CBSE Test Paper 05

Chapter 5 Laws of Motion

1. Two bodies of masses 10 kg and 20 kg respectively kept on a smooth, horizontal surface are tied to the ends of a light string. a horizontal force F = 600 N is applied to the 10 kg mass so as to pull it. What is the tension in the string? **1**
    a. 450 N
    b. 300 N
    c. 400 N
    d. 370 N
2. A train runs along an unbanked circular track of radius 30 m at a speed of 54 km/h. The mass of the train is 106 kg. What is the angle of banking required to prevent wearing out of the rail? (g =10m/s^2) **1**
    a. 37^o
    b. 32^o
    c. 27^o
    d. 42^o
3. A truck starts from rest and accelerates uniformly at 2.0 m s^{-2}. At t = 10 s, a stone is dropped by a person standing on the top of the truck (6 m high from the ground). What is the magnitude of velocity (in m s^{-1}) of the stone at t = 11s? (Neglect air resistance.) **1**
    a. 22.4 m/s
    b. 19.6 m/s
    c. 18.5 m/s
    d. 21.0 m/s
4. A man of mass 70 kg stands on a weighing scale in a lift which is moving upwards with a uniform speed of 10 m s^{-1}, what would be the reading on the scale? **1**
    a. 75 kg

b. 70 kg
c. 35 kg
d. 105 kg

5. 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

6. Explain why passengers are thrown forward form their seats when a speeding bus stops suddenly. **1**

7. A car and a truck have the same momentum. Which of the two have greater speed and why? **1**

8. Name the factor on which coefficient of friction depends. **1**

9. A constant retarding force of 50 N is applied to a body of mass 30 kg moving initially with a speed of 18 ms^{-1}. How long does the body take to come to a halt? **2**

10. A nucleus is at rest in the laboratory frame of reference. Show that if it disintegrates into two smaller nuclei the products must move in opposite directions. **2**

11. What is kinetic friction? Is it self-adjusting? **2**

12. A hammer of mass 1 kg strikes on the head of a nail with a velocity of 10 ms^{-1}. It drives the nail 1 cm into a wooden block. Calculate the force applied by the hammer and the time of impact. **3**

13. A pebble of mass 0.05 kg is thrown vertically upwards. Give the direction and magnitude of the net force on the pebble, **3**

   a. during its upward motion,
   b. during its downward motion,
   c. at the highest point where it is momentarily at rest. Do your answers change if the

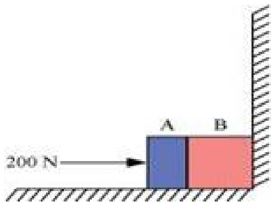
pebble was thrown at an angle of 45° with the horizontal direction? Ignore air resistance.

14. a. State impulse-momentum theorem.
    b. A ball of mass 0.1kg is thrown against a wall. It strikes the wall normally with a velocity of 30m/s and rebounds with a velocity of 20m/s. Calculate the impulse of the force exerted by the ball on the wall. **3**

15. Two bodies A and B of masses 5 kg and 10 kg in contact with each other rest on a table against a rigid wall. The coefficient of static friction, μ_s between the bodies and the table is 0.15. A force of 200 N is applied horizontally to A. What are

    i. the reaction of the partition
    ii. the action-reaction forces between A and B?

    What happens when the wall is removed? Does the answer to (b) change, when the bodies are in motion? Ignore the difference between μ_s and μ_k .(Given, g = 10 m/s^2) **5**



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Answer

1. c. 400 N

   Explanation: Let, T= tension on the string

   a = acceleration, m_1 = mass of light body= 10 kg and m_2= mass of heavy body = 20 kg

   $a=\frac{F}{m_1+m_2}=\frac{600}{30}=20\ ms^{-2}$

   Now the tension in the string will be,

   $T=m_2a=20\times 20=400\,N$

2. a. 37^o

   Explanation: Here,

   r = 30

   v = 54 km/h = 15 m/s

   Angle of banking = θ

   for safe turn $\tan\theta=\frac{v^2}{rg}$

   $\tan\theta=\frac{v^2}{rg}=\frac{(15)^2}{30\times 10}=\frac{15\times 15}{30\times 10}=\frac{3}{4}$

