PROBLEM 11.99

A baseball pitching machine “throws” baseballs with a horizontal velocity $v_0$. Knowing that height $h$ varies between 788 mm and 1068 mm, determine $(a)$ the range of values of $v_0$, $(b)$ the values of $\alpha$ corresponding to $h = 788$ mm and $h = 1068$ mm.

SOLUTION

(a) Vertical motion:

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

or

$$t = \sqrt{\frac{2(y_0 - y)}{g}}$$

At Point $B$,

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

When $h = 788$ mm = 0.788 m,

$$t_B = \sqrt{\frac{2(1.5 - 0.788)}{9.81}} = 0.3810 \text{ s}$$

When $h = 1068$ mm = 1.068 m,

$$t_B = \sqrt{\frac{2(1.5 - 1.068)}{9.81}} = 0.2968 \text{ s}$$

Horizontal motion:

$x = 0$, $(v_x)_0 = v_0$,

$$v_0 = \frac{x}{t} = \frac{x_B}{t_B}$$
PROBLEM 11.99 (Continued)

With \( x_B = 12.2 \, \text{m} \), we get \( v_0 = \frac{12.2}{0.3810} = 32.02 \, \text{m/s} \)

and \( v_0 = \frac{12.2}{0.2968} = 41.11 \, \text{m/s} \)

\( 32.02 \, \text{m/s} \leq v_0 \leq 41.11 \, \text{m/s} \)

or \( 115.3 \, \text{km/h} \leq v_0 \leq 148.0 \, \text{km/h} \)

\( b \) 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 \( h = 0.788 \, \text{m} \),

\( \tan \alpha = \frac{(9.81)(0.3810)}{32.02} = 0.11673, \quad \alpha = 6.66^\circ \)

For \( h = 1.068 \, \text{m} \),

\( \tan \alpha = \frac{(9.81)(0.2968)}{41.11} = 0.07082, \quad \alpha = 4.05^\circ \)
PROBLEM 11.100

While delivering newspapers, a girl throws a newspaper with a horizontal velocity $v_0$. 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)

$$x = 0 + (v_x)_0t = v_0t$$

At B:

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

or

$$t_b = 0.455016 \text{ s}$$

Then

$$x: \quad 7 \text{ ft} = (v_0)_b (0.455016 \text{ s})$$

or

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

At C:

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

or

$$t_c = 0.352454 \text{ s}$$

Then

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

or

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

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

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PROBLEM 11.103

A volleyball player serves the ball with an initial velocity $v_0$ 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 $C$

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

Vertical motion. (Uniformly accelerated motion)

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

At $C$:

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

$$= 2.87 \text{ m}$$

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

(b) At $B$, $y = 0$:

$$0 = 2.1 \text{ m} + (4.5831 \text{ m/s})t - \frac{1}{2}(9.81 \text{ m/s}^2) t^2$$

Solving

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

Then

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

$$= 16.01 \text{ m}$$

The ball lands

$$b = (16.01 - 9.00) \text{ m} = 7.01 \text{ m} \ from \ the \ net$$