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PHYS - 230

TEST 2

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Q1. Ans:- According to the laws of physics, energy is conserved only when the system is under conservative forces (like gravity).

In both cases (a) & (b), non-conservative force of friction is absent and the system is only under the influence of the gravitational force.

∴ Energy is conserved in both cases.

Q2. Ans: (a) Let K be the minimum value of spring constant.

∴ Work done by the frictional force on the box = Energy stored in the spring.

∴ Frictional force = $\mu_k mg$

∴ Displacement of box = $l + x_i$

∴ Work done by frictional force = $-\mu_k mg(l + x_i)$

Energy stored in the spring = $\frac{1}{2} k x_i^2$

$\therefore \frac{1}{2} k x_i^2 = \mu_k mg (l + x_i)$

$\therefore k = \frac{2 \mu_k mg (l + x_i)}{x_i^2}$

P.T.O

(b-) Energy stored in spring, $E = \frac{1}{2} k x_i^2$

$\therefore \quad E = \frac{1}{2} \times 2500 \times (0.15)^2 = 28.125\ J$

Work done by box against friction $= \mu_k mg (l + x_i)$

$\therefore \quad W_f = 0.35 \times 1.8 \times 9.8 \times (0.75 + 0.15)$

$= 0.35 \times 1.8 \times 9.8 \times 0.90$

$= 5.5566\ J$

Let v be the speed of the box when it leaves the table, then $\frac{1}{2} m v^2 = 28.125 - 5.5566$

$= 22.5684$

$\therefore \quad v = \sqrt{\frac{2 \times 22.5684}{1.8}}$

$v = 5.006\ m/s$

$\therefore$ Speed of the box after it leaves the table $= 5.006\ m/s$

Q3. (a) :- Work $= \frac{1}{2} m v_i^2$

$m = 145\ g$

$= 0.145\ kg$

$v_i = 46\ m/s$

$\therefore \quad W = \frac{1}{2} \times 0.145 \times (46)^2$

$W = 153.41\ J$

(e) Displacement, $S = r\theta$

$\theta = 115^\circ = 115 \times \frac{\pi}{180}$ rad

$r = 55\text{cm} = 0.55\text{m}$

$\therefore S = 0.55 \times \frac{115 \times \pi}{180}$

$\therefore S = 1.104\text{m}$

$\therefore$ Work = Force x Displacement

$\therefore F = \frac{W}{S}$

$= \frac{153.41}{1.104}$

$F = 138.96$

$F \approx 139\text{N}$

(f) $(K.E.)_{final} = \frac{1}{2} m v_b^2$

$(W - W_a) = \frac{1}{2} m v_b^2$

$\sqrt{\frac{2(W - W_a)}{m}} = v_b$

$\therefore v_b = \sqrt{\frac{2(153.41 - 37)}{0.145}}$

$v_b = 40.07\ m/s$

P.T.O

Q4. Ans:- $F_{ave} = 1926\ N$

$t = 0.004\ s$

Impulse = $F_{ave} \times t$

$= 1926 \times 0.004$

$= 7.704$

Impulse = Change in momentum

$= m_b (v_f - v_i)$

$7.704 = 0.145\ (v_f + 25)$

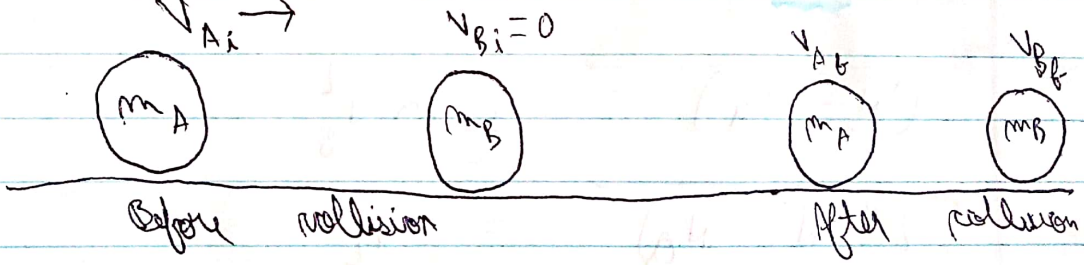
$\frac{7.704}{0.145} - 25 = v_f$

$\therefore v_f = 53.13 - 25$

$v_f = 28.13\ m/s$

$\therefore$ Velocity of the ball just after it leaves the bat = $28.13\ m/s$

Q5. Ans:- For elastic collision :-



Given :- $m_A = 1.5\ m_B$

$v_{Ai} = 4.5\ m/s$

$v_{Bi} = 0\ m/s$

$v_{Bf} = 2\ m/s$

P. T. O

(a) V_{Af} = final velocity of cart A.

$$\therefore V_{Af} = \frac{(1.5 m_B - m_B)}{(1.5 m_B + m_B)} \times 4.5$$

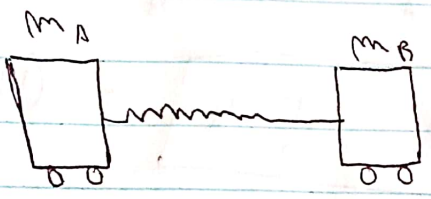
$$V_{Af} = \frac{0.5 m_B}{2.5 m_B} \times 4.5$$

$$= 0.9 \text{ m/s}$$

(b) $$m_A = 1.5 m_B$$

$$\therefore m_B = \frac{m_A}{1.5} = \frac{2}{3} m_A$$

Q.No:



$K = 250 \text{ J/m}^2$

$m_B = 0.55 \text{ kg}$

$m_A = \frac{4}{3} \times 0.55$

(a) Total energy = Initial stored energy in spring

$$= \frac{1}{2} k x_i^2$$

$$= \frac{1}{2} \times 250 \times (0.25)^2 \quad [\because x_i = 0.25 \text{ m}]$$

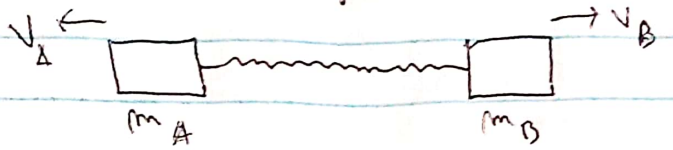
$$= 7.8125 \text{ J}$$

P.T.O

(b) After release, when the spring returns to natural length all its stored potential energy is converted into kinetic energy of blocks.

∴ The collision is an elastic collision.

(c) At natural length, $x = 0$



Applying conservation of linear momentum:-

$$m_A V_A = m_B V_B$$

$$\frac{4}{3} \cancel{m_B} V_A = \cancel{m_B} V_B$$

$$\boxed{V_B = \frac{4}{3} V_A} \quad - (1)$$

Now, conservation of energy:-

$$E_i = E_f$$

$$\frac{1}{2} k x_i^2 = \frac{1}{2} m_A V_A^2 + \frac{1}{2} m_B V_B^2$$

$$k x_i^2 = \frac{4}{3} \times 0.55 \times V_A^2 + 0.55 \times \frac{16}{9} \times V_A^2$$

Substituting 250 J/m² in K & 0.25 m in x_i, we get:-

$$V_A = 3.021836 \text{ m/s}$$

$$\Rightarrow$$

Substituting V_A in ①, we get:

$$V_B = 4,0291148 \text{ m/s}$$