PART (A): PHYSICS

SECTION I: (SINGLE CHOICE QUESTIONS)

This section contains **30 multiple choice questions.** Each question has four choices (1), (2), (3) and (4) out of which **ONLY ONE is correct**

1. The angle between the two vectors $\vec{A} = 3\hat{i} + 4\hat{j} + 5\hat{k}$ and $\vec{B} = 3\hat{i} + 4\hat{j} - 5\hat{k}$ will be

(1) 90° (2) 0° (3) 60° (4) 45°

1. **(1)**

$$\cos\theta = \frac{\vec{A}.\vec{B}}{|A||B|} = \frac{(3\hat{i}+4\hat{j}+5\hat{k})(3\hat{i}+4\hat{j}-5\hat{k})}{\sqrt{9+16+25}\sqrt{9+16+25}}$$

$$= \frac{9+16-25}{50} = 0$$

$\Rightarrow \cos\theta = 0$

$\therefore \theta = 90°$

2. What vector must be added to the two vectors $\hat{i} - 2\hat{j} + 2\hat{k}$ and $2\hat{i} + \hat{j} - \hat{k}$, so that the resultant may be a unit vector along x-axis

(1) $2\hat{i} + \hat{j} - \hat{k}$ (2) $-2\hat{i} + \hat{j} - \hat{k}$ (3) $2\hat{i} - \hat{j} + \hat{k}$ (4) $-2\hat{i} - \hat{j} - \hat{k}$

2. **(2)**

$(\hat{i} - 2\hat{j} + 2\hat{k}) + (2\hat{i} + \hat{j} - \hat{k}) + \vec{R} = i$

$\therefore$ Required vector $\vec{R} = -2\hat{i} + \hat{j} - \hat{k}$

3. Temperature can be expressed as a derived quantity in terms of any of the following

(1) Length and mass (2) Mass and time
(3) Length, mass and time (4) None of these

3. **(4)**

Because temperature is a fundamental quantity.

4. The frequency of vibration f of a mass m suspended from a spring of spring constant K is given by a relation of this type $f = C m^x K^y$; where C is a dimensionless quantity. The value of x and y are

(1) $x = \frac{1}{2}, y = \frac{1}{2}$ (2) $x = -\frac{1}{2}, y = -\frac{1}{2}$ (3) $x = \frac{1}{2}, y = -\frac{1}{2}$ (4) $x = -\frac{1}{2}, y = \frac{1}{2}$

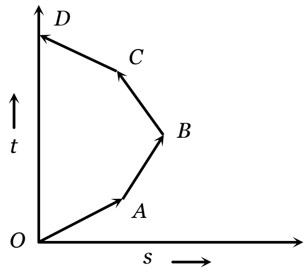
4. **(4)**

By putting the dimensions of each quantity both the sides we get $[T^{-1}] = [M]^x [MT^{-2}]^y$

Now comparing the dimensions of quantities on both sides we get $x + y = 0$ and $2y = 1$

$\therefore x = -\frac{1}{2}, y = \frac{1}{2}$

5. Which of the following options is correct for the object having a straight line motion represented by the following graph?



(1) The object moves with constantly increasing velocity from O to A and then it moves with constant velocity.
(2) Velocity of the object increases uniformly
(3) Average velocity is zero
(4) The graph shown is impossible

5. **(3)**
From given figure, it is clear that the net displacement is zero.
So average velocity will be zero.

6. The position of a particle moving in the *xy*-plane at any time t is given by $x = (3t^2 - 6t)$ metres, $y = (t^2 - 2t)$ metres. Select the correct statement about the moving particle from the following
(1) The acceleration of the particle is zero at $t = 0$ second
(2) The velocity of the particle is zero at $t = 0$ second
(3) The velocity of the particle is zero at $t = 1$ second
(4) The velocity and acceleration of the particle are never zero

6. **(3)**
$$v_x = \frac{dx}{dt} = \frac{d}{dt}(3t^2 - 6t) = 6t - 6$$
At $t = 1, v_x = 0$
$$v_y = \frac{dy}{dt} = \frac{d}{dt}(t^2 - 2t) = 2t - 2$$
At $t = 1, v_y = 0$
Hence $v = \sqrt{v_x^2 + v_y^2} = 0$

