Date: 7/02/2022 | Unit-1

Day: Monday | Laws of Motion

Solved Problems:

1) Calculate the velocity of a moving body of mass 5kg whose linear momentum is $2.5\ kgms^{-1}$.

Solution:-

Given:-

Mass of a moving body $(m) = 5\ kg$

Linear Momentum $(P) = 2.5\ kgms^{-1}$

Velocity of a moving body $(v) = ?$

Soln:-

Linear Momentum $P = mv$

$$v = \frac{P}{m}$$

$$v = \frac{2.5}{5}$$

$$v = \frac{2.5}{5} \times \frac{10}{10}$$

$$v = \frac{25}{50_2}$$

$$v = \frac{1}{2}$$

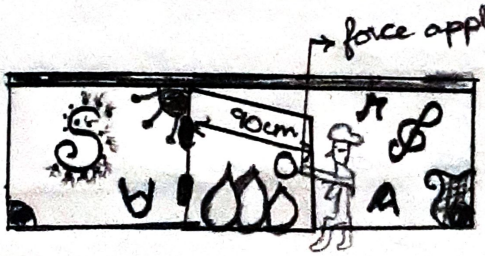
$$\boxed{v = 0.5\ ms^{-1}}$$

	0.5
2	10
	10
	0

$\therefore$ The velocity of moving body is $0.5\ ms^{-1}$.

2) A door is pushed, at a point whose distance from the hinges is 90cm, with a force of 40N. Calculate the moment of the force about the hinges.

Solution:



Given

Distance $(d) = 90cm$ $\quad \because 1M = 100\ cm$

$= \frac{90}{100}\ m$

$= \frac{9}{10}$

Distance (d) = 0.9cm

Force (F) = 40N

Moment of face (τ) = ?

Soln

Moment of face (τ) = F × d

$\tau = 40 \times 0.9$

$\tau = 36 Nm$

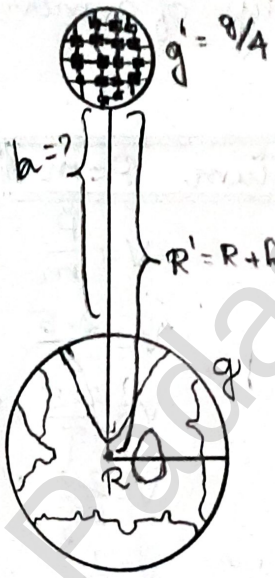
40 × 0.9 = 360, 00+ = 36.0

∴ The moment of force is 36Nm

3. At what height from the centre of the Earth the acceleration due to gravity will be $1/4^{th}$ of its value as at the Earth.

Solution

Data:-



Height of the object from the centre of the Earth } $R' = R + h \rightarrow (1)$

The acceleration due to gravity at that height } $g' = \frac{g}{4} \rightarrow (2)$

Soln

$$g = \frac{GM}{R^2} \rightarrow (3)$$

$$g' = \frac{GM}{R'^2} \rightarrow (4)$$

On dividing the equation (3) and equation (4)

$$\frac{g}{g'} = \frac{\left(\frac{GM}{R^2}\right)}{\left(\frac{GM}{R'^2}\right)}$$

$$\frac{g}{g/4} = \frac{GM}{R^2} \times \frac{R'^2}{GM}$$

$$4 = \left(\frac{R'^2}{R^2}\right)$$

$$4 = \left(\frac{R'}{R}\right)^2$$

Taking square roots on both sides.

