Exercise-1

ONLY ONE OPTION CORRECT TYPE

SECTION (A) : KINEMATICS OF CIRCULAR MOTION

1. Two racing cars of masses m_1 and m_2 are moving in circles of radii r_1 and r_2 respectively; their speeds are such that they each make a complete circle in the same time t. The ratio of the angular speed of the first to the second car is :

(1) $m_1 : m_2$ (2) $r_1 : r_2$ (3) 1 : 1 (4) $m_1r_1 : m_2r_2$

2. A wheel is at rest. Its angular velocity increases uniformly and becomes 80 radian per second after 5 second. The total angular displacement is :

(1) 800 rad (2) 400 rad (3) 200 rad (4) 100 rad

3. When a particle moves in a circle with a uniform speed

(1) its velocity and acceleration are both constant
(2) its velocity is constant but the acceleration changes
(3) its acceleration is constant but the velocity changes
(4) its velocity and acceleration both change

4. The relation between an angular velocity, the position vector and linear velocity of a particle moving in a circular path is.

(1) $\vec{\omega} \times \vec{r} = \vec{v}$ (2) $\vec{\omega}.\vec{r} = \vec{v}$ (3) $\vec{r} \times \vec{\omega} = \vec{v}$ (4) $\vec{\omega}\vec{r} = \vec{v}$

5. A wheel is of diameter 1m. If it makes 30 revolutions/sec., then the linear speed of a point on its circumference will be.

(1) 30π m/s (2) π m/s (3) 60π m/s (4) $\pi/2$ m/s

6. In uniform circular motion

(1) Both the angular velocity and the angular momentum vary
(2) The angular velocity varies but the angular momentum remains constant.
(3) Both the angular velocity and the angular momentum stay constant
(4) The angular momentum varies but the angular velocity remains constant.

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

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

8. The angular velocity of the second's needle in watch is-

(1) $\frac{\pi}{30}$ (2) 2π (3) π (4) $\frac{60}{\pi}$

9. The average acceleration vector for a particle having a uniform circular motion is-

(1) A constant vector of magnitude $\frac{\upsilon^2}{r}$
(2) A vector of magnitude $\frac{\upsilon^2}{r}$ directed normal to the plane of the given uniform circular motion.
(3) Equal to the instantaneous acceleration vector at the start of the motion.
(4) A null vector.

10. Angular velocity of minute hand of a clock is :

(1) $\frac{\pi}{30}$ rad/s (2) π rad/s (3) 2π rad/s (4) $\frac{\pi}{1800}$ rad/s

11. The second's hand of a watch has length 6 cm. Speed of end point and magnitude of difference of velocities at two perpendicular positions will be :

(1) 2π & 0 mm/s (2) $2\sqrt{2}\pi$ & 4.44 mm/s
(3) $2\sqrt{2}\pi$ & 2π mm/s (4) 2π & $2\sqrt{2}\pi$ mm/s

12. An aeroplane revolves in a circle above the surface of the earth at a fixed height with speed 100 km/hr. The change in velocity after completing 1/2 revolution will be.
(1) 200 km/hr (2) 150 km/hr (3) 300 km/hr (4) 400 km/hr

13. A particle moving on a circular path travels first one third part of circumference in 2 sec & next one third part in 1 sec. Average angular velocity of the particle is (in rad/sec) -
(1) $\frac{2\pi}{3}$ (2) $\frac{\pi}{3}$ (3) $\frac{4\pi}{9}$ (4) $\frac{5\pi}{3}$

14. A grind-stone starts revolving from rest, if its angular acceleration is 4.0 rad/sec^2 (uniform) then after 4 sec.What is its angular displacement & angular velocity respectively -
(1) 32 rad, 16 rad/sec (2) 16 rad, 32 rad/sec (3) 64 rad, 32 rad/sec (4) 32 rad, 64 rad/sec

15. Angular displacement of any particle is given $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$ where ω_0 & α are constant if ω_0 = 1 rad/sec, α = 1.5 rad/sec^2 then in t = 2 sec. angular velocity will be (in rad/sec)
(1) 1 (2) 5 (3) 3 (4) 4

16. A particle of mass M is revolving along a circle of radius R and another particle of mass m is revolving in a circle of radius r. If time periods of both particles are same, then the ratio of their angular velocities is :
(1) 1 (2) $\frac{R}{r}$ (3) $\frac{r}{R}$ (4) $\sqrt{\frac{R}{r}}$

17. In a uniform circular motion
(1) Velocity and acceleration remain constant
(2) Kinetic energy remains constant
(3) Speed and acceleration changes
(4) Only velocity changes, acceleration remain constant

18. Which of the following statements is false for a particle moving in a circle with a constant angular speed?

(1) The velocity vector is tangent to the circle
(2) The acceleration vector is tangent to the circle
(3) The acceleration vector point to the center of the circle
(4) The velocity and acceleration vectors are perpendicular to each other

19. A particle is acted upon by a force of constant magnitude which is always perpendicular to the velocity of the particle. The motion of the particle takes place in a plane, it follows that
(1) its velocity is constant (2) its acceleration is constant
(3) its kinetic energy is constant (4) it moves in a straight line

