CBSE Test Paper 04

Chapter 5 Laws of Motion

1. A man of mass 70 kg stands on a weighing scale in a lift which is moving upwards with a uniform acceleration of 5 m s^{-2} what would be the reading on the scale?**1**
   a. 130 kg
   b. 120 kg
   c. 150 kg
   d. 105 kg
2. Impulse is **1**
   a. the derivative of force over a short period
   b. the integral of force over a short period
   c. the difference of force over a short period
   d. the average of force over a short period
3. A rocket with a lift-off mass 20,000 kg is blasted upwards with an initial acceleration of 5.0 m s-2. Calculate the initial thrust (force) of the blast. **1**
   a. 300000 N
   b. 350000 N
   c. 378000 N
   d. 365000 N
4. A monkey of mass 40 kg climbs on a rope which can stand a maximum tension of 600 N. What is the tension in the rope if the monkey climbs up with an acceleration of 6 m s^{-2} **1**
   a. 740 N
   b. 760 N
   c. 600 N
   d. 640 N
5. Friction is **1**
   a. perpendicular to contact surface and aids motion
   b. perpendicular to contact surface and opposes i motion
   c. parallel to contact surface and opposes the relative motion
   d. parallel to contact surface and aids motion

6. A force of 36 dyne is inclined to the horizontal at an angle of 60°. Find the acceleration it will produce in a mass of 18 g that moves in a horizontal direction. **1**

7. Action and reaction forces do not balance each other. Why? **1**

8. Why does a child feel more pain when she/he falls down on a hard cement floor than when she/he falls on the soft muddy ground in the garden? **1**

9. Define impulse and impulse-momentum theorem. **2**

10. A body of mass 2 kg is being dragged with a uniform velocity of 2 ms^{-1} on a rough horizontal plane. The coefficient of friction between the body and the surface is 0.2. Calculate the amount of heat generated per second. Take g = 9.8 ms^{-2} and J = 4.2 $Jcal^{-1}$. **2**

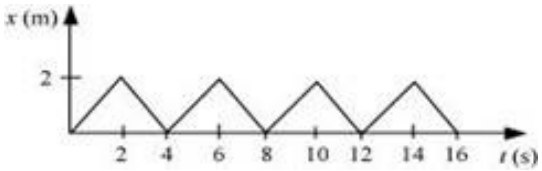
11. A girl riding a bicycle along a straight road at a speed of 5 m s^{-1} throws a stone of mass 0.5 kg which has a speed of 15 ms^{-1} with respect to the ground along with her direction of motion. The mass of the girl and bicycle is 50 kg. Does the speed of the bicycle change after the stone is thrown? What is the change in speed, if so? **2**

12. Show that Newton's third law of motion is contained in the second law. **3**

13. An aircraft executes a horizontal loop at a speed of 720 km/h with its wings banked at 15°. What is the radius of the loop? **3**

14. Obtain an expression for the centripetal force required to make a body of mass m moving with a speed v around a circular path of radius r. **3**

15. Figure shows the position-time graph of a body of mass 0.04 kg. Suggest a suitable physical context for this motion. What is the time between two consecutive impulses received by the body? What is the magnitude of each impulse? **5**



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Answer

1. d. 105 kg

   Explanation: When the lift moves upward with acceleration = 5 ms^{-2} the net force acting upward

   R - mg = ma

   R = mg + ma

   R = m (g + a)

   R = 70 (10 + 5) R = 1050N

   R = 1050 N

   (We experience weight due to reaction)

   therefore Apparent weight $= \frac{1050}{g} = \frac{1050}{10} = 105\ kg$

2. b. the integral of force over a short period

   Explanation: A resultant force causes acceleration and a change in the velocity of the body for as long as it acts.The change in momentum is equal to the product of the average force and duration. Conversely, a small force applied for a long time produces the same change in momentum, the same impulse, as a larger force applied for a short time interval.

   Impulse J is

   $J = F_{\text{average}}(t_2 - t_1)$

   The impulse is the integral of the resultant force (F) with respect to time

   $J = \int_{t_1}^{t_2} F.dt$

3. a. 300000 N

   Explanation: Initial thrust = upthrust required to impart acceleration + uthrust to overcome gravity

   = $ma + mg = m(a + g) = 20000(5 + 10) = 300000\,N$

4. d. 640 N

   Explanation: T - mg = ma

T = mg + ma

T = m (g+a) = 40(10+6) = 640 N

5. c. parallel to contact surface and opposes the relative motion
   Explanation: Whenever a body of mass m moves or tends to move over the surface of another body, then the opposite force acts parallel to the surface contact which opposes the relative motion.

6. Given, F = 36 dyne acts at an angle of 60^{o} with respect to the horizontal,
   ∴ Component of force acting along x-direction is given by
   $F_x = F\cos 60^\circ = 36 \times \frac{1}{2} = 18\text{dyne}$
   Also, $F_x = ma_x$, from second law of motion,
   $a_x = \frac{F_x}{m} = \frac{18}{18} = 1\text{cm/s}^2$

7. Two equal and opposite forces balance each other when they act on the same body or at the same point. Action and reaction do not balance each other because a force of action and reaction acts always on two different bodies.

8. The effect of force F = ma. i.e., if the mass is constant for a system to decrease force, the 'a' should be decreased a $= \frac{v-u}{t}$ initial and final velocity of falling body on a surface are u and zero. so it cannot be changed. If time during hitting is increased, the acceleration decreased and force will decrease.
   On cemented hard floor the time to stop after fall on it is very-very small. But when she/he falls on soft ground of garden she/he sinks in ground and takes more time to stop hence smaller force or pain acts on her/him.