$$\sqrt{4} = \sqrt{\left(\frac{R'}{R}\right)^2}$$

$$2 = \frac{R+h}{R}$$

$$2 = \frac{R}{R} + \frac{h}{R}$$

$$2 = 1 + \frac{h}{R}$$

$$2 - 1 = \frac{h}{R}$$

$$1 = \frac{h}{R}$$

$$\boxed{R = h} \rightarrow (5)$$

Substituet equation (5) in equation (1)

$$(1) \Rightarrow R' = R + R$$

$$\boxed{R' = 2R}$$

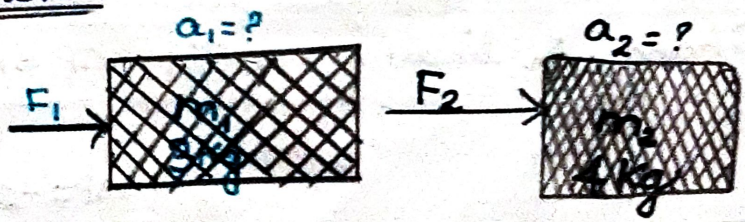
∴ From the centre of the Earth the object is placed at **twice the radius** of the Earth.

VII. Solve the given problems :-

1. Two bodies have a mass ratio of 3:4 - The force applied on the bigger mass produces an acceleration of $12\ ms^{-2}$. What could be the accleration of the other body if the same force act on it.

Solution

Given :-



Mass of smaller body $(m_1) = 3Kg$

Mass of bigger body $(m_2) = 4Kg$

$F_1 = F_2$ (Same force act on two bodies).

The acceleration of bigger body $(a_2) = 12\ ms^{-2}$

The acceleration of smaller body $(a_1) = ?$

Soln:-

Method : 1

$F = ma$

$F_1 = F_2$

$m_1a_1 = m_2a_2$

$a_1 = \frac{m_2a_2}{m_1}$

$a_1 = \frac{4 \times 12}{3}$

$a_1 = 16ms^{-2}$

∴ The acceleration of smaller body is $16ms^{-2}$

Method : 2

$\frac{F_1}{F_2} = \frac{m_1a_1}{m_2a_2}$

$F_1 = F_2$

$\frac{F_2}{F_2} = \frac{3 \times a_1}{4 \times 12}$ (4)

$1 = \frac{a_1}{16}$

$a_1 = 16ms^{-2}$

∴ The acceleration of other body is $16ms^{-2}$.

2. A ball of mass 1Kg moving with a speed of $10ms^{-1}$ rebounds after a perfect elastic collision with the floor. Calculate the change in linear momentum of the ball.

Solution

Given:-

Mass of ball $(m) = 1Kg$

Initial velocity $(u) = 10ms^{-1}$

Final velocity $(v) = -10\ ms^{-1}$.

Change in linear momentum $(\Delta P) = ?$

Soln:-

Change in linear momentum $\Delta P = m(v-u)$

$= 1(-10-10)$

$\Delta P = -20kg\ ms^{-1}$

∴ Change in linear momentum of the ball is $-20\ Kg\ ms^{-1}$.

3) A mechanic unscrews a nut by applying a force of 140N with a spanner of length 40cm. What should be the length of the spanner if a force of 40N is applied to unscrew the same units?

Solution

Given

The spanner of length $\} L_1 = 40cm$

$L_1 = 40 \times 10^{-2} m$

Applying force $F_1 = 140N$.

Applying force $F_2 = 40N$.

∴ The spanner of length $L_2 = ?$

Soln

$$F_1 \times L_1 = F_2 \times L_2$$

$$L_2 = \frac{F_1 \times L_1}{F_2}$$

$$L_2 = \frac{140 \times 40 \times 10^{-2}}{40}$$

$$L_2 = 140 \times 10^{-2} m$$

(or)

$$L_2 = 1.4cm$$

∴ The length of spanner if a force 40N is applied to 140 m or 1.4 m.

4. The ratio of masses of two planet is 2:3 and the ratio of their radii is 4:7. Find the ratio of their acceleration due to gravity.

Solution

Given

The ratio of masses of two planets $\} M_1 : M_2 = 2:3$

The ratio of radii of two planets } $R_1 : R_2 = 4 : 7$.