   $\theta=\tan^{-1}\left(\frac{3}{4}\right)=37^\circ$

3. a. 22.4 m/s

   Explanation: During first 10 , the horizontal component of the velocity is v_x = u + at = 0+2x10 = 20 m/s

   From 10 to 11 s, the vertical component of the velocity is v_y=u + gt = 0 + 10x1 = 10m/s

   Relative velocity is,

   $v=\sqrt{v_x^2+v_y^2}$

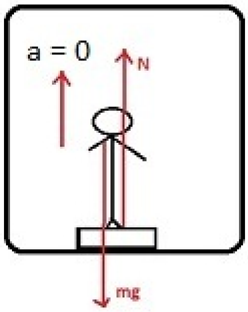
   $=\sqrt{20^2+10^2}$

   $=\sqrt{500}$ = 22.4 m/s

4. b. 70 kg

Explanation: Mass of the man, m = 70 kg

Acceleration, a = 0



Using Newton's second law of motion,

we can write the equation of motion as: R – mg = ma

Where ma is the net force acting on the man.

As the lift is moving at a uniform speed, acceleration a = 0

$\therefore$ R = mg = 70 $\times$ 10 = 700 N

$\therefore$ Reading on the weighing scale = 700 / g = $\frac{700}{10}$ = 70 kg

5. 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

6. This happens solely due to inertia of motion. When the speeding bus stops suddenly, lower part of the body in contact with the seat comes to rest at the very moment. But the upper part of the body of the passengers tends to maintain its uniform motion according to the inertia of motion. Hence the passengers are thrown forward.

7. As we know, Momentum (p) = Mass (m) $\times$ Velocity (v)

   For a given momentum, v $\propto \frac{1}{m}$

   Thus, car will have greater speed because its mass is less than truck.

8. Coefficient of friction $\mu_s = \frac{F}{R}$ depends on the nature of surfaces in contact and nature of motion.

9. Here F = - 50 N, m = 30 kg, u = 18 ms^{-1} and v = 0.

   Acceleration, a = $\frac{F}{m} = \frac{-50}{30} = \frac{-5}{3} ms^{-2}$

   Now from the equation v = u + at, we have, t = $\frac{v-u}{a} = \frac{0-18}{\left(\frac{-5}{3}\right)} = 10.8 \text{ sec}$

10. Let m, m_1, and m_2 be the respective masses of the parent nucleus and the two daughter nuclei. The parent nucleus is at rest.
Initial momentum of the system (parent nucleus) = 0
Let v_1 and v_2 be the respective velocities of the daughter nuclei having masses m_1 and m_2.
Total linear momentum of the system after disintegration = $m_1v_1 + m_2v_2$
According to the law of conservation of momentum:
Total initial momentum = Total final momentum
$0 = m_1v_1 + m_2 + v_2$
$v_1 = \frac{-m_2v_2}{m_1}$
Here, the negative sign indicates that the fragments of the parent nucleus move in directions opposite to each other.

11. Kinetic friction is the force of friction which comes into play between the surfaces of contact of two bodies when one body is in steady motion over the surface of another body. Kinetic friction is not self-adjusting. Rather it has a constant value for a given normal reaction.

12. It is given that the mass of hammer M = 1 kg and hammer strikes the nail with a velocity of 10 ms^{-1} . As mass of nail is extremely small, hence nail also start moving with same velocity.
Thus, for nail u = 10 ms^{-1}, v = 0 and distance covered, s = 1 cm = 0.01 m.
By using the relation $v^2 - u^2 = 2as$, we have
$(0)^2 - (10)^2 = 2 \times a \times (0.01)$
$\Rightarrow a = -\frac{10\times10}{2\times0.01} = -5 \times 10^3 \text{ms}^{-2}$ .... (1)
Now using the relation v = u + at, we obtain
$0 = 10 - 5 \times 10^3 . t$ [by using equation (1)]
$\Rightarrow t = \frac{10}{5\times10^3} = 2 \times 10^{-3}\text{s}$ or 2 ms
Therefore, Force exerted by the hammer on the nail =
$\frac{\Delta p}{\Delta t} = \frac{Mu-0}{\Delta t} = \frac{1\times10}{2\times10^{-3}} = 5 \times 10^3 \text{N}$

13. When an object is thrown vertically upward or it falls vertically downward under gravity then an acceleration g $= 10m/s^{-2}$ acts downward due to the earth's gravitational pull.