20. A wheel is subjected to uniform angular acceleration about its axis. Initially its angular velocity is zero. In the first 2 sec, it rotates through an angle θ_1. In the next 2 sec, it rotates through an additional angle θ_2.
The ratio of $\frac{\theta_2}{\theta_1}$ is
(1) 1 (2) 2 (3) 3 (4) 5

21. If the equation for the displacement of a particle moving on a circular path is given by $(\theta) = 2t^3 + 0.5$, where θ is in radians and t in seconds, then the angular velocity of the particle after 2 sec from its start is
(1) 8 rad/sec (2) 12 rad/sec (3) 24 rad/sec (4) 36 rad/sec

22. For a particle in a non-uniform accelerated circular motion
(1) Velocity is radial and acceleration is transverse only
(2) Velocity is transverse and acceleration is radial only

(3) Velocity is radial and acceleration has both radial and transverse components
(4) Velocity is transverse and acceleration has both radial and transverse components

SECTION (B) : RADIAL AND TANGENTIAL ACCELERATION

1. Two particles P and Q are located at distances r_P and r_Q respectively from the axis of a rotating disc such that $r_P > r_Q$:
(1) Both P and Q have the same acceleration (2) Both P and Q do not have any acceleration
(3) P has greater acceleration than Q (4) Q has greater acceleration than P

2. Let a_r and a_t represent radial and tangential acceleration. The motion of a particle may be circular if :
(1) $a_r = 0, a_t = 0$ (2) $a_r = 0, a_t \neq 0$ (3) $a_r \neq 0, a_t = 0$ (4) none of these

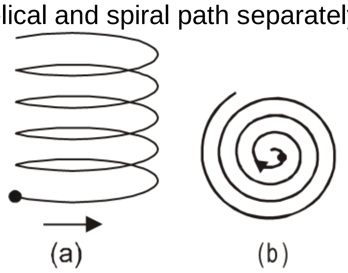
3. A stone tied to one end of string 80 cm long is whirled in a horizontal circle with a constant speed. If stone makes 25 revolutions in 14 sec, the magnitude of acceleration of stone is :
(1) 850 cm/s^2 (2) 996 cm/s^2 (3) 720 cm/s^2 (4) 650 cm/s^2

4. A body is moving in a circular path with acceleration a. If its velocity gets doubled, find the ratio of acceleration after and before the change :
(1) 1 : 4 (2) 4: 1 (3) 2 : 1 (4) 2 : 1

5. A spaceman in training is rotated in a seat at the end of a horizontal arm of length 5m. If he can withstand acceleration upto 9 g then what is the maximum number of revolutions per second permissible ? (Take g = 10 m/s^2)
(1) 13.5 rev/s (2) 1.35 rev/s (3) 0.675 rev/s (4) 6.75 rev/s

6. A particle of mass m is moving in an uniform circular motion. The momentum of the particle is
(1) Constant over the entire path
(2) Constantly changes and direction of change is along the tangent
(3) Constantly chages and direction of chage is along the radial direction
(4) Constantly chages and direction of change is along a direction which is the instantaneous vector sum of the radial and tangential direction

7. A particle is going in a uniform helical and spiral path separately as shown in figure with constant speed.



(1) The velocity of the particle is constant in both cases
(2) The acceleration of the particle is constant in both cases
(3) The magnitude of accleration is constant in (a) and decreasing in (b)
(4) The magnitude of accleration is decreasing continuously in both the cases

8. A car is travelling with linear velocity v on a circular road of radius r. If the speed is increasing at the rate of 'a' metre/sec^2, then the resultant acceleration will be -
(1) $\sqrt{\left[\frac{v^2}{r^2} - a^2\right]}$ (2) $\sqrt{\left[\frac{v^4}{r^2} + a^2\right]}$ (3) $\sqrt{\left[\frac{v^4}{r^2} - a^2\right]}$ (4) $\sqrt{\left[\frac{v^2}{r^2} + a^2\right]}$

9. If mass, speed & radius of rotation of a body moving on a circular path are increased by 50% then to keep the body moving in circular path increase in force required will be -
(1) 225% (2) 125% (3) 150% (4) 100%

10. A motor cycle driver doubles its velocity when he is having a turn. The force exerted outwardly will be.
(1) Double (2) Half (3) 4 times (4) 1/4 times

11. For a particle in circular motion the centripetal acceleration is
(1) Less than its tangential acceleration
(2) Equal to its tangential acceleration

(3) More than its tangential acceleration
(4) May be more or less than its tangential acceleration

12. If the radii of circular paths of two particles of same masses are in the ratio of 1 : 2, then in order to have same centripetal force, their speeds should be in the ratio of :
(1) 1 : 4 (2) 4 : 1 (3) 1 : $\sqrt{2}$ (4) $\sqrt{2}$: 1

