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Unit - 5

(a) State impulse-momentum principal and conservation of momentum principle.

Ans impulse-momentum principal-

The Impulse momentum theorem state that the change in momentum of an object equals the impulse applied to it.

$$J = \Delta P$$

ΔP - change in momentum

J - Impulse

Conservation of momentum principal-

Law of conservation of momentum state that "for 2 or more bodies in an isolated system acting upon each other, their total momentum remains constant unless an external force is applied".

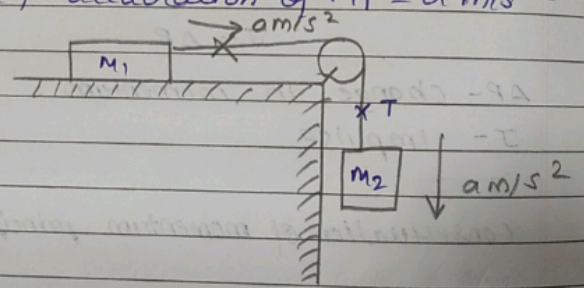
Therefore,

momentum can neither be created nor be destroyed.

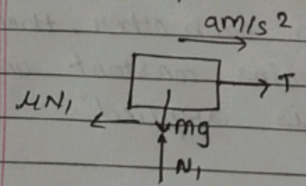
(b) Find the acceleration of the masses and tension of the string. Consider $M_1 = 10Kg$ and $M_2 = 5kg$. Coefficient of friction between all contact surface is 0.25

Sol^n Let acceleration of $M_2 = a\ m/s^2$

therefore, acceleration of $M_1 = a\ m/s^2$



Consider M_1 as a rigid body in Kinetic Equilibrium



$\Sigma fx - max = 0$ [cause of motion i.e T is always +ve]

$(T - \mu N_1) - m_1 a = 0$

$T - 0.25 N_1 - 10a = 0$ —— (1)

$\Sigma fy - may = 0$

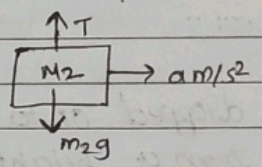
$N_1 - m_1 g = 0$

$N_1 = m_1 g$

$= 10 \times 9.8$

$\boxed{N_1 = 98N}$

Now, consider M_2 as a rigid body in Kinetic Equilibrium.



$\Sigma fx - max = 0$

$ax = 0$

$\Sigma fy - may = 0$

$(m_2 g - T) - m_2 a = 0$

$m_2 g - T = m_2 a$

$5 \times 9.8 - T = 5a$

$49 - T = 5a$ —— (2)

$T = 49 - 5a$ (from 2)

put in eq^n (1)

$49 - 5a - 0.25 N_1 - 10a = 0$ [$N_1 = 98$]

$15a = 49 - 24.5$

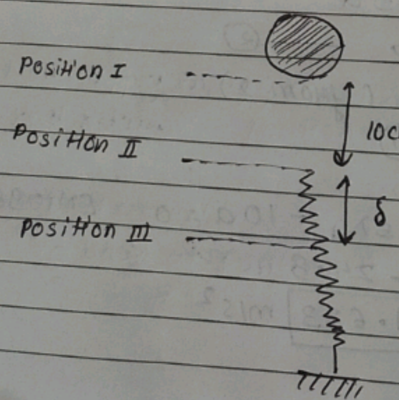
$\boxed{a = 1.633}\ m/s^2$

and tension. (from 2)

$$T = 49 - 5a$$
$$= 49 - 5 \times 1.633$$
$$\boxed{T \Rightarrow 40.83\,N}$$

therefore $T = 40.83\,N$ and
$a = 1.633\ m/s^2$

(d) A ball of mass m is dropped onto a spring of stiffness K from a height h find the maxium deflection δ of the
Assume $m = 5\,Kg$ $K = 500\,N/m$
$h = 10\,cm$



Soln let maximum Deflection in spring = δ
let velocity of ball at position I = V_1 m/s
velocity of ball at position II = V_2 m/s
velocity of ball at position III = V_3 m/s

Apply Energy conservation principle in ball between Position - I and position II

Total stored energy in ball at position I = Total stored energy in ball at position II

$$E_1 = E_2 \quad \text{--- (1)}$$
$$E_1 = KE_1 + PE_1$$
$$KE_1 = \frac{1}{2} m v_1^2 \qquad [v_1 = 0 \text{ (Inital)}]$$
$$\Rightarrow KE_1 = 0$$

$$PE_1 = mgh \qquad [(h = 10cm) = 0.1\,m$$
$$= mg \times 0.1 \qquad \text{Refernce P-II})$$
$$PE_1 = 0.1\,mg$$

$$\therefore E_1 = 0 + 0.1\,mg \quad \text{--- (2)}$$

Now, $E_2 = KE_2 + PE_2$

$KE_2 = \frac{1}{2} m v_2^2$

$PE_2 = mgh$ (Reference P-II)

$PE_2 = mg \times 0$ $\quad h=0$

$PE_2 = 0$

$\therefore E_2 = \frac{1}{2} m v_2^2$ — (3)

from (2) and (3) put in (1)

$0.1 mg = \frac{1}{2} m v_2^2$

$0.1 \times 9.8 = \frac{1}{2} v_2^2$

$v_2 = \sqrt{1.96}$

$v_2 = 1.4$ m/s.

Now, Apply Energy conservation principle in ball between position - II and position III

Total stored Energy in ball at position II = total stored energy in ball at position III

$E_2 = E_3$ — (4)

$E_2 = KE_2 + PE_2$

$KE_2 = \frac{1}{2} m v_2^2$

$PE_2 = mg\delta$ (Reference P-III)

$E_2 = \frac{1}{2} m v_2^2 + mg\delta$ — (5)

$E_3 = KE_3 + PE_3 +$ Spring energy

$KE_3 = \frac{1}{2} m v_3^2$ $\quad (v_3 = 0)$

$\therefore KE_3 = 0$

$PE = mg \times 0$ (Reference P III) $\quad h=0$

$\therefore PE_3 = 0$

spring Energy $= \frac{1}{2} k\delta^2$

$\therefore E_3 = \frac{1}{2} k \delta^2$ — (6)

from (5) and (6) put in (4)

$\frac{1}{2} m v_2^2 + mg\delta = \frac{1}{2} k \delta^2$

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$\frac{1}{2} \times 5 \times 1.96 + 5 \times 9.8 \times \delta = \frac{1}{2} \times 500 \times \delta^2$

$4.9 + 49\delta = 250\delta^2$

$\Rightarrow 250\delta^2 - 49\delta - 4.9 = 0$

$\delta = \dfrac{49 \pm \sqrt{49^2 + 4 \times 250 \times 4.9}}{500}$

$\delta = 0.27 m$

or

$\delta = 27 cm$

$\therefore$ maximum deflection in the spring is 27 cm