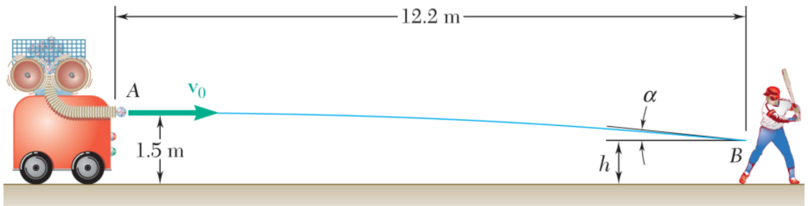
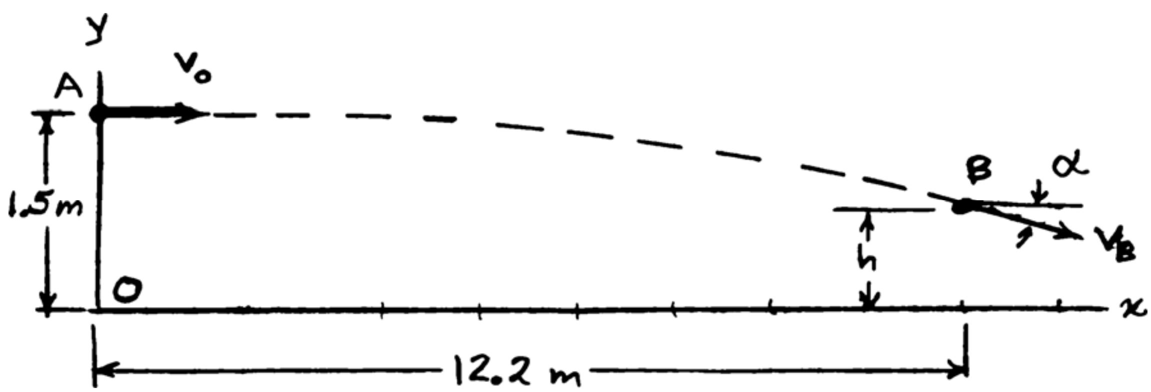


PROBLEM 11.99

A baseball pitching machine "throws" baseballs with a horizontal velocity $\mathbf{v}_0$. Knowing that height h varies between 788 mm and 1068 mm, determine (*a*) the range of values of v_0, (*b*) the values of α corresponding to $h = 788$ mm and $h = 1068$ mm.

SOLUTION



(*a*) Vertical motion: $y_0 = 1.5 \text{ m}, \quad (v_y)_0 = 0$

$$y = y_0 + (v_y)_0 t - \frac{1}{2}gt^2 \quad \text{or} \quad t = \sqrt{\frac{2(y_0 - y)}{g}}$$

At Point B, $\quad y = h \quad \text{or} \quad t_B = \sqrt{\frac{2(y_0 - h)}{g}}$

When $h = 788 \text{ mm} = 0.788 \text{ m}$, $\quad t_B = \sqrt{\frac{(2)(1.5 - 0.788)}{9.81}} = 0.3810 \text{ s}$

When $h = 1068 \text{ mm} = 1.068 \text{ m}$, $\quad t_B = \sqrt{\frac{(2)(1.5 - 1.068)}{9.81}} = 0.2968 \text{ s}$

Horizontal motion: $x_0 = 0, \; (v_x)_0 = v_0,$

$$x = v_0 t \quad \text{or} \quad v_0 = \frac{x}{t} = \frac{x_B}{t_B}$$

With $x_B = 12.2$ m, we get $v_0 = \dfrac{12.2}{0.3810} = 32.02$ m/s

and $v_0 = \dfrac{12.2}{0.2968} = 41.11$ m/s

$32.02 \text{ m/s} \le v_0 \le 41.11 \text{ m/s}$ or $115.3 \text{ km/h} \le v_0 \le 148.0 \text{ km/h}$ ◀

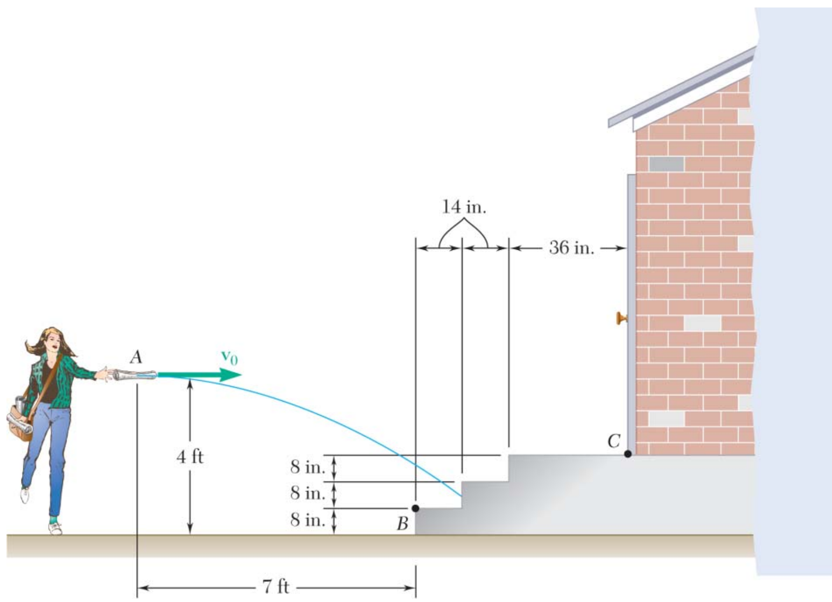
(*b*) Vertical motion: $v_y = (v_y)_0 - gt = -gt$

