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Qno1:

Sol: $a = 3.00\hat{j}\ m/s^2$

$v_i = 55.00\ m/s$

(a) The position of the particale is given by

$$vec\,r_f = r_i + v_i t + \frac{1}{2} a t^2$$

$$= (55\ m/s)\,t\,\hat{i} + \frac{1}{2}(3.00\ m/s^2)\,t^2\,\hat{j}$$

$$\boxed{r_f = 55t\,\hat{i} + 1.50\,t^2\,\hat{j}}\ m$$

(b) The velocity of particale is given by

$$v_f = v_i + at$$

$$v_f = 55.00\,\hat{i} + 3.00\,t\,\hat{j}$$

$$\boxed{v_f = 5.800\ m/s}$$

(c) Corrainates of particle at $t = 52s$

$$r_f = (55.00\ m/s)(52.00\ s)\,\hat{i} + (1.50)\ m/s^2)(52.00s)^2\,\hat{j}$$

$$= (2860.00\,\hat{i} + 78\,\hat{j})\ m$$

So $X = 2860.00\ m$, $Y = 78\ m$

(d) The speed of particle at $t = 52.00s$

$$v_f = v_i + at$$

$$= (55.00m/s) + (3.00m/s)(52.00s)\hat{j}$$

$$= (55.00\hat{i} + 55.00\hat{j})\ m/s$$

$$v_f = \sqrt{v^2_{xf} + v^2_{yf}}$$

$$= \sqrt{(55.00m/s^2) + (55.00m/s^2}$$

$$= \boxed{77.78m/s}$$

Question: 2

Sol:

Given data:

$$x_i = 0$$

$$x_f = d$$

$$y_i = h$$

$$y_f = 0$$

$$v_{yi} = 0$$

$$a_x = 0$$

$$a_y = -g$$

(a) First we find the time at which the mug hits the ground there is horizontal acceleration

$a_x = 0$ so we use

$$x_f = x_i + v_{xi}t + \frac{1}{2}a_x t^2$$

$$d = 0 + v_{xi}t + 0$$

Find (t)

$$\therefore t = \frac{d}{v_{xi}} \rightarrow (i)$$

now we substitive the value of t from eq (i)

$$y_f = y_i + v_{yi}t + \frac{1}{2}a_y t^2$$

$$0 = h - \frac{1}{2}(g)\left(\frac{d}{v_{xi}}\right)^2$$

now for v_{xi}

$$v_{xi} = \sqrt{\frac{d^2 g}{2h}}$$

$$= d\sqrt{\frac{g}{2h}}.$$

(b) To find the direction of final velocity of the mug, we need to find it components v_{xf} and v_{yf} but we have $v_{xf} = v_{xi}$ since there is no acceleration in horizontal direction, so we use this equation

$$v_{yf} = v_{yi} + a_y t$$

$$v_{yf} = 0 - (g)\left(\frac{d}{v_{xi}}\right) = (-g)\left(\frac{d}{d\sqrt{\frac{g}{2h}}}\right) = -\sqrt{2gh}$$

$$\theta = \tan^{-1}\frac{v_{yf}}{v_{xf}}$$

$$= \tan^{-1}\frac{-\sqrt{2g\,h}}{d\sqrt{g/2h}}$$

$$= \tan^{-1} - \frac{\sqrt{4gh^2}}{d\sqrt{g}}$$

$$= \tan^{-1}\frac{-2h\sqrt{g}}{d\sqrt{g}}$$

$$= \tan^{-1}\frac{-2h}{g}$$

Qno3:

Sol: If u is the initial velocity, θ is the projectiles projected angle,

$$H = \frac{u^2 \sin^2\theta}{2g}$$

Let u is the initial velocity of projectile and θ is angle

$$R = \frac{2u^2 \sin\theta \cos\theta}{g}$$

The maximum hight attend by the projectile is,

$$H = \frac{u^2 \sin^2\theta}{2g}$$

$$R = 3H$$

$$2u^2 \sin\theta \cos\theta = \frac{3u^2 \sin^2\theta}{2g}$$

$$4\cos\theta = 3\sin\theta$$

$$\frac{\sin\theta}{\cos\theta} = \frac{3}{4}$$

$$\tan\theta = \frac{3}{4}$$

$$\theta = \tan^{-1}\left(\frac{3}{4}\right)$$

$$= 53.13^\circ$$

Ans 4:

Sol:

Given data:

$x_i = 0$

$y_i = 0$

$v_i = 8 m/s$

$a_x = 0$

$a_y = g$

$\theta = 20^\circ$

$t = 3s$

First we find initial velocity into horizontal (x) and vertical (y)