9. Impulse of a force is defined as the product of force and the time for which force is acting. According to impulse-momentum theorem, the impulse of a force in a given time is equal to the total change in momentum of the object during that time.

10. Given, m = 2kg, u = 2 ms^{-1}, μ = 0.2
    Force of friction, F = μR
    F = μmg [since, R = mg]
    F = $0.2 \times 2 \times 9.8$
    F = 3.92 N

Distance moved per second, S = ut

S = $2 \times 1 = 2$

Work done per second, W = F $\times$ S

W = $3.92 \times 2 = 7.84$ J

Heat produced, H = $\frac{W}{J} \Rightarrow$ H = $\frac{7.84}{4.2}$

H = 1.87 cal

11. Girl and cycle Body

$m_1 = 50kg, m_2 = 0.5kg$

$u_1 = 5m/s$forward $u_2 = 5m/s$forward

$v_1 = ?, v_2 = 15\mathrm{m/s}$ forward

According to the law of conservation of momentum.

Initial momentum (Girl, cycle, body)= Final momentum (cycle+Girl) and body

$(m_1 + m_2)\, u_1 = m_1 v_1 + m_2 v_2$

$(50 + 0.5) \times 5 = 50 \times v_1 + 0.5 \times 15$

$50.5 \times 5 - 7.5 = 50 v_1$

$50 v_1 = 252.5 - 7.5 = 245.0$

$v_1 = \frac{245.0}{50} = 4.9\mathrm{m/s}$

Hence, the speed of cycle and girl decreased by 5-4.9 = 0.1 m/s.

12. Let F_{ba} be the force (action) exerted by A on B and $\frac{d\mathbf{p}_B}{dt}$ be the resulting change of the momentum of B.

Let F_{AB} be the force (reaction) exerted by B on A and $\frac{d\mathbf{p}_A}{dt}$ be the resulting change of momentum of A.

According to Newton's second law, F = $\frac{d\mathbf{p}}{dt}$

Then, $\mathrm{F}_{BA} = \frac{d\mathbf{p}_B}{dt}$ and $\mathbf{F}_{AB} = \frac{d\mathbf{p}_A}{dt}$

$\therefore \quad \mathrm{F}_{BA} + \mathrm{F}_{AB} = \frac{d\mathbf{p}_B}{dt} + \frac{d\mathbf{p}_A}{dt} = \frac{d}{dt}(\mathbf{p}_B + \mathbf{p}_A)$ ...(i)

In the absence of any external force, the rate of change of momentum of the whole system zero.

i.e. $\frac{d}{dt}(\mathbf{p}_B + \mathbf{p}_A) = 0$

So, $F_{BA} + F_{AB} = 0$ or $F_{BA} = - F_{AB}$

or Action = - reaction

and it is a Newton's third law of motion.

Hence, proved.

13. Speed of the aircraft, v = 720 km/h = 720 × 5 / 18 = 200 m/s, Acceleration due to gravity, g = 10 m/s^2
    Angle of banking, θ = 15°
    For radius r, of the loop, we have the relation:
    $tan\ \theta = v^2 / rg$
    $r = v^2 / g \tan \theta$
    = 200^2 / (10 × tan 15)
    = 4000 / 0.26
    = 14925.37 m= 14.92 km

14. In order to maintain uniform circular motion of a particle, a force is needed because uniform circular motion is an accelerated motion. The force is known as the centripetal force. Thus, centripetal force is the force required in order to make an object move along a circular path with uniform speed. The force acts along the radius and is directed towards the centre of circular path. The centripetal force F acting on a particle moving uniformly in a circle may depend upon mass (m), velocity (v), and radius (r) of the circle.
    We know that centripetal acceleration of a particle moving with a constant speed v along a circle of radius r is given by:
    $a_c = \frac{v^2}{r}$ .....(1)
    Hence, according to Newton's second law of motion, for a particle of mass m, we have
    The centripetal force F = $ma_c = \frac{mv^2}{r}$ [by using equation (1)]
    As v = rω, where ω is the angular velocity of the particle, then
    F = $\frac{m}{r}(r\omega)^2 = mr\omega^2$
    which is the required expression for the centripetal force.

15. A ball rebounding between two walls located between at x = 0 cm and x = 2 cm; after every 2 s, the ball receives an impulse of magnitude $0.08 \times 10^{-2} \mathrm{kgm/s}$ from the walls
    If we take any one of the triangular portion of the graph, we can see that the position of the ball is increasing uniformly in first 2s and then decreasing at the same rate in

the next 2s. i.e. The ball is coming back to the same position after every 4s. The given graph shows that a body changes its direction of motion after every 2 s. Physically, this situation can be visualized as a ball rebounding to and fro between two stationary walls situated between positions x = 0 cm and x = 2 cm. Since the slope of the x-t graph reverses after every 2 s, the ball collides with a wall after every 2 s. Therefore, ball receives an impulse after every 2 s.

Mass of the ball, m = 0.04 kg

The slope of the graph gives the velocity of the ball. Using the graph (in first 2s), we can calculate initial velocity (u) as:

$u = \frac{(2-0)\times 10^{-2}}{(2-0)} = 10^{-2} m/s$

Velocity of the ball before collision(taking any one of the triangle of the graph and time for the first 2s), u = 10^{-2} m/s

Velocity of the ball after collision(taking the same triangle and time for next 2s), v = -10^{-2} m/s

(Here, the negative sign arises as the ball reverses its direction of motion i.e. the decrease of position of the ball for next 2s.)

Now from the mathematical explanation of Newton's 2nd law of motion, Magnitude of impulse = Change in momentum

= |mv - mu|

= |0.04(v - u)|

= |0.04(-10^{-2} - 10^{-2})|

$= 0.08 \times 10^{-2} \text{kgm/s}$