Horizontal motion: $v_x = v_0$

$$\tan\alpha = -\frac{dy}{dx} = -\frac{(v_y)_B}{(v_x)_B} = \frac{gt_B}{v_0}$$

For $h = 0.788$ m, $\tan\alpha = \dfrac{(9.81)(0.3810)}{32.02} = 0.11673,$ $\alpha = 6.66°$ ◀

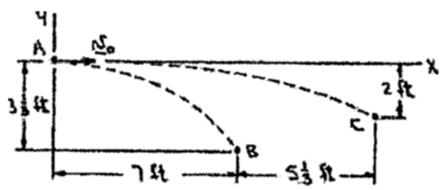
For $h = 1.068$ m, $\tan\alpha = \dfrac{(9.81)(0.2968)}{41.11} = 0.07082,$ $\alpha = 4.05°$ ◀



PROBLEM 11.100

While delivering newspapers, a girl throws a newspaper with a horizontal velocity $\mathbf{v}_0$. Determine the range of values of v_0 if the newspaper is to land between Points B and C.

SOLUTION



Vertical motion. (Uniformly accelerated motion)

$$y = 0 + (0)t - \frac{1}{2}gt^2$$

Horizontal motion. (Uniform)

$$x = 0 + (v_x)_0 t = v_0 t$$

At B: y: $-3\frac{1}{3}\text{ ft} = -\frac{1}{2}(32.2\text{ ft/s}^2)t^2$

or $t_B = 0.455016\text{ s}$

Then x: $7\text{ ft} = (v_0)_B(0.455016\text{ s})$

or $(v_0)_B = 15.38\text{ ft/s}$

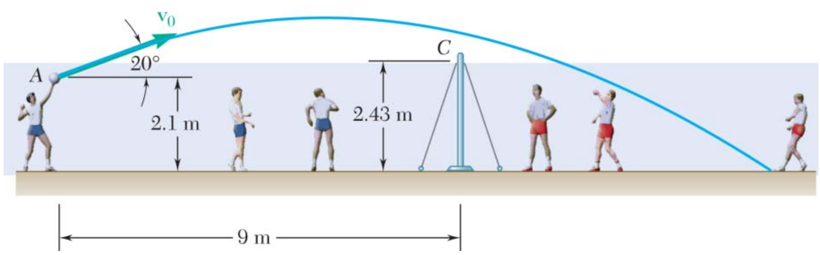
At C: y: $-2\text{ ft} = -\frac{1}{2}(32.2\text{ ft/s}^2)t^2$

or $t_C = 0.352454\text{ s}$

Then x: $12\frac{1}{3}\text{ ft} = (v_0)_C(0.352454\text{ s})$

or $(v_0)_C = 35.0\text{ ft/s}$

$$15.38\text{ ft/s} < v_0 < 35.0\text{ ft/s} \blacktriangleleft$$



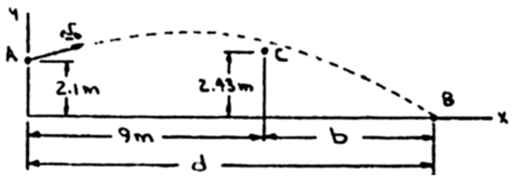
PROBLEM 11.103

A volleyball player serves the ball with an initial velocity $\mathbf{v}_0$ of magnitude 13.40 m/s at an angle of 20° with the horizontal. Determine (*a*) if the ball will clear the top of the net, (*b*) how far from the net the ball will land.

SOLUTION

First note

$$(v_x)_0 = (13.40 \text{ m/s}) \cos 20° = 12.5919 \text{ m/s}$$
$$(v_y)_0 = (13.40 \text{ m/s}) \sin 20° = 4.5831 \text{ m/s}$$



(*a*) Horizontal motion. (Uniform)

$$x = 0 + (v_x)_0 t$$

At C $\quad 9 \text{ m} = (12.5919 \text{ m/s})t \quad \text{or} \quad t_C = 0.71475 \text{ s}$

Vertical motion. (Uniformly accelerated motion)

$$y = y_0 + (v_y)_0 t - \frac{1}{2} g t^2$$

At C:

$$y_C = 2.1 \text{ m} + (4.5831 \text{ m/s})(0.71475 \text{ s}) - \frac{1}{2}(9.81 \text{ m/s}^2)(0.71475 \text{ s})^2 = 2.87 \text{ m}$$

$$y_C > 2.43 \text{ m} \ \text{(height of net)} \Rightarrow \text{ball clears net} \ \blacktriangleleft$$

(*b*) At B, $y = 0$: $\quad 0 = 2.1 \text{ m} + (4.5831 \text{ m/s})t - \frac{1}{2}(9.81 \text{ m/s}^2)t^2$

Solving $\quad t_B = 1.271175 \text{ s} \quad$ (the other root is negative)

Then

$$d = (v_x)_0 t_B = (12.5919 \text{ m/s})(1.271175 \text{ s}) = 16.01 \text{ m}$$

The ball lands $\quad b = (16.01 - 9.00) \text{ m} = 7.01 \text{ m}$ from the net $\blacktriangleleft$