

2. FORCE AND LAWS OF MOTION

Ncert Folder Pg. NO 234

VERY SHORT ANSWER TYPE [QUESTION REFER TB]

1. Inertia is the property of a body by which it resists any change in the state of rest or Uniform motion in a straight line.
2. $m = 20 \text{ kg}$ $a = 2 \text{ m/s}^2$
 $F = ma$
 $F = 20 \times 2$
 $F = 40 \text{ N}$
3. Due to gravitational force.
4. plastic ball, because it rebounds and undergoes greater change in momentum.
5. One Newton is the force that produces an acceleration of 1 m/s^2 in a 1 kg mass.

⑥ $m = 2000 \text{ kg}$

$$a = -1.5 \text{ m/s}^2$$

$$F = ma$$

$$F = 2000 \times (-1.5)$$

$$= -3000 \text{ N}$$

$$F = -3000 \text{ N}$$

7. $F = 80 \text{ N}$ $m = 25 \text{ kg}$

$$F = ma$$

$$a = \frac{F}{m}$$

$$a = \frac{80}{25}$$

$$a = 3.2 \text{ m/s}^2$$

8. Case: (i) $F = ma$

$$m = 2 \quad a = 5$$

$$F = 2 \times 5$$

$$F = 10 \text{ N}$$

Case: (ii)

$$m = 4 \quad a = 2$$

$$F = 4 \times 2$$

$$F = 8 \text{ N}$$

2 kg at 5 m/s^2 requires greater force.

9.

$$u = 1.8 \text{ m/s} \quad v = 4.2 \text{ m/s} \quad t = 1.2 \text{ s}$$

$$a = \frac{v - u}{t}$$

$$a = \frac{4.2 - 1.8}{1.2}$$

$$a = \frac{2.4}{1.2}$$

$$a = 2.$$

speed change $a = 2 \quad t = 2$

$$\Delta v = at$$

$$\Delta v = 2 \times 2$$

$$\Delta v = 4 \text{ m/s}$$

10) Given:-

3N and 4N at 90°

$$\text{Resultant Vector} = \sqrt{x^2 + y^2}$$

$$= \sqrt{3^2 + 4^2}$$

$$= \sqrt{9 + 16}$$

$$= \sqrt{25}$$

$$= 5 \text{ N}$$

11. Breaking force.

$$m = 1000 \text{ kg} \quad u = 30 \text{ m/s} \quad v = 0 \quad t = 4 \text{ s}$$

Formula: (i) $a = \frac{v-u}{t}$

(ii) $F = m \times a$

$$a = \frac{0-30}{4}$$

$$a = \frac{-30}{4}$$

$$a = -7.5 \text{ m/s}^2$$

$$F = 1000 \times (-7.5)$$

$$F = -7500 \text{ N}$$

$$F = 7500 \text{ N}$$

12. Net force = 0 N

13. Inside lift:

$a = g$ downward

Ground observer: g downward

14. Tension $T = p$

15. Spring Balance:

Reading = 4 kg - wt, $\theta = 30^\circ$

$$W = \frac{R}{\cos 30^\circ}$$

$$W = \frac{4}{\sqrt{3}/2}$$

$$W = \frac{4 \times 2}{\sqrt{3}}$$

$$W = \frac{8}{\sqrt{3}}$$

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$$1.732$$

$$\sqrt{3} = 1.732$$

$$W = \frac{8}{1.732}$$

$$W = 4.618$$

$$W = 4.62 \text{ kg.}$$

Pg. NO 2.34 & 2.35

II SHORT ANSWER TYPE [QUESTIONS REFER TB]

1. Engine acceleration : (smaller)

$$u = 80 \text{ m/s} \quad v = 95 \text{ m/s} \quad a_1 = ? \quad t_1 = 10 \text{ s}$$

$$v = u + at$$

$$95 \text{ m/s} = 80 \text{ m/s} + a_1 (10 \text{ s})$$

$$a_1 = \frac{95 - 80}{10}$$

$$a_1 = 1.5 \text{ m/s}^2$$

ship mass :-

$$F = ma$$

$$F_1 = 300 \text{ N} \quad a_1 = 1.5 \text{ m/s}^2$$

$$300 \text{ N} = m \cdot 1.5 \text{ m/s}^2$$

$$m = \frac{300}{1.5}$$

$$m = 200 \text{ kg}$$

Larger engine acceleration :