7. Speed of two identical cars are u and $4u$ at a specific instant. The ratio of the respective distances in which the two cars are stopped from that instant is (Assume same retardation for both the cars)
(1) 1 : 1 (2) 1 : 4 (3) 1 : 8 (4) 1 : 16

7. **(4)**
$$S \propto u^2 \Rightarrow \frac{S_1}{S_2} = \left(\frac{1}{4}\right)^2 = \frac{1}{16}$$

8. A boat moves with a speed of 5 km/h relative to water in a river flowing with a speed of 3 km/h and having a width of 1 km. The minimum time taken around a round trip is
(1) 5 min (2) 60 min (3) 20 min (4) 30 min

8. **(4)**
For the round trip he should cross perpendicular to the river
$\therefore$ Time for trip to that side $= \dfrac{1km}{4km/hr} = 0.25hr$
To come back, again he take 0.25 hr to cross the river.

Total time is 30 min, he goes to the other bank and come back at the same point.

9. An object is projected vertically upwards with a velocity of 100m/s. It will strike the ground after (approximately)

(1) 10 sec (2) 20 sec (3) 15 sec (4) 5 sec

9. **(2)**

Time of flight $= \frac{2u}{g} = \frac{2\times 100}{10} = 20\ sec$

10. If a freely falling body travels in the last second a distance equal to the distance travelled by it in the first three seconds, the time of the travel is

(1) 6 sec (2) 5 sec (3) 4 sec (4) 3 sec

10. **(2)**

The distance traveled in last second.

$S_{\text{Last}} = u + \frac{g}{2}(2t-1) = \frac{1}{2}\times 9.8(2t-1) = 4.9(2t-1)$

and distance traveled in first three second,

$S_{\text{Three}} = 0 + \frac{1}{2}\times 9.8\times 9 = 44.1\,m$

According to problem $S_{\text{Last}} = S_{\text{Three}}$

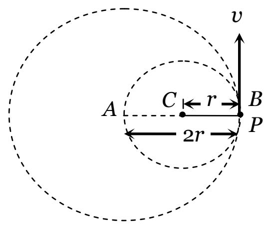
$\Rightarrow 4.9(2t-1) = 44.1 \Rightarrow 2t-1 = 9 \Rightarrow t = 5\,\text{sec}$.

11. A particle P is moving in a circle of radius $'a'$ with a uniform speed v. C is the centre of the circle and AB is a diameter. When passing through B the angular velocity of P about A and C are in the ratio

(1) 1 : 1 (2) 1 : 2 (3) 2 : 1 (4) 4 : 1

11. **(2)**

Angular velocity of particle *P* about point *A*,



$\omega_A = \frac{v}{r_{AB}} = \frac{v}{2r}$

Angular velocity of particle *P* about point *C*,

$\omega_C = \frac{v}{r_{BC}} = \frac{v}{r}$

Ratio $\frac{\omega_A}{\omega_C} = \frac{v/2r}{v/r} = \frac{1}{2}$.

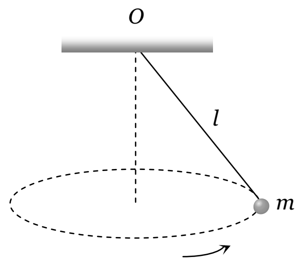
12. The angular speed of a fly wheel making 120 revolutions/minute is

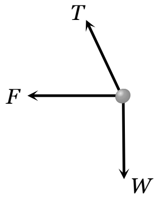
(1) $2\pi\ rad/s$ (2) $4\pi^2\ rad/s$ (3) $\pi\ rad/s$ (4) $4\pi\ rad/s$

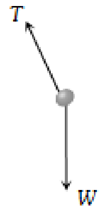
12. **(4)**

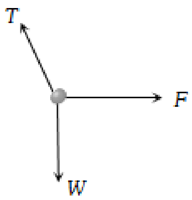
$120\,rev/\min = 120\times\frac{2\pi}{60}\,rad/\sec = 4\pi\,rad/\sec$

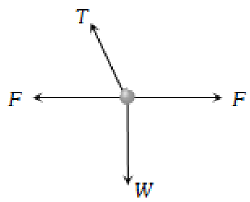
13. A point mass m is suspended from a light thread of length *l*, fixed at *O*, is whirled in a horizontal circle at constant speed as shown. From your point of view, stationary with respect to the mass, the forces on the mass are



(1) 

(2) 

(3) 

(4) 

(T = tension, W = weight and F = centrifugal force)

13. **(3)**

T = tension, W = weight and F = centrifugal force.