The ratio of acceleration due to gravity } $g_1 : g_2 = ?$

Soln

$$g_1 = \frac{GM_1}{R_1^2} \longrightarrow (1)$$

$$g_2 = \frac{GM_2}{R_2^2} \longrightarrow (2)$$

On dividing equation (1) with equation (2)

$$\frac{g_1}{g_2} = \frac{\left[\frac{GM_1}{R_1^2}\right]}{\left[\frac{GM_2}{R_2^2}\right]}$$

$$\frac{g_1}{g_2} = \frac{GM_1}{R_1^2} \times \frac{R_2^2}{GM_2}.$$

$$\frac{g_1}{g_2} = \left(\frac{M_1}{M_2}\right) \times \left(\frac{R_2}{R_1}\right)^2$$

$$\frac{g_1}{g_2} = \frac{2 \times 7 \times 7}{3 \times 4 \times 4}$$

$$\frac{g_1}{g_2} = \frac{49}{24}.$$

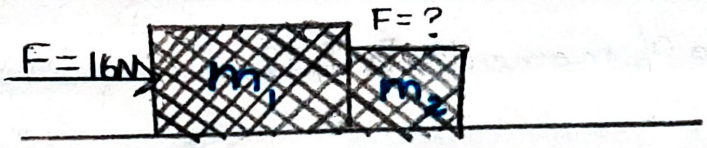
$$\boxed{g_1 : g_2 = 49 : 24}.$$

∴ The ratio of acceleration due to gravity of two planets are **49:24**.

IX. HOTS question

1. Two blocks of masses 8kg and 2kg respectively lie on a smooth horizontal surface in contact with one other. They are pushed by a horizontal applied force of 15N. Calculate the force exerted on the 2kg mass.

Solution



Given:-

Mass of the body(m_1) = 8 Kg

Mass of the body(m_2) = 2 kg

Force applied (F) = 15N

∴ The force exerted on 2 Kg mass = ?

Soln

By newton's second law of motion

$$F = ma$$

$$F = (m_1 + m_2)\, a$$

$$F = (8+2)\, a$$

$$15 = (10)a$$

$$\frac{15}{10} = a$$

$$a = 1.5 ms^{-2}$$

1.5
10 | 15
-10
50
-50
0

∴ Force escerted on 2Kg mas

$$F = ma$$

$$F = 2 \times 1.5$$

$$F = 3N$$

∴ The force exerted on 2kg mass is 3N.

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2. A heavy truck and bike are moving with the same kinetic energy. If the mass of the truck is four times that of the bike, then calculate the ratio of their momenta. (Ratio of momenta = 2:1).

Solution

Given

Mass of bike = m_b

Mass of truck(m_t) = $4 m_b$

Kinetic energy of bike = $\frac{1}{2} m_b v_b^2$

Kinetic energy of truck = $\frac{1}{2} m_t v_t^2$

Kinetic energy of bike = Kinetic energy of truck

$$\frac{1}{2} m_b v_b^2 = \frac{1}{2} m_t v_t^2$$

Ratio of momenta $P_t : P_b = ?$

Soln

$$\frac{1}{2} m_b v_b^2 = \frac{1}{2} m_t v_t^2$$

$$m_b v_b^2 = 4 m_b v_t^2$$

$$v_b^2 = 4 v_t^2$$

$$4 = \left(\frac{v_b}{v_t}\right)^2$$

Taking square roots on both sides

$$\sqrt{4} = \sqrt{\left(\frac{v_b}{v_t}\right)^2}$$

$$2 = \frac{v_b}{v_t}$$

∴ To find

$$\frac{P_t}{P_b} = \frac{m_t v_t}{m_b v_b}$$

$$= \frac{4 m_b v_t}{m_b v_b}$$

$$\frac{P_t}{P_b} = 4 \times \left(\frac{v_t}{v_b}\right)$$

$$\frac{P_t}{P_b} = \frac{2}{4} \times \frac{1}{2_1}$$

$$\frac{P_t}{P_b} = \frac{2}{1}$$

$$P_t : P_b = 2 : 1$$

∴ The ratio of momenta $P_t : P_b = 2 : 1$.

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