$v_{xi} = v_i \cos\theta = 8 \times \cos 20^\circ = 7.52 m/s$

$v_{yi} = v_i \sin\theta = 8 \times \sin 20^\circ = 2.74 m/s$

Horizontal position

(a) $x_f = x_i + v_{xi} t + \frac{1}{2} a_x t^2$

$x_f = 7.52 \times 3$

$x_f = 22.6 m$

(b) vertical position

$y_f = y_i + v_{yi} t + \frac{1}{2} a_y t^2$

$y_f = (2.74 \times 3) + (\frac{1}{2} \times 9.8 \times 3^2)$

$y_f = 52.4 m$

(c) The time is takes the ball to reach $y_f = 10\,m$

$$y_f = y_i + v_{yi}t + \frac{1}{2}gt^2$$

$$10 = 2.74 + \frac{1}{2}(9.8)t^2$$

$$4.9t^2 + 2.74t - 10 = 0$$

for t using quadratic formula

$$t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$t = \frac{-2.74 \pm \sqrt{2.74^2 - 4 \times 4.9(-10)}}{2 \times 4.9} = -1.735$$

$$t = 1.18s$$ Ans.

Ans:

Sol:

(a) For horizontal motion, we have

$x_f = d = 24m$

$x_f = x_i + V_{xi}t + \frac{1}{2} a_x t^2$

$24m = 0 + v_i (\cos 53^\circ)(2.2s) + 0$

$v_i = 18.1 m/s$

(b). It passes over the wall, the ball is above the street by

$y_f = y_i + v_{yi}t + \frac{1}{2} a_y t^2$

$y_f = 0 + (18.1 m/s)(\sin 53^\circ)(2.2s) + \frac{1}{2}(-9.8 m/s^2)(2.2s)^2 = 8.13m$

The parapet by $8.13m - 7m = 1.13m$

(c) for the whole flight we have

$y_f = (\tan\theta_i) x_f - \left(\frac{g}{2v_i^2\cos^2\theta_i}\right) x_f^2$

$6m = (\tan 53^\circ) x_f - \left(\frac{g}{2v_i\cos^2 53^\circ}\right) x_f^2$

$(0.0412m^{-1}) x_f^2 - 1.33x_f + 6m = 0$

$$x_f = \frac{1.33 \pm \sqrt{1.33^2 - 4(0.412)(6)}}{2(0.0412)}$$

$x_f = 26.8m$

the ball passes twice through level of the roof. It hits the roof at distance from the wall

$26.8m - 24m = 2.79\ m$

origin at the mouth of the cannon. we have $x_f = V_{xi}t$ which is $2000m = (1000m/s)\cos\theta_i t$

$$t = \frac{2.00s}{\cos\theta_i}$$

$y_f = V_{yi}t + \frac{1}{2}a_y t^2$

$800m = (1000m/s)\sin\theta_i t + \frac{1}{2}(-9.80m/s^2)t^2$

$800m(\cos^2\theta_i) = 2000m(\sin\theta_i \cos\theta_i) - 19.6m$

$19.6m + 800m(\cos^2\theta_i) = 2000m\sqrt{(1-\cos^2\theta_i)}(\cos\theta_i)$

$384 + (31360)\cos^2\theta_i + (640000)\cos^4\theta_i$

$= 4000000)\cos^2\theta_i - (4000000)\cos^4\theta_i$

$4640000\cos^4\theta_i - 3968640\cos^2\theta_i + 384 = 0$

$$\cos^2\theta_i = \frac{3968640 \pm \sqrt{(3968640)^2 - 4(4640000)(384)}}{9280000}$$

Qno7:
Sol:

(a) Initial Coordinates:

$x_i = 0.00m$, $y_i = 0.00m$

(b) Components of initial velocity:

$v_{xi} = 18.0 m/s$, $v_{yi} = 0$

(c) Free fall motion, with constant downward acceleration $g = 9.80 m/s^2$

(d) Constant velocity motion in the horizontal direction. There is no horizontal acceleration from gravity

(e) $v_{xf} = v_{xi} + a_x t \rightarrow v_{xf} = v_{xi}$

$v_{yf} = v_{yi} + a_y t \rightarrow v_{yf} = -gt$

(f) $x_f = x_i + v_{xi} t + \frac{1}{2} a_x t^2 \rightarrow x_f = v_{xi} t$

$y_f = y_i t + v_{yi} t + \frac{1}{2} a_y t^2 \rightarrow y_f = -\frac{1}{2} g t^2$

g) Time of impact:

$v_f = -\frac{1}{2} g t^2$

$-h = -\frac{1}{2} g t^2 \Rightarrow t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2(50.0m)}{9.80 m/s^2}}$

