Name: MD Ikramul Kayes

ID : 21301576

Sec : 08

1) For person,

velocity of the person $V_p = u_0 + gt = 0 + (-9.8)0.5$

$= -4.9 \ ms^{-1} \hat{j}$

Displacement of the person $y'_p = -\frac{1}{2}gt^2$

$= -1.225 \ m \ \hat{j}$

So

Displacement from the axis (as it is mesured

from the ground) so $y_p = h - |y'_p|$

$= (11.5 - 1.225)\hat{j}$

$= 10.275 \ \hat{j}$

For the ball,

Velocity of the ball $V_B = u - gt = (9.8 - 4.9)\hat{j}$

$= 4.9\ ms^{-1}\ \hat{j}$

Displacement of the ball $y_B = ut - \frac{1}{2}g.t^2$

$= 3.675 m\hat{j}$

Both of the person got some displacement

towards $x \rightarrow$ axis

Displacement of the person from x-axis

$x_p = 5\hat{i}$

Displacement of the Ball from x-axis

$x_B = 20\hat{j}$

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Position of the center of mass

$$= \frac{m_p(x_p\hat{i} + y_p\hat{j}) + m_B(x_B\hat{i} + y_B\hat{j})}{m_p + m_B}$$

$$= \frac{60(5\hat{i} + 10.275\hat{j}) + 0.2(20\hat{i} + 3.675\hat{j})}{60 + 0.2}$$

$$= 5.03\hat{i} + 10.25\hat{j}$$

Velocity of the center of mass,

$$= \frac{m_p(V_p\hat{j}) + m_B(V_B\hat{j})}{m_p + m_B}$$

$$= \frac{60(-4.9\hat{j}) + 0.2(4.9\hat{j})}{60 + 0.2}$$

$$= -4.87\,ms^{-1}\,\hat{j}$$

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b) ~~Ans~~ Final velocity of the person when he hits the ground $V = \sqrt{2gh}$

$= \sqrt{2 \times 9.8 \times 10}$

$= 14 \ ms^{-1}$

magnitude of impulse $J = m|\Delta v|$

$= 60 \times 14$

$= 840 \ kg \ ms^{-1}$

average force $= \frac{J}{\Delta t} = \frac{840}{0.02} = 84000 \ kgms^{-2}$

average force acting on the person is $84 \times 10^3 \ kgms^{-2}$ ~~(Ans)~~

$= 84 \times 10^3 \ N$ (Ans)

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e) From (b) we get $v = 14 ms^{-1}$

we can say in 0.15 m the person decelerates to $0 ms^{-1}$

$$\therefore a = \frac{v^2 - u^2}{2h} = \frac{(14)^2 - 0^2}{2 \times 0.15} = 653.33 ms^{-2}$$

we know,

$F = ma$

in 0.15m the person will be ~~dee~~ at rest and the normal force acting on the person will be $F_{N} = ma = 60 \times 653.33$

$= 39200 N$

As when the person travels ~~[illegible]~~ 0.15 m then the gravitational force still acts on that person ~~is~~ along with the decele-ration,

So, the normal force will be

$F_N = mg + F$

$= 60 \times 9.8 + 39200\ N$

$= 39788\ N$

As, $F_N < 50000\ N$

His legs can withstand the force and it will not break his legs.

2) a) Given that,

Last velocity $v = \frac{50}{3.6} = 13.89\ ms^{-1}$

past velocity $v_0 = \frac{90}{3.6} = 25\ ms^{-1}$

we know,

$$v = v_0 + at$$

$$\therefore a = \frac{v - v_0}{t} = \frac{13.89 - 25}{15} = -0.74074\ ms^{-2}$$

$\therefore$ Magnitude of the tangential acceleration is $-0.74074\ ms^{-1}$,

$\therefore$ Direction of tangential acceleration is in opposite direction of the velocity of the train,

b) Given,

$$V = \frac{90}{3.6} = 13.89 ms^{-1}$$

Radius $r = 150 m$

$\therefore$ Radial acceleration $a_c = \frac{V^2}{r}$

$$= \frac{(13.89)^2}{150}$$

$$= 1.286 \, ms^{-2}$$

The magnitude of radial acceleration is $1.286 ms^{-2}$

The direction of radial acceleration is directed towards center.

c] From a, b we get,

tangentual acceleration $a_t = -0.74074\,ms^{-2}$

radial acceleration $a_r = 1.286\,ms^{-2}$

$\therefore$ Magnitude of total acceleration

$$= \sqrt{(a_t)^2 + (a_r)^2}$$

$$= \sqrt{(1.286)^2 + (0.74074)^2}$$

$$= 1.484\,ms^{-2}$$

Direction of acceleration $\theta = \tan^{-1}\left(\frac{|a_c|}{|a_t|}\right)$

$$= \tan^{-1}\left(\frac{1.286}{0.74047}\right)$$

$$= 60.067^\circ$$

Magnitude of the acceleration $1.484\ ms^{-2}$

Direction of the acceleration ~~from~~ is 60.067° and it is relative to the direction of tangential acceleration.