13. On horizontal smooth surface a mass of 2 kg is whirled in a horizontal circle by means of a string at an initial angular speed of 5 revolutions per minute. Keeping the radius constant the tension in the string is doubled. The new angular speed is nearly:
(1) 14 rpm (2) 10 rpm (3) 2.25 rpm (4) 7 rpm

14. If a_r and a_t represent radial and tangential accelerations, the motion of a particle will be uniformly circular if
(1) $a_r = 0$ and $a_t = 0$ (2) $a_r = 0$ but $a_t \neq 0$ (3) $a_r \neq 0$ but $a_t = 0$ (4) $a_r \neq 0$ and $a_t \neq 0$

SECTION (C) : CIRCULAR MOTION IN HORIZONTAL PLANE

1. A string breaks if its tension exceeds 10 newtons. A stone of mass 250 gm tied to this string of length 10 cm is rotated in a horizontal circle. The maximum angular velocity of rotation can be.
(1) 20 rad/s (2) 40 rad/s (3) 100 rad/s (4) 200 rad/s

2. A particle moving along a circular path due to a centripetal force having constant magnitude is an example of motion with :
(1) constant speed and velocity (2) variable speed and velocity
(3) variable speed and constant velocity (4) constant speed and variable velocity.

3. A stone of mass 0.5 kg tied with a string of length 1 metre is moving in a circular path with a speed of 4 m/sec. The tension acting on the string in newton is -
(1) 2 (2) 8 (3) 0.2 (4) 0.8

4. The formula for centripetal acceleration in a circular motion is.
(1) $\vec{\alpha} \times \vec{r}$ (2) $\vec{\omega} \times \vec{v}$ (3) $\vec{\alpha} \times \vec{v}$ (4) $\vec{\omega} \times \vec{r}$

5. A stone is moved round a horizontal circle with a 20 cm long string tied to it. If centripetal acceleration is 9.8 m/sec$_2$, then its angular velocity will be
(1) 7 rad/s (2) 22/7 rad/s (3) 49 rad/s (4) 14 rad/s

6. A particle of mass m is executing a uniform motion along a circular path of radius r. If the magnitude of its linear momentum is p, the radial force acting on the particle will be.
(1) pmr (2) rm/p (3) mp^2/r (4) p^2/mr

7. A particle moves in a circular orbit under the action of a central attractive force inversely proportional to the distance 'r'. The speed of the particle is.
(1) Proportional to r^2 (2) Independent of r (3) Proportional to r (4) Proportional to 1/r

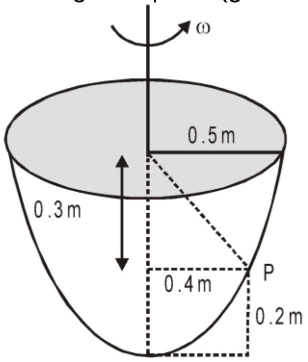
8. A particle of mass m is moving in a horizontal circle of radius r under a centripetal force equal to $-k/r_2$. The total kinetic energy of the particle is-
(1) –k/r (2) k/r (3) k/2r (4) –k/2r

9. A 500 kg car takes around turn of radius 50 m with a speed of 36 km/hr. The centripetal force acting on the car will be :
(1) 1200 N (2) 1000 N (3) 750 N (4) 250 N

10. If the radii of circular paths of two particles of same masses are in the ratio of 1 : 2, then in order to have same centripetal force, their speeds should be in the ratio of :
(1) 1 : 4 (2) 4 : 1 (3) 1 : $\sqrt{2}$ (4) $\sqrt{2}$: 1

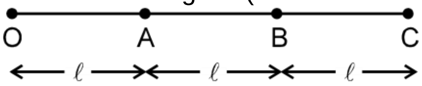
11. A particle is moving in a horizontal circle with constant speed. It has constant
(1) Velocity (2) Acceleration (3) Kinetic energy (4) Displacement

12. A particle P will be equilibrium inside a hemispherical bowl of radius 0.5 m at a height 0.2 m from the bottom when the bowl is rotated at an angular speed (g = 10 m/sec^2)-



(1) $10/\sqrt{3}$ rad / sec (2) $10\sqrt{3}$ rad / sec (3) 10 rad/sec (4) $\sqrt{20}$ rad / sec

13. Three identical particles are joined together by a thread as shown in figure. All the three particles are moving on a smooth horizontal plane about point O. If the speed of the outermost particle is v_0, then the ratio of tensions in the three sections of the string is : (Assume that the string remains straight)



(1) 3 : 5 : 7 (2) 3 : 4 : 5 (3) 7 : 11 : 6 (4) 3 : 5 : 6

14. A heavy & big sphere is hang with a string of length ℓ, this sphere moves in a horizontal circular path making an angle θ with vertical then its time period is -

(1) $T = 2\pi\sqrt{\frac{\ell}{g}}$ (2) $T = 2\pi\sqrt{\frac{\ell \sin\theta}{g}}$ (3) $T = 2\pi\sqrt{\frac{\ell \cos\theta}{g}}$ (4) $T = 2\pi\sqrt{\frac{\ell}{g\cos\theta}}$

15. A gramophone recorder rotates at angular velocity of ω a coin is kept at a distance r from its centre. If μ is static friction constant then coil will rotate with gramophone if -

(1) $r > \mu g > \omega^2$ (2) $r = \mu g/\omega^2$ only (3) $r < \mu g/\omega^2$ (4) $r \le \mu g/\omega^2$

16. A train A runs from east to west and another train B of the same mass runs from west to east at the same speed along the equator. A presses the track with a force F_1 and B presses the track with a force F_2.