14. A body of mass 0.5 kg is projected under gravity with a speed of 98 m/s at an angle of 30^o with the horizontal. The change in momentum (in magnitude) of the body when it strikes the ground is (during the complete journey)

(1) $24.5\,N-s$ (2) $49.0\,N-s$ (3) $98.0\,N-s$ (4) $50.0\,N-s$

14. **(2)**

Change in momentum $= 2mu\sin\theta$

$= 2\times 0.5\times 98\times \sin 30 = 49 N\text{-}s$

15. A particle reaches its highest point when it has covered exactly one half of its horizontal range. The corresponding point on the displacement time graph is characterised by (Assume upwards to be positive and downwards to be negative)

(1) Negative slope and zero curvature (2) Zero slope and negative curvature

(3) Zero slope and positive curvature (4) Positive slope and zero curvature

15. **(2)**

16. A stone projected with a velocity u at an angle θ with the horizontal reaches maximum height H_1. When it is projected with velocity u at an angle $\left(\frac{\pi}{2}-\theta\right)$ with the horizontal, it reaches maximum height H_2. The relation between the horizontal range R of the projectile, H_1 and H_2 is

(1) $R = 4\sqrt{H_1 H_2}$ (2) $R = 4(H_1 - H_2)$ (3) $R = 4(H_1 + H_2)$ (4) $R = \frac{H_1^2}{H_2^2}$

16. **(1)**

$$H_1 = \frac{u^2\sin^2\theta}{2g} \text{ and } H_2 = \frac{u^2\sin^2(90-\theta)}{2g} = \frac{u^2\cos^2\theta}{2g}$$

$$H_1H_2 = \frac{u^2\sin^2\theta}{2g}\times\frac{u^2\cos^2\theta}{2g} = \frac{(u^2\sin 2\theta)^2}{16g^2} = \frac{R^2}{16}$$

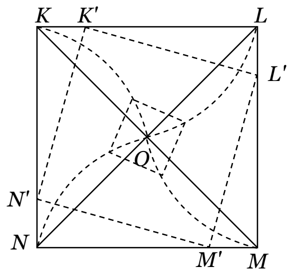
$\therefore\ R = 4\sqrt{H_1H_2}$

17. Four persons K, L, M and N are initially at the corners of a square of side d. If every person starts moving with velocity v, such that K is always headed towards L, L towards M, M is headed directly towards N and N towards K, then the four persons will meet after

(1) $\frac{d}{v}$ (2) $\frac{\sqrt{2}d}{v}$ (3) $\frac{d}{\sqrt{2}v}$ (4) $\frac{d}{2v}$

17. **(1)**

It is obvious from considerations of symmetry that at any moment of time all of the persons will be at the corners of square whose side gradually decreases (see fig.) and so they will finally meet at the centre of the square *O*.



The speed of each person along the line joining his initial position and *O* will be $v\cos 45 = v/\sqrt{2}$.

As each person has displacement $d\cos 45 = d/\sqrt{2}$ to reach the centre, the four persons will meet at the centre of the square *O* after time.

$$\therefore\ t = \frac{d/\sqrt{2}}{v/\sqrt{2}} = \frac{d}{v}$$

18. A force of 100 dynes acts on mass of 5 gm for 10 sec. The velocity produced is

(1) 2 cm/sec (2) 20 cm/sec (3) 200 cm/sec (4) 2000 cm/sec

18. **(3)**

Acceleration $a = \frac{F}{m} = \frac{100}{5} = 20\ cm/s^2$

Now $v = at = 20\times 10 = 200\,cm/s$

19. A hemispherical bowl of radius R is rotated about its axis of symmetry which is kept vertical. A small block is kept in the bowl at a position where the radius makes an angle θ with the vertical. The block rotates with the bowl without any slipping. The friction coefficient between the block and the bowl surface is μ. Find the maximum angular speed for which the block will not slip.

