Laws Of Motion **Marks: 30**

ANSWER KEY

Physics

Q.1 C	Q.2 B	Q.3 B	Q.4 A	Q.5 B	Q.6 B	Q.7 B	Q.8 B
Q.9 B	Q.10 B	Q.11 B	Q.12 A	Q.13 C	Q.14 D	Q.15 A	Q.16 C
Q.17 B	Q.18 C	Q.19 C	Q.20 B	Q.21 B	Q.22 C	Q.23 C	Q.24 C
Q.25 B	Q.26 C	Q.27 D	Q.28 C	Q.29 C	Q.30 B		

Physics

Q.1 A block of mass 'm' collides with another stationary block of mass '2m'. The lighter block comes to rest after collision. If the velocity of first block is 'u', then the value of coefficient of restitution is

Correct option: (C)

According to law of conservation of momentum,

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$\therefore$ $mu + 2m \times 0 = m \times 0 + 2m \times v_2$

$\therefore$ $v_2 = \frac{u}{2}$

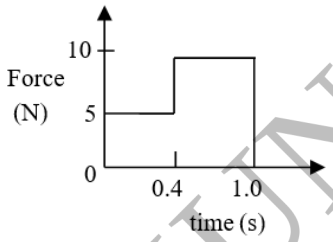
Now, $e = \frac{v_2 - v_1}{u_1 - u_2} = \frac{\frac{u}{2} - 0}{u - 0} = \frac{u/2}{u} = \frac{1}{2} = 0.5$

Q.2 The centre of mass of a body

Correct option: (B)

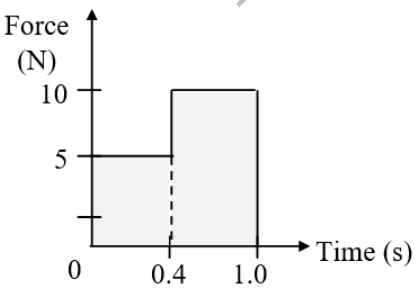
Depends on the distribution of mass in the body.

Q.3 Force is applied to a body of mass 2 kg at rest on a frictionless horizontal surface as shown in the force against time (F – t) graph. The speed of the body after 1 s is



Correct option: (B)

Change in momentum is given by the area under the F – t graph.



Area = 5 × 0.4 + 10 × 0.6

= 2 + 6 = 8 N–s

$\therefore$ mv = 8 N–s

$\therefore$ $v = \frac{8}{2} = 4$ m/s

Q.4 Condition of mechanical equilibrium of a rigid body is

Correct option: (A)

The condition for a rigid body to be in mechanical equilibrium is that the net force and net torque acting on the body must be zero. The net force is represented by $\sum \vec{f}$ and the net torque is represented by $\sum \vec{\tau}$. Thus, the correct option is $\sum \vec{f} = 0$, $\sum \vec{\tau} = 0$; which states that both the net force and torque acting on the body are zero. This ensures that the body is not undergoing linear or rotational acceleration and is in translational and rotational equilibrium.

Q.5 A couple produces

Correct option: (B) purely rotational motion.

Couple consists of two equal and opposite forces which causes pure rotational motion.

Q.6 A stationary body of mass 3 kg explodes into three equal pieces. Two of the pieces fly off at right angles to each other, one with a velocity $2\hat{i}$ m/s and the other with a velocity $3\hat{j}$ m/s. If the explosion takes place in 10^{-5} s, the average force acting on the third piece in newton is

Correct option: (B)

Mass of each piece (m) = 1 kg.

Initial momentum = 0.

Final momentum = $p_1 + p_2 + p_3$.

From the principle of conservation of momentum, we have

$p_1 + p_2 + p_3 = 0$

$p_3 = -(p_1 + p_2)$

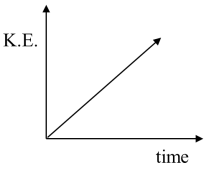
$= -(mv_1 + mv_2) = -m(v_1 + v_2)$

$= -1 \text{ kg} \times (2\hat{i} + 3\hat{j})\text{ m s}^{-1} = -(2\hat{i} + 3\hat{j})\text{ kg m s}^{-1}$

Force $F = \frac{p_3}{t} = \frac{-(2i + 3j)}{10^{-5}}$

$= -(2\hat{i} + 3\hat{j}) \times 10^5$ newton

Q.7 A body moves along a straight line and the variation of its kinetic energy with time is linear as shown in the figure below. Then the force acting on the body is



Correct option: (B)

As, KE is constantly increasing, velocity (v) is also constantly increasing

⇒ acceleration is constant and positive

∴ Force is also constant and greater than zero.

