81} = 5.786\ \text{m/s}$$

Problem 32 (Book chapter 4):

You throw a ball toward a wall at speed 25.0 m/s and at angle 40.0° above the horizontal (as shown in the figure). 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?



Answer:

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

$y - y_0 = (25)(\sin\ 40^0)\ t - 4.9\ t^2$

$y - y_0 = (25)(0.6428)t - 4.9\ t^2$

$y - y_0 = 16.07t - 4.9\ t^2$

To find t we use the following formula,

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

$t = \frac{x - x_0}{v_0 \cos\theta_0} = \frac{22}{25\ cos 40^0} = \frac{22}{(25)(0.7660)}$

$t = 1.149\ s$

Therefore,

$y - y_0 = (16.07)(1.149) - (4.9)(1.149)^2 = 18.46 - 6.469 = 11.99\ m$

$(a)\ y - y_0 = ?\ \ (b)\ v_x = ?\ \ and\ (c)\ v_y = ?$

$(d)\ Did\ the\ ball\ pass\ the\ highest\ point?$

(b) We know $v_x = v_{0x} = v_0 \cos\theta_0 = 25\cos 40^0 = (25)(0.766) = 19.15\ m/s$

(c) We know $v_y = v_0 \sin\theta_0 - gt = 25\sin 40^0 - (9.8)(1.149)$ [v = u +at]

$$v_y = (25)(0.6428) - 11.26 = 4.81\ \text{m/s}$$

(d) Since v_y *is positive, that is,* $v_y > 0$, *the ball did not reach to the highest point on hitting the wall.*

$v_y = ?$

$v_x = ?$