(1) $F_1 > F_2$
(2) $F_1 < F_2$
(3) $F_1 = F_2$
(4) the information is insufficient to find the relation between F_1 and F_2.

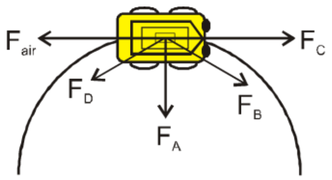
17. A cyclist is moving on a circular track of radius 80 m with a velocity of 72 km/hr. He has to lean from the vertical approximately through an angle -

(1) $\tan^{-1}(1/4)$ (2) $\tan^{-1}(1)$ (3) $\tan^{-1}(1/2)$ (4) $\tan^{-1}(2)$

18. A car of mass m is taking a circular turn of radius 'r' on a fictional level road with a speed v. In order that the car does not skid -

(1) $\frac{mv^2}{r} \ge \mu mg$ (2) $\frac{mv^2}{r} \le \mu mg$ (3) $\frac{mv^2}{r} = \mu mg$ (4) $\frac{v}{r} = \mu mg$

19. A car travels with constant speed on a circular road on level ground. In the figure shown, F_{air} is the force of air resistance on the car. Which of the other forces best represents the horizontal force of the road on the car's tires ?



(1) F_A (2) F_B (3) F_C (4) F_D

20. The driver of a car travelling at full speed suddenly sees a wall at a distance r directly in front of him. To avoid collision,

(1) he should apply brakes sharply
(2) he should turn the car sharply
(3) he should apply brakes and then sharply turn
(4) None of these

21. A mass is supported on a frictionless horizontal surface. It is attached to a string and rotates about a fixed centre at an angular velocity ω_0. If the length of the string and angular velocity are doubled, the tension in the string which was initially T_0 is now -

(1) T_0 (2) $T_0/2$ (3) $4T_0$ (4) $8T_0$

22. Two masses M and m are attached to a vertical axis by weightless threads of combined length ℓ. They are set in rotational motion in a horizontal plane about this axis with constant angular velocity ω. If the tensions in the threads are the same during motion, the distance of M from the axis is.

(1) $\frac{M\ell}{M+m}$ (2) $\frac{m\ell}{M+m}$ (3) $\frac{M+m}{M}\ell$ (4) $\frac{M+m}{m}\ell$

23. A stone tied to the end of a string of 1 m long is whirled in a horizontal circle with a constant speed. If the stone makes 22 revolutions in 44 s, what is the magnitude and direction of acceleration of the stone?

(1) $\frac{\pi^2}{4}$ ms^{-2} and direction along the radius towards the centre
(2) $\pi^2 ms^{-2}$ and direction along the radius away from centre
(3) $\pi^2 ms^{-2}$ and direction along the radius towards the centre
(4) $\pi^2 ms^{-2}$ and direction along the tangent to the circle

24. The maximum velocity (in ms^{-1}) with which a car driver can traverse a flat curve of radius 150 m and cofficient of friction 0.6 to avoid skidding is :

(1) 60 (2) 30 (3) 15 (4) 25

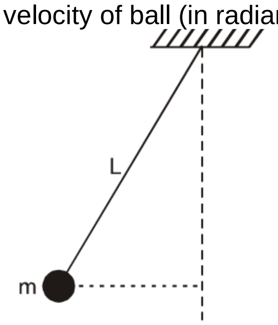
25. A cylindrical vessel partially filled with water is rotated about its vertical central axis. It's surface will

(1) Rise equally (2) Rise from the sides (3) Rise from the middle (4) Lowered equally

26. A long horizontal rod has a bead which can slide along its length and is initially placed at a distance L from one end A of the rod. The rod is set in angular motion about A with a constant angular acceleration, α . If the coefficient of friction between the rod and the bead is μ, and gravity is neglected, then the time after which the bead starts slipping is-

(1) $\sqrt{\frac{\mu}{\alpha}}$ (2) $\frac{\mu}{\sqrt{\alpha}}$ (3) $\frac{1}{\sqrt{\mu\alpha}}$ (4) Infinitesimal

27. A ball of mass (m) 0.5 kg is attached to the end of a string having length (L) 0.5 m. The ball is rotated on a horizontal circular path about vertical axis. The maximum tension that the string can bear is 324 N. The maximum possible value of angular velocity of ball (in radian/s) is :



(1) 9 (2) 18 (3) 27 (4) 36

SECTION (D) : RADIUS OF CURVATURE

1. A particle of mass m is moving with constant velocity $\vec{v}$ on smooth horizontal surface. A constant force $\vec{F}$ starts acting on particle perpendicular to velocity v. Radius of curvature after force F start acting is :