(1) $\left[\frac{g(\sin\theta+\mu\cos\theta)}{R\sin\theta(\cos\theta-\mu\sin\theta)}\right]^{\frac{1}{2}}$ (2) $\left[\frac{g(\sin\theta-\mu\cos\theta)}{R(\cos\theta+\mu\sin\theta)}\right]^{\frac{1}{2}}$

(3) $\left[\frac{g(\sin\theta+\mu\cos\theta)}{R(\cos\theta-\mu\sin\theta)}\right]^{\frac{1}{2}}$ (4) None of these

19. **(1)**

20. A particle of mass 0.3 kg is subjected to a force $F = -kx$ with $k = 15\,N/m.$ What will be its initial acceleration if it is released from a point 20 cm away from the origin

(1) 5 m/s^2 (2) 10 m/s^2 (3) 3 m/s^2 (4) 15 m/s^2

20. **(2)**

Force on particle at 20 cm away $F = kx$

F = 15 × 0.2 = 3 N $\left[\text{As } k = 15\,N/m\right]$

$\therefore$ Acceleration = $\dfrac{\text{Force}}{\text{Mass}} = \dfrac{3}{0.3} = 10\,m/s^2$

21. A lift accelerated downward with acceleration 'a'. A man in the lift throws a ball upward with acceleration $a_0 (a_0 < a)$. Then acceleration of ball observed by observer, which is on earth, is

(1) $(a + a_0)$ upward (2) $(a - a_0)$ upward

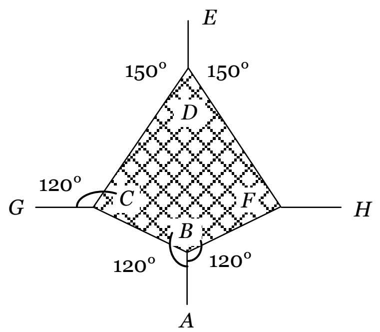
(3) $(a + a_0)$ downward (4) $(a - a_0)$ downward

21. **(4)**

The effective acceleration of ball observed by observer on earth = $(a - a_0)$

As $a_0 < a,$ hence net acceleration is in downward direction.

22. The adjacent figure is the part of a horizontally stretched net. Section *AB* is stretched with a force of 10 N. The tensions in the sections *BC* and *BF* are



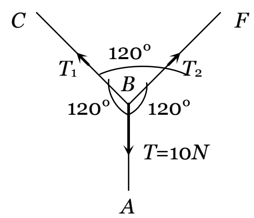
(1) 10 N, 11 N (2) 10 N, 6 N

(3) 10 N, 10 N (4) Can't calculate due to insufficient data

22. **(3)**

By drawing the free body diagram of point *B*

Let the tension in the section *BC* and *BF* are T_1 and T_2 respectively.

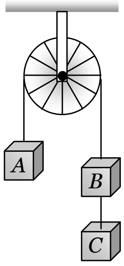


From Lami's theorem

$$\frac{T_1}{\sin 120°} = \frac{T_2}{\sin 120°} = \frac{T}{\sin 120°}$$

$\Rightarrow T = T_1 = T_2 = 10\ N.$

23. Three equal weights *A*, *B* and *C* of mass 2 kg each are hanging on a string passing over a fixed frictionless pulley as shown in the figure. The tension in the string connecting weights *B* and *C* is (g = 9.8 m/sec^2)



(1) Zero (2) 13 N (3) 3.3 N (4) 19.6 N

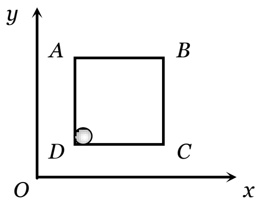
23. **(2)**

Tension between m_2 and m_3 is given by

$$T = \frac{2m_1m_3}{m_1+m_2+m_3} \times g$$

$$= \frac{2\times2\times2}{2+2+2}\times 9.8 = 13 \text{ N}$$

24. A solid sphere of mass 2 kg is resting inside a cube as shown in the figure. The cube is moving with a velocity $v = (5t\,\hat{i} + 2t\,\hat{j})m/s$. Here t is the time in second. All surfaces are smooth. The sphere is at rest with respect to the cube. What is the total force exerted by the sphere on the cube. (Consider g = 10 m/s^2 along negative y-axis)