$$F_2 = 750 \text{ N} \quad a_2 = ? \quad m = 200 \text{ kg}$$

$$F_2 = m \cdot a_2$$

$$750\text{N} = 200\text{kg } a_2$$

$$a_2 = \frac{750}{200}$$

$$a_2 = 3.75\text{m/s}^2$$

solve for velocity:

$$v_2 = v_1 + a_2 t_2$$

$$v_2 = 95\text{m/s} + (3.75\text{m/s}^2 \cdot 12\text{s})$$

$$v_2 = 95 + 45\text{m/s}$$

$$v_2 = 140\text{m/s}$$

2. Calculate deceleration rate

$$v^2 = u^2 + 2as$$

$$v=0 \quad u=40\text{m/s} \quad s=80\text{m}$$

$$0 = (40\text{m/s})^2 + 2 \times a \times 80\text{m}$$

$$0 = 1600 + 16a$$

$$a = -10\text{m/s}^2$$

Finding net stopping force:

$$F_{\text{net}} = m \cdot |a|$$

$$m = 1000\text{kg} \quad a = -10$$

$$F_{\text{net}} = 1000\text{kg} \times 10\text{m/s}^2$$

$$F_{\text{net}} = 10000\text{N}$$

$$\therefore |-10| = 10$$

Isolate the braking force.

$$F_{\text{net}} = F_{\text{braking}} + F_{\text{resistance}}$$

$$\begin{aligned} F_{\text{braking}} &= 10000\text{N} - 100\text{N} \\ &= 9900\text{N} \end{aligned}$$

3. Calculate pushing force per person.

If 2 people push:

Acceleration = 0, hence the force on body is balanced

Force by 2 people = Force of friction

$$2F = \text{Force of friction}$$

If 3 people push:

$$\text{Acceleration} = 0.02 \text{ m/s}^2$$

$$\text{Net force} = \text{Force of 3 people} - \text{Force of 2 people}$$

$$= 3F - 2F$$

$$= F$$

Let's find F.

$$\text{Mass of motor car} = 1200\text{kg}$$

$$\text{Acceleration} = a = 0.2 \text{ m/s}^2$$

$$\text{Force} = F$$

$$F = m \times a$$

$$F = 1200 \times 0.2$$

$$F = 1200 \times \frac{2}{10}$$

$$F = 120 \times 2$$

$$F = 240 \text{ N}$$

4)

$$m_1 = 2 \text{ kg}, m_2 = 3 \text{ kg}$$

$$u_1 = 5 \text{ m/s}, u_2 = -2 \text{ m/s}$$

Apply Conservation of momentum.

$$m_1 u_1 + m_2 u_2 = m_1 v + m_2 v$$

$$m_1 u_1 + m_2 u_2 = (m_1 + m_2) v$$

$$(2 \text{ kg} \times 5 \text{ m/s}) + (3 \text{ kg} \times (-2 \text{ m/s})) = (2 + 3) v$$

$$10 \text{ kg m/s} - 6 \text{ kg m/s} = 5 v$$

$$4 = 5 v$$

$$v = \frac{4 \text{ m/s}}{5}$$

$$v = 0.8 \text{ m/s}$$

5.

Convert given values to SI units

Mass of each bullet (m)

$$m = 25g \rightarrow 25 \times \frac{1}{1000}$$

$$= 25 \times 10^{-3}$$

$$= 25 \times 10^{-3}$$

$$= 0.025 \text{ kg}$$

Firing rate (n):

$$n = 600 \text{ bullet}$$

60 seconds

$$n = 10 \text{ bullets/seconds}$$

According to Newton's second law of motion

$$F = \frac{\Delta p}{\Delta t}$$

'n' bullets are fired at a constant velocity

$$[p = mv]$$

$$F = n \frac{mv}{1}$$

$$F = 10 \times 0.625 \text{ kg} \times 200 \text{ m/s}$$

$$F = 50 \text{ N}$$

6

$$F = m \times a$$

$$A = 4 \text{ kg} \quad B = 2 \text{ kg} \quad C = 1 \text{ kg}$$

$$F_{\text{net}} = 14 \text{ N}$$

$$a = \frac{F_{\text{net}}}{M_{\text{total}}} = \frac{14}{4+2+1} = \frac{14}{7} = 2 \text{ m/s}^2$$