(1) $\frac{mv^2}{F}$ (2) $\frac{mv^2}{F\cos\theta}$ (3) $\frac{mv^2}{F\sin\theta}$ (4) none of these

2. A stone is projected with speed u and angle of projection is θ. Find radius of curvature at t = 0.

(1) $\frac{u^2\cos^2\theta}{g}$ (2) $\frac{u^2}{g\sin\theta}$ (3) $\frac{u^2}{g\cos\theta}$ (4) $\frac{u^2\sin^2\theta}{g}$

3. The velocity and acceleration vectors of a particle undergoing circular motion are $\vec{v} = 2\hat{i}$ m/s and $\vec{a} = 2\hat{i} + 4\hat{j}$ m/s^2 respectively at an instant of time. The radius of the circle is
(1) 1m (2) 2m (3) 3m (4) 4m

4. A particle is projected horizontally from the top of a tower with a velocity v_0. If v be its velocity at any instant, then the radius of curvature of the path of the particle at that instant is directly proportional to:
(1) v^3 (2) v^2 (3) v (4) 1/v

SECTION (E) : CIRCULAR MOTION IN VERTICAL PLANE

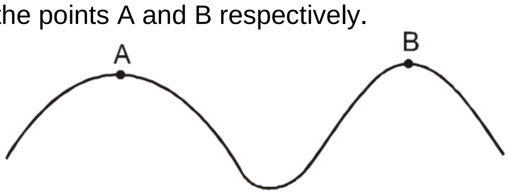
1. The tension in the string revolving in a vertical circle with a mass m at the end when it is at the lowest position.
(1) $\frac{mv^2}{r}$ (2) $\frac{mv^2}{r} - mg$ (3) $\frac{mv^2}{r} + mg$ (4) mg

2. A motorcycle is going on an overbridge of radius R. The driver maintains a constant speed. As the motorcycle is ascending on the overbridge, the normal force on it :
(1) increase (2) decreases
(3) remains constant (4) first increases then decreases.

3. In a circus, stuntman rides a motorbike in a circular track of radius R in the vertical plane. The minimum speed at highest point of track will be :
(1) $\sqrt{2gR}$ (2) 2gR (3) $\sqrt{3gR}$ (4) $\sqrt{gR}$

4. A particle is moving in a vertical circle. The tensions in the string when passing through two positions at angles 30° and 60° from vertical (lowest positions) are T_1 and T_2 respectively. Then
(1) $T_1 = T_2$ (2) $T_2 > T_1$
(3) $T_1 > T_2$ (4) Tension in the string always remains the same

5. A car moves at a constant speed on a road as shown in figure. The normal force by the road on the car is N_A and N_B when it is at the points A and B respectively.



(1) $N_A = N_B$ (2) $N_A > N_B$ (3) $N_A < N_B$ (4) insufficient

6. A heavy mass is attached to a thin wire and is whirled in a vertical circle. The wire is most likely to break.
(1) When the mass is at the height point of the circle
(2) When the mass is at the lowest point of the circle
(3) When the wire is horizontal
(4) At an angle of $\cos^{-1}$ (1/3) from the upward vertical

7. A hollow sphere has radius 6.4 m. Minimum velocity required by a motor cyclist at bottom to complete the circle will be.
(1) 17.7 m/s (2) 10.2 m/s (3) 12.4 m/s (4) 16.0 m/s

8. A body of mass 100 g is rotating in a circular path of radius r with constant speed. The work done in one complete revolution is.
(1) 100 rJ (2) (r/100) J (3) (100/r) J (4) Zero "

9. A weightless thread can bear tension upto 3.7 kg wt. A stone of mass 500 gms is tied to it and revolved in a circular path of radius 4 m in a vertical plane. If g = 10 ms^{-2}, then the maximum angular velocity of the stone will be.
(1) 4 radians/sec (2) 16 radians/sec (3) $\sqrt{21}$ radians/sec (4) 2 radians/sec

10. A small disc is on the top of a hemisphere of radius R. What is the smallest horizontal velocity v that should be given to the disc for it to leave the hemisphere and not slide down it ? [There is no friction]

(1) $v = \sqrt{2gR}$ (2) $v = \sqrt{gR}$ (3) $v = \frac{g}{R}$ (4) $v = \sqrt{g^2R}$

11. The maximum velocity at the lowest point, so that the string just slack at the highest point in a vertical circle of radius ℓ.

(1) $\sqrt{g\ell}$ (2) $\sqrt{3g\ell}$ (3) $\sqrt{5g\ell}$ (4) $\sqrt{7g\ell}$

12. A simple pendulum oscillates in a vertical plane. When it passes through the mean position, the tension in the string is 3 times the weight of the pendulum bob. What is the maximum displacement of the pendulum of the string with respect to the vertical.