(1) $\sqrt{29}$ N (2) 29 N (3) 26 N (4) $\sqrt{89}$ N

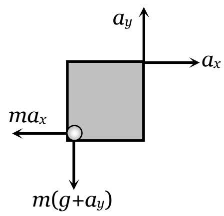
24. **(3)**

As $\vec{v} = 5t\,\hat{i} + 2t\,\hat{j}$

$\therefore\ \vec{a} = a_x\hat{i} + a_y\hat{j} = 5\hat{i} + 2\hat{j}$

$\vec{F} = ma_x\hat{i} + m(g+a_y)\hat{j}$

$\therefore\ |\vec{F}| = m\sqrt{a_x^2 + (g+a_y)^2} = 26\ N$



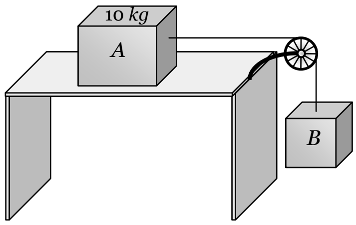
25. A block of 1 kg is stopped against a wall by applying a force F perpendicular to the wall. If $\mu = 0.2$ then minimum value of F will be (g = 9.8 m/sec^2)

(1) 980 N (2) 49 N (3) 98 N (4) 490 N

25. **(2)**

$$F = \frac{W}{\mu} = \frac{1\times 9.8}{0.2} = 49N$$

26. If mass of $A = 10\ kg$, coefficient of static friction = 0.2, coefficient of kinetic friction = 0.2. Then minimum mass of B to start motion is



(1) 2 kg (2) 2.2 kg (3) 4.8 kg (4) 200 gm

26. (1)

$$\mu_s = \frac{m_B}{m_A} \Rightarrow 0.2 = \frac{m_B}{10} \Rightarrow m_B = 2\ kg$$

27. A car turns at a corner on a slippery road at a constant speed of 10 m/s. If the coefficient of friction is 0.5, the minimum radius of the arc in meters in which the car turns is (g = 10 m/sec^2)

(1) 20 (2) 10 (3) 5 (4) 4

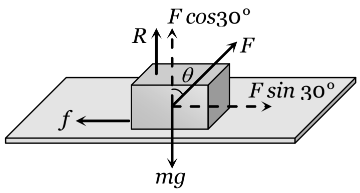
27. (1)

$$v = \sqrt{\mu\ g\ r} \Rightarrow r = \frac{v^2}{\mu g} = \frac{100}{0.5\times 10} = 20$$

28. A block of mass 50 kg can slide on a rough horizontal surface. The coefficient of friction between the block and the surface is 0.6. The least force of pull acting at an angle of 30° to the upward drawn vertical which causes the block to just slide is (g = 10 m/sec^2)

(1) 29.43 N (2) 219.6 N (3) 21.96 N (4) 294.3 N

28. (4)



For limiting condition $f = \mu R$

$F \sin 30° = \mu(mg - F\cos 30°)$, By solving $F = 294.3\ N$

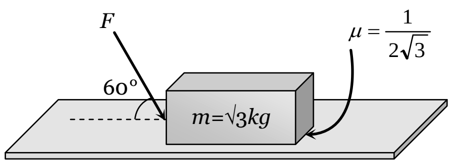
29. A given object takes *n* times as much time to slide down a 45° rough incline as it takes to slide down a perfectly smooth 45° incline. The coefficient of kinetic friction between the object and the incline is given by

(1) $\left(1-\frac{1}{n^2}\right)$ (2) $\frac{1}{1-n^2}$ (3) $\sqrt{\left(1-\frac{1}{n^2}\right)}$ (4) $\sqrt{\frac{1}{1-n^2}}$

29. (1)

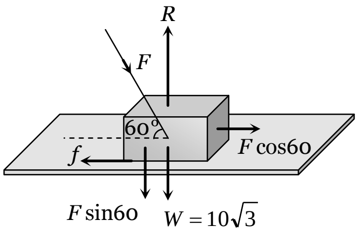
$$\mu = \tan\theta\left(1-\frac{1}{n^2}\right) = 1-\frac{1}{n^2} \qquad [\text{As } \theta = 45°]$$

30. What is the maximum value of the force F such that the block shown in the arrangement, does not move? (g = 10 m/sec^2)



(1) 20 N (2) 10 N (3) 12 N (4) 15 N

30. **(1)**



$f = \mu R$

$F\cos 60° = \mu(W + F\sin 60°)$

Substituting $\mu = \dfrac{1}{2\sqrt{3}}$ & $W = 10\sqrt{3}$ we get $F = 20N$