$= 3.19 s$

(h) At impact $v_f = v_{xi} = 18.0 m/s$ The vertical component is $v_{yf} = -gt$

$-g\sqrt{\frac{2h}{g}} = -\sqrt{2gh} = -\sqrt{2(9.8 m/s^2)(50.0 m)}$

$= -31.3 m/s$

$v_f = \sqrt{v_{xf}^2 + v_{yf}^2} = \sqrt{(18.0 m/s^2) + (-31.3 m/s)^2}$

$= 36.1 m/s$

$\theta_f = \tan^{-1}\left(\frac{v_{yf}}{v_{xf}}\right) = \tan^{-1}\left(\frac{-31.3}{18.0}\right)$

$= -60.1^\circ$

Q no 8:
Sol: The satellite is in free fall. Its acceleration is due to gravity and is by effect a centripetal acceleration:

$$a_c = g$$

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

for velocity

$$v = \sqrt{rg} = \sqrt{(6400+600)(10^3 m)(8.21 ms^{-2})}$$

$$= 7.58 \times 10^3 m/s$$

$$v = \frac{2\pi r}{T}$$

$$T = \frac{2\pi r}{v} = \frac{2\pi(7000 \times 10^3 m)}{7.58 \times 10^3 m/s}$$

$$= 5.80 \times 10^3 s$$

$$T = 5.80 \times 10^3 s \left(\frac{1 min}{60 s}\right)$$

$$= 96.7 min$$

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Qno9:
Sol:

(a) The speed of the boy relative to the ground for upstream

$VBGUP = VBW - VWG$

$= 1.2ms^{-1} - 0.5ms^{-1}$

$= 0.7ms^{-1}$

The speed of the boy relative to the ground for downstream

$VBG\ DW = VBW + VWG$

$= 1.2ms^{-1} + 0.5ms^{-1}$

$= 1.7ms^{-1}$

The distance covered in upstream trip dup = 1km = 1000m and the distance covered in downstream trip

ddn = 1km = 1000m

$$t = \frac{d}{v}$$

$$t = \frac{dup}{VBGUP} + \frac{ddn}{VBGdn}$$

$$= \frac{1000m}{0.7ms^{-1}} + \frac{1000m}{1.7ms^{-1}}$$

$= 2016.8\ s$

$= 33.61\ min$

$= 0.56\ h$

(b) the speed of water relative to the ground $V_{WG} = 0\ ms^{-1}$

speed of boy relative to the still river water ~~V~~ $V_{BW} = 1.2\ ms^{-1}$

$V_{BG+} = V_{BW} - V_{BG}$

$= 1.2\ ms^{-1} - 0\ ms^{-1}$

$= 1.2\ ms^{-1}$

The speed of the boy relative to the ground for motion along negative x-axis.

$V_{BG} = V_{BW} + V_{WG}$

$= 1.2\ ms^{-1} + 0\ ms^{-1}$

$= 1.2\ ms^{-1}$

$$t = \frac{d}{v}$$

$$t = \frac{dt}{V_{BGt}} + \frac{d}{V_{BG}}$$

$$= \frac{1000m}{1.2ms^{-1}} + \frac{1000m}{1.2ms^{-1}}$$

$$= 1666.67s$$

$$= 27.78 \text{ min}$$

$$= 0.46h$$

(c) The time taken in complete trip (upstream+downstream) is $t = 0.56h$

$$v_{avg_c} = \frac{D}{t}$$

$$= \frac{2000m}{2016ms^{-1}}$$

$$= 0.992ms^{-1}$$

now for part (b) time taken in complete trip $t = 0.46h$

$$v_{avg_s} = \frac{D}{t}$$

$$= \frac{2000m}{1666.67s}$$

$$= 1.2ms^{-1}$$

now we can see avg speed of boy is higher in still water

$V_{avg_s} > V_{avg_c}$

so the swim take longer when there is a current

Qno10:

Sol: River flow in the x direction.

(a) To minimize time, swim perpendicular to the banks in the y direction in the water for time t in $\Delta y = V_y t$.

$$t = \frac{80\,m}{1.5\,m/s} = 53.3\,s$$

(b) The water carries you down stream by

$$\Delta x = V_x t = (2.50\,m/s)\,53.3\,s$$

$$= 133\,m.$$

c) To minimize downstream drift you should swim so that your resultant velocity $\vec{V_s} + \vec{V_w}$ is perpendicular to your swimming velocity $\vec{V_s}$ relative to the water, maximizes the angle between the resultant velocity and the shore the angle between $\vec{V_s}$ and the shore is

$$\cos\theta = \frac{1.5\,m/s}{2.5\,m/s}$$

$$\theta = 53.1^\circ$$

d) $$V_y = V_s \sin\theta$$

$$= (1.5\,m/s)\sin 53.1^\circ$$

$$= 1.20\,m/s$$

$$t = \frac{\Delta y}{V_y} = \frac{80m}{1.2m/s} = 66.7s$$

$$\Delta x = V_x t$$

$$= \left[2.5m/s - (1.5m/s)\cos 53.1^\circ\right](66.7s)$$

$$= \boxed{107m}$$