(1) 30° (2) 45° (3) 60° (4) 90°

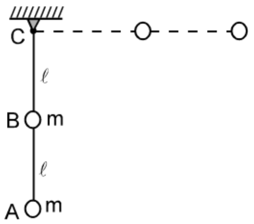
13. A coin placed on a rotating turntable just slips if it is placed at a distance of 4 cm from the centre. If the angular velocity of the turntable is doubled, it will just slip at a distance of

(1) 1 cm (2) 2 cm (3) 4 cm (4) 8 cm

14. A cane filled with water is revolved in a vertical circle of radius 4 meter and the water just does not fall down. The time period of revolution will be-

(1) 1 sec (2) 10 sec (3) 8 sec (4) 4 sec

15. A weightless rod of length 2ℓ carries two equal masses 'm', one tied at lower end A and the other at the middle of the rod at B. The rod can rotate in vertical plane about a fixed horizontal axis passing through C. The rod is released from rest in horizontal position. The speed of the mass B at the instant rod, become vertical is :

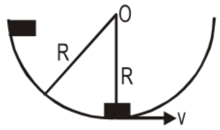


(1) $\sqrt{\frac{3g\ell}{5}}$ (2) $\sqrt{\frac{4g\ell}{5}}$ (3) $\sqrt{\frac{6g\ell}{5}}$ (4) $\sqrt{\frac{7g\ell}{5}}$

16. A body is suspended from a smooth horizontal nail by a string of length 0.25 metre. What minimum horizontal velocity should be given to it in the lowest position so that it may move in a complete vertical circle with the nail at the centre ?

(1) 3.5 ms^{-1} (2) 4.9 ms^{-1} (3) $7\sqrt{2}$ ms^{-1} (4) $\sqrt{9.8}$ ms^{-1}

17. A block of mass m slides down along the surface of the bowl from the rim to the bottom as shown in fig. The velocity of the block at the bottom will be -

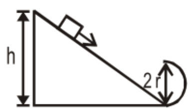


(1) $\sqrt{\pi Rg}$ (2) $2\sqrt{\pi Rg}$ (3) $\sqrt{2Rg}$ (4) $\sqrt{gR}$

18. A mass m is revolving in a vertical circle at the end of a string of length 20 cm. By how much times does the tension of the string at the lowest point exceed the tension at the topmost point -

(1) 2 mg (2) 4 mg (3) 6 mg (4) 8 mg

19. A block follows the path as shown in the figure from height h. If radius of circular path is r, then relation holds good to complete full circle is.



(1) h < 5r/2 (2) h > 5r/2 (3) h = 5r/2 (4) h ≥ 5r/2

20. A particle is kept at rest at the top of a sphere of diameter 42 m. When disturbed slightly, it slides down. At what height 'h' from the bottom, the particle will leave the sphere.

(1) 14 m (2) 28 m (3) 35 m (4) 7 m

21. A stone of 1 kg tied up with 10/3 metre long string rotated in a vertical circle. If the ratio of maximum & minimum tension in string is 4 then speed of stone at heighest point of circular path will be - (g = 10 m/s^2)

(1) 20 m/s (2) $10\sqrt{3}$ m/s (3) $5\sqrt{2}$ m/s (4) 10 m/s

22. A child is swinging a swing, Minimum and maximum heights of swing from earth's surface are 0.75 m and 2 m respectively. The maximum velocity of this swing is :

(1) 5 m/s (2) 10 m/s (3) 15 m/s (4) 20 m/s

23. A stone is tied to a string of length ℓ and is whirled in a vertical circle with the other end of the string as the centre. At a certain instant of time, the stone is at its lowest position and has a speed u. The magnitude of the change in velocity as it reaches a position where the string is horizontal (g being acceleration due to gravity) is :

(1) $\sqrt{2\left(u^2 - g\ell\right)}$ (2) $\sqrt{\left(u^2 - g\ell\right)}$ (3) $u - \sqrt{\left(u^2 - 2g\ell\right)}$ (4) $\sqrt{2g\ell}$

24. In a circus, stuntman rides a motorbike in a circular track of radius R in the vertical plane. The minimum speed at highest point of track will be :

(1) $\sqrt{2gR}$ (2) 2gR (3) $\sqrt{3gR}$ (4) $\sqrt{gR}$

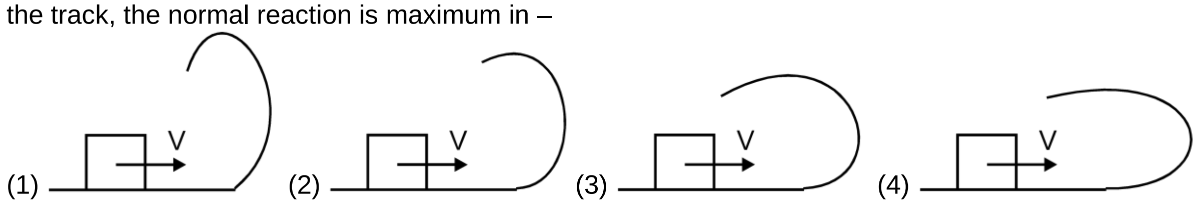
25. A particle of mass m begins to slide down a fixed smooth sphere from the top. What is its tangential acceleration when it breaks off the sphere ?