Q.8 A ball weighing 10 g hits a hard surface vertically with a speed of 5 m s^{-1} and rebounds with the same speed. The ball remains in contact with the surface for 0.01 s. The average force exerted by the surface on ball is

Correct option: (B)

Impulse = Ft = change in momentum

= mv – (–mv) = 2 mv = 2 × 0.01 × 5 = 0.1

∴ $F = \frac{0.1}{0.01} = 10$ N

Q.9 Where will be the centre of mass on combining two masses m and M (M > m)?

Correct option: (B)

Centre of mass always lies towards heavier mass.

Q.10 A ball kept at 20 m height falls freely in downward direction vertically and hits the ground. The coefficient of restitution is 0.4. After the first rebound the upward velocity is g = 10 m/s^2

Correct option: (B)

Given, h = 20 m, e = 0.4 m

∴ $v^2 = 0 + 2gh = 2 \times 10 \times 20 = 400$

∴ v = 20 m/s

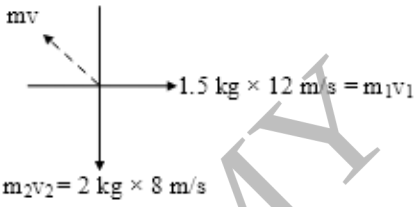
Now, e = $\frac{u}{v}$

∴ u = ev = 0.4 × 20 = 8 m/s

Q.11 An explosion blows a rock into three parts. Two parts go off at right angles to each other. The first part of 1.5 kg is moving with a velocity of 12 m s^{-1} and second part of 2 kg is moving with a velocity 8 m s^{-1}. If the third part flies off with a velocity of 6 m s^{-1}, its mass would be

Correct option: (B) 4 kg

When an explosion breaks a rock, its initial momentum is zero. Hence, according to the law of conservation of momentum, final momentum will be zero.



Total momentum of the two pieces of 1.5 kg and 2 kg

$= \sqrt{18^2 + 16^2} \approx 24$ kg m s^{-1}.

The third piece will have the same momentum but in direction opposite to the resultant of these two momenta.

∴ Momentum of the third piece = 24 kg m s^{-1}

velocity = 6 m s^{-1}.

∴ Mass of the 3rd piece = $\frac{mv}{v} = \frac{24}{6} = 4\ kg$

Q.12 Work is always done on a body when

Correct option: (A)

Work done on a body is defined as the product of the force applied to the body and the displacement of the body in the direction of the force. The formula for work is given by $W = F \cdot d \cdot \cos(\theta)$

where F is the magnitude of the force, d is the magnitude of the displacement, and θ is the angle between the force and displacement vectors. For work to be done, it is essential that a force acts on the body and that the body undergoes a displacement. If there is no displacement, or if the force is perpendicular to the displacement, no work is done. Therefore, work is always done on a body when *a force acts on body to displace it*.

Q.13 A force $\vec{F} = 3\hat{i} + 6\hat{j} + 2\hat{k}$ acting on a particle causes displacement $\vec{S} = -4\hat{i} + x\hat{j} + 3\hat{k}$ in the direction of $\vec{F}$

. If the work done is 12 J, then value of 'x' is

Correct option: (C)

$\vec{F} = 3\hat{i} + 6\hat{j} + 2\hat{k}$

$\vec{S} = -4\hat{i} + x\hat{j} + 3\hat{k}$

Work done, W = $\vec{F} \cdot \vec{S}$

$\therefore$ 12 = –12 + 6x + 6

24 – 6 = 6x

$\therefore$ 6x = 18

$\therefore$ x = 3

Q.14 A particle moves in the x-y plane under the influence of a force such that the linear momentum is $\vec{p}(t)$ = A $\left[\hat{i}\ \cos kt - \hat{j}\ \sin kt\right]$ where, A and k are constants. The angle between force and momentum is [BCECE 2014]

Correct option: (D) 90°

$\vec{p}$ = Acos kt $\hat{i}$ – Asin kt$\hat{j}$

$\therefore$ $\vec{F} = \frac{d\vec{p}}{dt}$ = – Ak sin kt $\hat{i}$ – Ak cos kt$\hat{j}$

Now, to find angle between $\vec{F}$ and $\vec{p}$

$\vec{F} \cdot \vec{p}$ = (–Ak sin kt) (A cos kt) + (–Ak cos kt) (–A sin kt)

$\therefore$ Fpcosθ = A^2 k sin kt (–cos kt + cos kt)

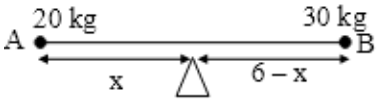
= A^2 k sin kt(0)

$\therefore$ cosθ = 0

$\therefore$ θ = 90°

Q.15 6 m long see-saw remains horizontal when two children weighing 20 kg and 30 kg respectively sit at two ends. Where is the see-saw supported?