Mass of pebble (m) = 0.05 kg

(i) During upward motion

Net force acting on pebble (F) = ma = 0.05 $\times$10 N

= 0.50N (vertically downward)

(ii) During downward motion

Net force acting on pebble (F) = ma = 0.05 $\times$10 N

= 0.50N (vertically downward)

(iii) At the highest point

Net force acting on pebble

(F) = ma = 0.05 $\times$10N

= 0.50 N (vertically downward) If pebble was thrown at an angle of 45° with the horizontal direction then acceleration acting on it and therefore force acting on it will remain unchanged, i.e., 0.50 N (vertically downward). In case , at the highest point the vertical component of velocity will be zero but horizontal component of velocity will not be zero.

14. a. The impulse-momentum theorem states that the change in momentum of an object equals the impulse applied to it Impulse= $m(v-u) = \overline{P}_2 - \overline{P}_1$

    b. m = 0.1kg ,u = 30m/s ,$v = -20m/s$

    Impulse = $\overline{P}_2 - \overline{P}_1 = m(v-u)$

    Impulse = $m(v-u)$

    Impulse = m (-20 – 30) = -5 Ns

15. i. Mass of body A, m_A = 5 kg

    Mass of body B, m_B = 10 kg

    Applied force, F = 200 N

    Coefficient of friction, μ_S = 0.15

    The force of friction acting on the system by the surface of the table, is given by the relation:

    $fs = \mu_s (m_A + m_B) g$

    = 0.15 $\times$ (5 + 10) $\times$ 10

= 1.5 $\times$ 15 = 22.5 N acting leftward

Net force acting on the partition = applied force acting rightward - force of friction acting leftward = 200 - 22.5 = 177.5 N acting rightward

As per Newton's third law of motion, the reaction force of the partition on the system (both A and B) will be in the direction opposite to the net applied force. Hence, the reaction of the partition will be 177.5 N, in the leftward direction.

ii. Force of friction on mass A by the surface of the table:

$f_A = \mu_s m_A g$

= 0.15 $\times$ 5 $\times$ 10 = 7.5 N leftward

Net force exerted by mass A on mass B = Applied force - force of friction on mass A = 200 - 7.5 = 192.5 N, directed rightward.

As per Newton's third law of motion, an equal and opposite reaction force will be exerted by mass B on mass A, i.e., 192.5 N will act leftward.

When the wall is removed and the two bodies start moving the answer to (b) will change. Now, the two bodies will move in the direction of the applied force.

We know that only when the applied force exceeds the static frictional force causes motion. Here, net force acting on the moving system = 177.5 N

Newton's 2nd equation of motion for the system of acceleration a, can be written as:

Net force = (m_A + m_B)a

$$\therefore a = \frac{\text{Net force}}{m_A + m_B}$$

$$= \frac{177.5}{5+10} = \frac{177.5}{15} = 11.83 \mathrm{m/s^2}$$

i.e. both the bodies A and B will start moving with the same acceleration, a = 11.83 m/s^2. Now, net force causing mass A to move:

F_A = m_Aa = 5 $\times$ 11.83 = 59.15 N

Net force exerted by mass A on mass B during their motion = Net force exerted by mass A on B when A is not moving - Net force causing mass A to move = 192.5 - 59.15 = 133.35 N

This force will act in the direction of motion. As per Newton's third law of motion, an equal amount of force will be exerted by mass B on mass A, i.e., 133.3 N, acting opposite to the direction of motion of the two bodies in absence of the wall.