(1) $\frac{2g}{3}$ (2) $\frac{\sqrt{5}g}{3}$ (3) g (4) $\frac{g}{3}$

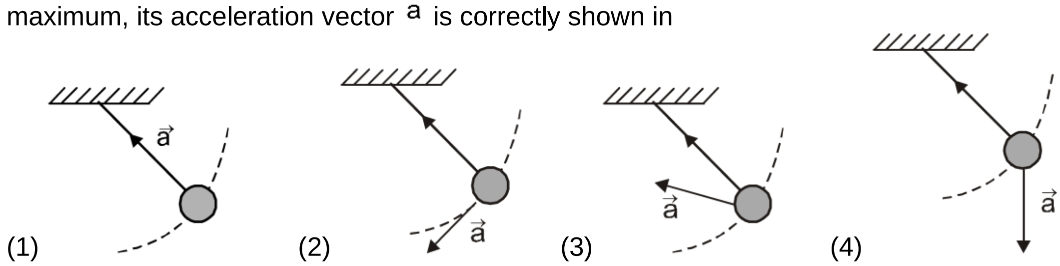
26. A body of mass 1 kg is moving in a vertical circular path of radius 1m. The difference between the kinetic energies at its highest and lowest position is

(1) 20J (2) 10J (3) $4\sqrt{5}$J (4) $10\left(\sqrt{5}-1\right)$J

27. A small block is shot into each of the four tracks as shown below. Each of the tracks rises to the same height. The speed with which the block enters the track is the same in all cases. At the highest point of the track, the normal reaction is maximum in –



28. A simple pendulum is oscillating without damping. When the displacements of the bob is less than maximum, its acceleration vector $\vec{a}$ is correctly shown in



SECTION (F) : MOTION OF A VEHICLE, CENTRIFUGAL FORCE AND ROTATION OF EARTH

1. A car moving on a horizontal road may be thrown out of the road in taking a turn :

(1) By the gravitational force (2) Due to lack of sufficient centripetal force
(3) Due to friction between road and the tyre (4) Due to reaction of earth

2. The magnitude of the centripetal force acting on a body of mass m executing uniform motion in a circle of radius r with speed υ is-

(1) $m\upsilon r$ (2) $\frac{m\upsilon^2}{r}$ (3) $\frac{\upsilon}{r^2 m}$ (4) $\frac{\upsilon}{rm}$

3. Radius of the curved road on national highway is R. Width of the road is b. The outer edge of the road is raised by h with respect to inner edge so that a car with velocity υ can pass safe over it. The value of h is-

(1) $\frac{\upsilon^2 b}{Rg}$ (2) $\frac{\upsilon}{Rgb}$ (3) $\frac{\upsilon^2 R}{g}$ (4) $\frac{\upsilon^2 b}{R}$

4. If the apparent weight of the bodies at the equator is to be zero, then the earth should rotate with angular velocity

(1) $\sqrt{\frac{g}{R}}$ rad/sec (2) $\sqrt{\frac{2g}{R}}$ rad/sec (3) $\sqrt{\frac{g}{2R}}$ rad/sec (4) $\sqrt{\frac{3g}{2R}}$ rad/sec

5. A road is 10 m wide. Its radius of curvature is 50 m. The outer edge is above the lower edge by a distance of 1.5 m. This road is most suited for the velocity

(1) 2.5 m/sec (2) 4.5 m/sec (3) 6.5 m/sec (4) 8.5 m/sec

6. Radius of the curved road on national highway is R. Width of the road is b. The outer edge of the road is raised by h with respect to inner edge so that a car with velocity v can pass safe over it. The value of h is

(1) $\frac{v^2 b}{Rg}$ (2) $\frac{v}{Rgb}$ (3) $\frac{v^2 R}{g}$ (4) $\frac{v^2 b}{R}$

7. A circular road of radius 1000 m has banking angle 45º. The maximum safe speed of a car having mass 2000 kg will be, if the coefficient of friction between tyre and road is 0.5

(1) 172 m/s (2) 124 m/s (3) 99 m/s (4) 86 m/s

8. A cane filled with water is revolved in a vertical circle of radius 4 meter and the water just does not fall down. The time period of revolution will be

(1) 1 sec (2) 10 sec (3) 8 sec (4) 4 sec

9. A motor cyclist moving with a velocity of 72 km/hour on a flat road takes a turn on the road at a point where the radius of curvature of the road is 20 meters. The acceleration due to gravity is 10 m/sec^2. In order to avoid skidding, he must not bend with respect to the vertical plane by an angle greater than-

(1) $\theta = \tan^{-1} 6$ (2) $\theta = \tan^{-1} 2$ (3) $\theta = \tan^{-1} 25.92$ (4) $\theta = \tan^{-1} 4$

Exercise-2

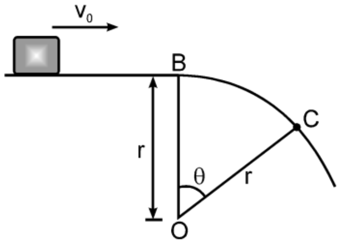
1. The kinetic energy k of a particle moving along a circle of radius R depends on the distance covered s as $k = as^2$ where a is a constant. The force acting on the particle is