Correct option: (A)



20 × x = 30(6 – x)

20x = 180 – 30x

$\therefore$ 50x = 180

$\therefore$ x = 3.6 m from 20 kg

Q.16 What is the amount of work done by a person when (i) he holds a mass of 2 kg for 5 second and (ii) he lifts the same mass through 1 metre to keep it on the top of a table? (g = 9.8 m/s^2)

Correct option: (C)

In the first case, there is no displacement. Hence work done is zero.

In the second case, work done

W = mgh = 2 × 9.8 × 1 = 19.6 J

Q.17 Which of the following statements are incorrect?

(I) Centre of mass of a body always coincides with the centre of gravity of the body.

(II) Centre of mass of a body is the point at which the total gravitational torque on the body is zero.

(III) A couple on a body produce both translational and rotational motion in a body.

(IV) Mechanical advantage greater than one means that small effort can be used to lift a large load.

Correct option: (B)

(I) Centre of mass of a body does not always coincide with the centre of gravity of the body.

(III) A couple on a body produces purely rotational motion.

Hence, (I) and (III) are incorrect.

Q.18 A balloon has 5 g of air. A small hole is pierced into it. The air escapes at a uniform rate with a velocity of 4 cm/s. If the balloon shrinks completely in 2.5 s, then the average force acting on the balloon is

Correct option: (C)

Given: m = 5 g, v = 4 cm/s, t = 2.5 s

we know,

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

and F = ma

$\therefore$ $a = \frac{4}{2.5}$ cm/s^2

$F = 5 \times \frac{4}{2.5} = 8$ dyne

Q.19 If the force applied to a body produces rotational motion in an anticlockwise

sense, the moment of the force is considered as _____.

Correct option: (C)

The moment of a force, also known as torque, is a vector quantity that measures the tendency of a force to rotate an object about an axis. The direction of the moment of force is determined by the right-hand rule. According to this rule, if you curl the fingers of your right hand in the direction of the rotation caused by the force, your thumb will point in the direction of the moment of force. In this case, the force produces an anticlockwise rotation. Following the right-hand rule, your thumb would point outwards, indicating a positive moment of force.

Q.20 A wooden block of mass 'm' moves with velocity 'V' and collides with another block of mass '4m', which is at rest. After collision the block of mass 'm' comes to rest. The coefficient of restitution will be

Correct option: (B)

Given that,

$m_1 = m, u_1 = v, v_1 = 0$

$m_2 = 4\,m, u_2 = 0,$

By law of conservation of momentum we have

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$\therefore \quad mv + 0 = 0 + 4\,m_2v_2$

$\therefore \quad v = 4v_2 \quad$ or $\quad v_2 = \frac{v}{4}$

Coefficient of restitution

$$e = \frac{v_2 - v_1}{u_1 - u_2} = \frac{\frac{v}{4} - 0}{v - 0} = \frac{1}{4}$$

$$= 0.25$$

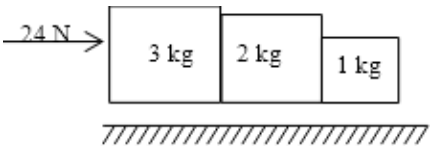
Q.21 A cyclist comes to skidding spot in 10 m. If the opposing force on the cycle due to the road is 200 N. The work done by the road on the cycle is

Correct option: (B)

$W = F \cdot s = Fs \cos 180°$

$= - Fs = -200 \times 10 = -2000$ J

Q.22 Three blocks of mass 3 kg, 2 kg and 1 kg are placed side-by-side on smooth surface as shown in figure. If a horizontal force of 24 N is applied on 3 kg block, then the net force on 2 kg block will be



Correct option: (C)

$a_{net} = \frac{F}{m_1 + m_2 + m_3}$

$a_{net} = \frac{24}{6} = 4$ m/s^2

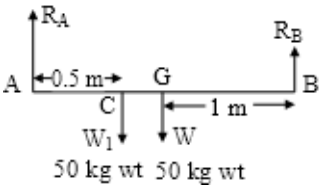
$F_{net} = m\,a_{net}$

$F_{net} = 2 \times 4$

$F_{net} = 8$ N

Q.23 Two men A and B support the ends of a uniform beam 2 m long and weighing 50 kg. A weight of 50 kg hangs from the beam from a point 0.5 m from A. Assuming the bar is horizontal, the load shared by each man is

Correct option: (C)



For equilibrium,

Considering moments about point A,

$R_A \times 0 - W_1 \times AC - W \times AG + R_B \times AB$

$R_A \times 0 - 50 \times 0.5 - 50 \times 1 + R_B \times 2 = 0$

$\therefore \quad 2R_B = 75$

$\therefore \quad R_B = 37.5$ kg wt

$R_A = 100 - 37.5 = 62.5$ kg wt

Q.24 The centre of mass of a system of two particles divides the distance between them

