PHY 111

ASSIGNMENT 03

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sec : 17

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Ans to the or no 1(a)

Given,

Mass of the first ice sled, $m_A = 22.7$ kg

Mass of the second ice sled, $m_B = 22.7$ kg

Mass of the cat, $m_c = 3.63$ kg

The cat makes two jumps which causes total four velocity to the sleds. We have to determine the final velocities.

Velocity of first sled with $v_{Ai} = 0$ after the first jump,

$$m_A v_{Ai} + m_c v_{ci} = m_A v_{Af} + m_c v_{cf} \quad [\vec{F}_{ext} = 0]$$

$$\Rightarrow m_A \cdot 0 + m_c \cdot 0 = 22.7 \cdot v_{Af} + 3.63 \times 3.05$$

$$\Rightarrow v_{Af} = -\frac{3.63 \times 3.05}{22.7}$$

$$\Rightarrow v_{Af} = 0.487 \text{ m/s}$$

$\therefore v_{Af} = -0.487$ m/s ; considering negative side.

When cat lands on the second sled, common velocity of cat and sled, V_B'

$$m_B V_{Bi} + m_c V_{ci} = (m_B + m_c) V_B'$$

$$\Rightarrow V_B' = \frac{m_B V_{Bi} + m_c V_{ci}}{m_B + m_c}$$

$$\Rightarrow V_B' = \frac{22.7 \times 0 + 3.63 \times 3.05}{(22.7 + 3.63)}$$

$$\Rightarrow V_B' = 0.42 \text{ m/s}$$

After that when cat makes its second jump, initial velocity of second sled $= V_B'$

$$(m_B + m_c) V_B' = m_B V_{Bf} + m_c(-V_{cf})$$

$$\Rightarrow V_{Bf} = \frac{(m_B + m_c) V_B' + m_c V_{cf}}{m_B}$$

$$\Rightarrow V_{Bf} = \frac{(22.7 + 3.63) 0.42 + 3.63 \times 3.05}{22.7}$$

$$\Rightarrow V_{Bf} = \frac{22.1301}{22.7} = 0.975 \text{ m/s}$$

Finally, after landing on the first sled, cat and the first sled will have a common velocity = V_A'

The inital velocity will be same as the final velocity after first jump. $V_{A}'i = V_{Af}$

$$m_A V_{A}'i + m_c(-V_{ci}) = (m_A + m_c) V_A'$$

$$\Rightarrow V_A' = \frac{m_A V_{A}'i - m_c V_{ci}}{(m_A + m_c)}$$

$$\Rightarrow V_A' = \frac{(-22.7 \times 0.487) - (3.63 \times 3.05}{(22.7 + 3.63)}$$

$$\Rightarrow V_A' = \frac{-22.1264}{26.33}$$

$$\Rightarrow V_A' = -0.84 \text{ m/s}$$

$\therefore$ Final speed of first sled S_{A}' = 0.84 m/s

Final speed of second sled S_{Bf} = 0.975 m/s

Ans to the Q no 1 (b)

We know,

Impulse, $\vec{I} = \Delta \vec{P}$

$= m v_f - m v_i$

Given, Mass of cat, $m_{C} = 3.63$ kg

We get from (a) that,

Final velocity, $v_f = 0.42$ m/s

$$\therefore \vec{I} = m_c v_f - m_c v_i$$

$$= m_c (v_f - v_i)$$

$$= 3.63 \times (0.42 - 3.035)$$

$$= 3.63 \times (-2.63)$$

$$= -9.547 \text{ kg m s}^{-1}$$

$\therefore$ The impulse on cat, $\vec{I} = -9.547$ kg ms^{-1}

Ans to the qr no 1 (c)

We know,

Average force, $F_{avg} = \frac{\vec{I}}{\Delta t}$

Given, chang in time, $\Delta t = 12$ ms

$= 12 \times 10^{-3}$ s

we get from (b)

The impulse, $\vec{I} = -9.547$

$\therefore F_{avg} = \frac{-9.547}{12 \times 10^{-3}}$

$= -795.58$ N

$\therefore$ The average force on the second sled by cat while landing is -795.58 N

Ans to the qr no 2 (a)

Given, Mass of the man, $m_1 = 67$ kg

Mass of the boat, $m_2 = 179$ kg

Length of boat, $L = 2.5$ m

we know, $X_{com} = \frac{1}{m_1 + m_2}(m_1 x_1 + m_2 x_2)$

(i) When origin is on the man's original location,

$x_1 = 0$ m

$x_2 = -\frac{2.5}{2} = -1.25$ m

$\therefore$ center of mass, $X_{com} = \frac{(67 \times 0) + 179 \times (-1.25)}{67 + 179}$

$= -\frac{223.75}{246}$

$= -0.91$ m

$\therefore X_{com} = -0.91$ m

(ii) When origin is on the back end,

$$x_1 = 2.5 \text{ m}$$

$$x_2 = 2.5/2 = 1.25 \text{ m}$$

$\therefore$ center of mass, $X'_{com} = \dfrac{(67 \times 2.5) + (179 \times 1.25)}{67 + 179}$

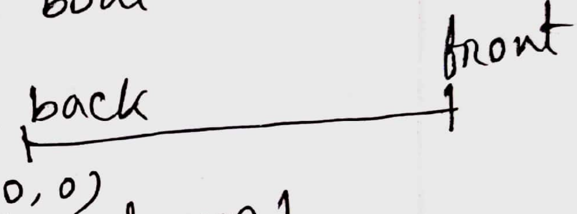
$$= \frac{391.25}{246}$$

$$= 1.59 \text{ m}$$

$\therefore$ center of mass, $X'_{com} = 1.59$ m

Ans to the qr no 2 (b)

Here, the man walks from the front to the back of the boat.



When the man is in the front end,

$$X_{com} = \frac{(67 \times 2.5) + (179 \times 1.25)}{67 + 179}$$

$$= 1.59 \text{ m}$$

When the man is in the back end,

$$X'_{com} = \frac{(67 \times 0) + (179 \times 1.25)}{67 + 179}$$

$$= 0.91 \text{ m}$$

Since $\vec{F}_{ext} = 0$, to keep the momentum same the displacement $= \Delta X_{com}$

$$= (1.59 - 0.91) \text{ m}$$

$$= 6.8 \text{ m}$$

$\therefore$ The displacement of the boat will be 6.8 m to the front side.

Ans to the or no 2 (c)

Given, Masses of the men, $m_1 = m_2 = 62$ kg

Mass of boat, $m_b = 179$ kg

initial velocity of moving boat, $u = 1.5$ m/s

velocity of the man, $V_1 = 3$ m/s

velocity of his friend, $V_2 = 4$ m/s

From conservation of momentum,

$$(m_1 + m_2 + m_b)u = m_1 V_1 - m_2 V_2 + m_b V_b$$

$$\Rightarrow (62+62+179)\,1.5 = (67 \times 3) - (67 \times 4) + 179 \times V_b$$

$$469.5 = -67 + 179\, V_b$$

$$\Rightarrow V_b = 536.5/179$$

$$\Rightarrow V_b = 2.99 \text{ m/s}$$

The speed of the boat after jumb, $S_{V_b} = 2.99$ m/s