Contact force b/w A and B (F_{AB})

$$F_{AB} = (m_B + m_C) \times a$$

$$F_{AB} = (2+1) \times 2$$

$$F_{AB} = 6 \text{ N}$$

8 The block is on an inclined plane with angle θ .

At θ , the block just begins to slide down.

$$mg \sin \theta = \mu_s mg \cos \theta$$

$$\mu_s = \frac{\sin \theta}{\cos \theta} \quad \mu_s = \tan \theta$$

Force Equation upward motion :

$$F = mg \sin \theta + f_s$$

$$F = mg \sin \theta + \mu_s mg \cos \theta$$

$$\text{Sub } \mu_s = \tan \theta$$

$$F = mg \sin \theta + \tan \theta mg \cos \theta$$

$$F = mg \left[\sin \theta + \frac{\sin \theta}{\cos \theta} \times \cos \theta \right]$$

$$F = mg [\sin \theta + \sin \theta]$$

$$F = 2mg \sin \theta$$

7.

Let λ represent the linear mass density of the uniform chain (mass per unit length)

Total length of the chain L

length of the chain on the table x

length of the hanging chain : $L - x$

Mass on the chain on table $m_1 = \lambda x$

Mass on the chain on table $m_2 = \lambda(L-x)$

Downward pulling force:-

$$F_{\text{pull}} = m_2 g = \lambda(L-x)g$$

Maximum static friction F_{friction}

$$\begin{aligned} F_{\text{friction}} &= \mu N = \mu m_1 g \\ &= \mu \lambda x g \end{aligned}$$

Equilibrium Constant

$$F_{\text{friction}} \geq F_{\text{pull}}$$

$$\mu \lambda x g \geq \lambda(L-x)g$$

$$\mu x \geq L-x$$

$$\mu x + x \geq L$$

$$x(\mu+1) \geq L$$

$$x \geq \frac{L}{\mu+1}$$

$\mu = 0.5$ Coefficient of friction

$$x > \frac{L}{0.5+1}$$

$$x > \frac{L}{1.5}$$

1.5 can be written as $\frac{3}{2}$

$$x > \frac{L}{\frac{3}{2}}$$

$$x > \frac{2L}{3}$$

9. Acting forces:

$$F_g = mg \text{ (Gravitational force)}$$

$$F_p = ma \text{ (pseudo force)}$$

Resolve force component:

The Vertical Component acting upwards:
 $T \cos \theta$

The horizontal Component acting downwards:
 $T \sin \theta$

Vertical forces

$$T \cos \theta = mg \quad - (1)$$

horizontal forces.

$$T \sin \theta = ma \quad - (2)$$

$$\frac{T \sin \theta}{T \cos \theta} = \frac{ma}{mg}$$

$$\tan \theta = a/g$$

$$\theta = \tan^{-1} (a/g)$$

LONG ANSWER Type

1. (i) Mass of the house

$$p = 3000 \text{ N s} \quad v = 15 \text{ m s}^{-1}$$

$$p = mv$$

$$m = \frac{p}{v} = \frac{3000}{15} = 200 \text{ kg}$$

(ii) Bullet force $v = 300 \text{ m s}^{-1}$ $t = 0.003 \text{ s}$.

$$m = 10 \text{ g} \xrightarrow{\text{kg}} = 0.01 \text{ kg}$$

$$a = \frac{v}{t} = \frac{300 \text{ m s}^{-1}}{0.003 \text{ s}} = 100000 \text{ m s}^{-2}$$

$$F = m \cdot a \Rightarrow 0.01 \text{ kg} \times 100000 \text{ m s}^{-2} \\ = 1000 \text{ N}$$

(iv) compute electron momentum.

$$m = 9 \times 10^{-31} \text{ kg} \quad v = 6 \times 10^7 \text{ ms}^{-1}$$

$$p = m \cdot v$$

$$p = (9 \times 10^{-31} \text{ kg}) \cdot (6 \times 10^7 \text{ ms}^{-1})$$

$$p = 5.4 \times 10^{-23} \text{ kg ms}^{-1}$$

(v) Determine body acceleration

$$a = \frac{F}{m}$$

$$a = \frac{200 \text{ N}}{5 \text{ kg}} = 40 \text{ ms}^{-2}$$

(vi) Body Velocity

$$p = 180 \text{ Ns}$$

$$m = 30 \text{ kg}$$

$$p = m v$$

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

$$v = \frac{180 \text{ Ns}}{30 \text{ kg}}$$

$$v = 6 \text{ ms}^{-1}$$

$$v = 6 \text{ ms}^{-1}$$

2)

(i) Concept: Distance equals the area under the speed-time graph?