Correct option: (C)

$m_1r_1 = m_2r_2$

$\Rightarrow \frac{r_1}{r_2} = \frac{m_2}{m_1}$

$\therefore \quad r \propto \frac{1}{m}$

Q.25 A body falls on a surface of coefficient of restitution 0.6 from a height of 1 m. Then the body rebounds to a height of

Correct option: (B)

As the body falls from a height

$u = 0$

$v^2 = u^2 + 2gh$

$\therefore \quad v^2 = 2 \times 9.8 \times 1 = 19.6$

$\therefore \quad v = \sqrt{19.6}$m/s

Coefficient of restitution $e = \frac{v}{u}$

$$e = \frac{Velocity\ after\ collision(v_f)}{Velocity\ \ before\ collision(v_b)}$$

$\therefore \quad v_f = e \times v_b$

$v_f = 0.6 \times \sqrt{19.6}$m/s

After the body rebounds,

$v^2 = u^2 - 2gh$

$\Rightarrow u^2 = 2gh$

$\therefore \quad h = u^2/2g$

Here, $u = v_f$

$$\therefore \quad h = \frac{\left(0.6 \times \sqrt{19.6}\right)^2}{2 \times 9.8}$$

$= 0.36$ m

Q.26 A body of mass 2 kg, travelling at 4 m/s makes a head-on collision with a body of mass 1 kg travelling in the opposite direction with a velocity of 2 m/s, the velocities of the two bodies after collision are

Correct option: (C)

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$2 \times 4 - 1 \times 2 = 2v_1 + v_2$

$\therefore \quad 2v_1 + v_2 = 6$

$\therefore \quad v_2 = 6 - 2v_1$

Also $\frac{1}{2}[m_1u_1^2 + m_2u_2^2] = \frac{1}{2}[m_1v_1^2 + m_2v_2^2]$

$\therefore \quad 2 \times (4)^2 + 1 \times (-2)^2 = 2(v_1^2) + (v_2^2)$

$\therefore \quad 32 + 4 = 2v_1^2 + v_2^2$

$\therefore \quad 36 = 2v_1^2 + v_2^2$

$\therefore \quad 2v_1^2 + (6 - 2v_1)^2 = 36$

$\therefore \quad v_1 = 0$ or $v_1 = 4$

When $v_1 = 0$, $v_2 = 6$ and $v_1 = 4$, $v_2 = -2$

$\therefore \quad v_1 = 0$, $v_2 = 6$ m/s

Q.27 A bomb at rest explodes into 3 parts of same mass. The momentum of two parts is $-3P\hat{i}$ and $2P\hat{j}$ respectively. The magnitude of momentum of the third part is

Correct option: (D)

Let, $\vec{P}_A = -3P\hat{i}$ and $\vec{P}_B = 2P\hat{j}$

According to law of conservation of momentum,

$\vec{P}_A + \vec{P}_B + \vec{P}_C = 0$

$\therefore \quad -3P\hat{i} + 2P\hat{j} + \vec{P}_C = 0$

$\therefore \quad \vec{P}_C = 3P\hat{i} - 2P\hat{j}$

$\therefore \quad |P_C| = \sqrt{9P^2 + 4P^2} = \sqrt{13}P$

Q.28 One metallic sphere is at rest. Another metallic sphere hits the first and comes to rest and second sphere moves. The ratio of their masses is

Correct option: (C)

$$v_1 = \frac{m_1 - m_2}{m_1 + m_2}u_1 + \frac{2m_2}{m_1 + m_2}u_2$$

$$\therefore \quad 0 = \frac{(m_1 - m_2)u_1}{m_1 + m_2} \ (\because u_2 = 0)$$

$\Rightarrow m_1 - m_2 = 0$

$\therefore \quad m_1 = m_2$

$\therefore \quad \frac{m_1}{m_2} = 1$

Q.29 A force $F_y = (3x + 2)$ N is acting on a body. The work done by this force if it tends to displace the body from $x = 0$ m to $x = 4$ m will be

Correct option: (C)

Displacement is in x direction and force is in y – direction,

$\therefore$ Force is perpendicular to displacement, hence work done will be zero.

Q.30 A mass of 10 kg is suspended from a rope wound on a wheel of diameter 40 cm. The torque about the axis of rotation is

Correct option: (B)

r = $\frac{d}{2}$ = 20 cm = 0.2 m,

$\vec{\tau} = \vec{r} \times \vec{F}$ = rF sin θ

In this case, motion of wheel is perpendicular to the axis of rotation. Hence, θ = 90°

∴ τ = rF = 0.2 × 10 × 9.8 = 19.6 N m