Triangle from $t=0$ to $t=2$

$$\text{Base} = 2$$

$$\text{Height} = 15$$

$$\text{Distance} = \frac{1}{2}bh$$

$$= \frac{1}{2} \times 2 \times 15$$

$$= 15\text{m}$$

(ii) initial velocity at $t=5\text{s}$, (u) = 15m/s

Final velocity at $t=6\text{s}$, (v) = 0m/s

$$\text{Time interval } \Delta t = 6 - 5$$

$$= 1\text{s}$$

Mass of the car (m) = 1000kg

$$a = \frac{v-u}{\Delta t} = \frac{0-15}{1} = -15\text{m/s}^2$$

$$F = m \cdot a \Rightarrow 1000 \times (-15)$$

-15000N (or) $[15000\text{N} - \text{opposing motion}]$

3.

$$f_{\max} = \mu \cdot m_1 \cdot g$$

$$\mu = 0.2 \quad m_1 = 3 \quad g = 10$$

$$\begin{aligned} f_{\max} &= \mu \cdot m_1 \cdot g \\ &= 0.2 \times 3 \times 10 \\ &= 6 \text{ N} \end{aligned}$$

$$\begin{aligned} a_c &= \frac{F_{\text{total}}}{m_1 + m_2} = \frac{20}{3 + 10} = \frac{20}{13} \text{ m/s}^2 \\ &= 1.54 \text{ m/s}^2 \end{aligned}$$

$$f_{\text{required}} = m_2 \cdot a_c$$

$$m_2 = 10 \quad a_c = \frac{20}{13}$$

$$= \frac{10 \times 20}{13} = \frac{200}{13}$$

$$= 15.38 \text{ N}$$

$$f_{\text{required}} (15.38 \text{ N}) > f_{\max} (6 \text{ N})$$

Individual acceleration.

(1) For 3kg block (a_1)

$$F - f_{\max} = m_1 \cdot a_1$$

$$20 - 6 = 3 \cdot a_1$$

$$14 = 3 \cdot a_1$$

$$a_1 = \frac{14}{3}$$

$$a_1 = 4.67 \text{ m/s}^2$$

$$f_{\max} = m_2 \cdot a_2$$

$$6 = 10 \cdot a_2$$

$$a_2 = \frac{6}{10}$$

$$a_2 = 0.6 \text{ m/s}^2$$

4

total mass = 5kg

$$m_1 = 2\text{kg}$$

$$m_2 = 2\text{kg}$$

$$m_3 = 5 - (2+2) = 1\text{kg}$$

$$\vec{P}_i = 0$$

$$\vec{P}_i = \vec{P}_f = m_1 \vec{V}_1 + m_2 \vec{V}_2 + m_3 \vec{V}_3$$

$$= 0$$

Let East be $\hat{i}$ and North be $\hat{j}$

$$\vec{V}_1 = 5\hat{j} \text{ m/s (N)}$$

$$\vec{V}_2 = 5\hat{i} \text{ m/s (E)}$$

$$2(5\hat{j}) + 2(5\hat{i}) + 1(\vec{V}_3) = 0$$

$$10\hat{j} + 10\hat{i} + \vec{V}_3 = 0$$

$$\vec{V}_3 = -10\hat{i} - 10\hat{j} \text{ m/s}$$

Magnitude:-

$$V_3 = \sqrt{(-10)^2 + (-10)^2}$$

$$= \sqrt{200}$$

$$= 10\sqrt{2} \text{ m/s}$$

Both components are negative,
the direction is South-West.

5)

F is applied to the system,
the horizontal acceleration (a)

$$a = \frac{F}{M+m}$$

Force balance on mass m along the incline
Component of gravity down the
incline $= m \cdot g \sin \theta$

Component of pseudo force up the
incline $= m \cdot a \cos \theta$.

$$m \cdot g \sin \theta = m \cdot a \cos \theta$$

$$\frac{a}{g} = \frac{\sin \theta}{\cos \theta}$$

$$a = g \cdot \tan \theta$$

$$g \cdot \tan \theta = \frac{F}{M+m}$$

$$F = (M+m) \cdot g \cdot \tan \theta$$

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$$F = (M+m) \cdot g \cdot \tan \theta$$