(1) $2a\frac{s^2}{R}$ (2) $2as\left(1+\frac{s^2}{R^2}\right)^{1/2}$ (3) 2as (4) $2a\frac{R^2}{s}$

2. A particle of mass m is moving in a circular path of constant radius r such that its centripetal acceleration a_c is varying with time t as $a_c = k^2rt^2$ where k is a constant. The power delivered to the particle by the force acting on it is-

(1) $2\pi mk^2 r^2$ (2) $mk^2 r^2 t$ (3) $\frac{(mk^4r^2t^5)}{3}$ (4) Zero

3. A small block slides with velocity $0.5\sqrt{gr}$ on the horizontal frictionless surface as shown in the Figure. The block leaves the surface at point C. The angle θ in the Figure is :



(1) $\cos^{-1}(4/9)$ (2) $\cos^{-1}(3/4)$ (3) $\cos^{-1}(1/2)$ (4) none of the above

4. A particle moves along a circle of radius $\left(\frac{20}{\pi}\right)$ m with constant tangential acceleration. If the speed of the particle is 80 m/s at the end of the second revolution after motion has begun, the tangential acceleration is:
(1) $160\,\pi$ m/s^2 (2) $40\,\pi$ m/s^2 (3) 40 m/s^2 (4) $640\,\pi$ m/s^2

5. Centrifugal force is an inertial force when considered by -
(1) An observer at the centre of circular motion
(2) An outside observer
(3) An observer who is moving with the particle which is experiencing the force
(4) none of the above

6. A rod of length L is pivoted at one end and is rotated with a uniform angular velocity in a horizontal plane . Let T_1 and T_2 be the tensions at the points L/4 and 3L/4 away from the pivoted ends.
(1) $T_1 > T_2$
(2) $T_2 > T_1$
(3) $T_1 = T_2$
(4) The relation between T_1 and T_2 depends on whether the rod rotates clockwise or anticlockwise

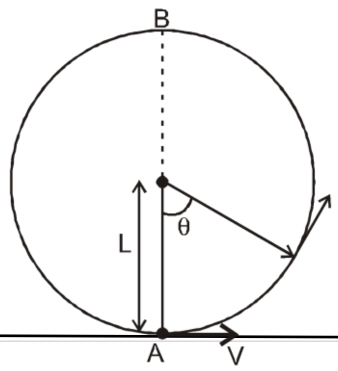
7. When a ceiling fan is switched off its angular velocity reduces to 50% while it makes 36 rotations. How many more rotation will it make before coming to rest (Assume uniform angular retardation)
(1) 18 (2) 12 (3) 36 (4) 48

8. A particle is moving in the vertical plane. It is attached at one end of a string of length ℓ whose other end is fixed. The velocity at the lowest point is u. The tension in the string $\vec{T}$ is and acceleration of the particle $\vec{a}$ is at any position. Then, $\vec{T}\cdot\vec{a}$ is zero at the highest point:
(1) only if $u \le \sqrt{2g\ell}$ (2) if $u = \sqrt{5g\ell}$ (3) only if $u = \sqrt{2g\ell}$ (4) only if $u > \sqrt{2g\ell}$

9. In the above question, $\vec{T}\cdot\vec{a}$ is non-negative at the lowest point for:
(1) $u \le \sqrt{2g\ell}$ (2) $u = \sqrt{2g\ell}$ (3) $u < \sqrt{2g\ell}$ (4) any value of u

10. In the above question, $\vec{T}\cdot\vec{u}$ is zero for:
(1) $u \le \sqrt{2g\ell}$ (2) $u = \sqrt{2g\ell}$ (3) $u \ge \sqrt{2g\ell}$ (4) any value of u

11. A bob of mass M is suspended by a massless string of length L. The horizontal velocity V at position A is just sufficient to make it reach the point B. The angle θ at which the speed of the bob is half of that at A, satisfies



(1) $\theta = \frac{\pi}{4}$ (2) $\frac{\pi}{4} < \theta < \frac{\pi}{2}$

(3) $\frac{\pi}{2} < \theta < \frac{3\pi}{4}$ (4) $\frac{3\pi}{4} < \theta < \pi$

12. If a particle of mass m is moving in a horizontal circle of radius r with a centripetal force $\left(-\frac{K}{r^2}\right)$, the total energy is-

(1) $-\frac{K}{2r}$ (2) $-\frac{K}{r}$ (3) $-\frac{2K}{r}$ (4) $-\frac{4K}{r}$

Exercise-3

PART - I : NEET / AIMPT QUESTION (PREVIOUS YEARS)

1. A particle moves in a circle of radius 5 cm with constant speed and time period 0.2 πs. The acceleraiton of the particle is : **[AIPMT-2011]**

(1) 15 m/s^2 (2) 25 m/s^2 (3) 36 m/s^2 (4) 5 m/s^2

2. A car of mass 1000 kg negotiates a banked curve of radius 90 m on a frictionless road. If the banking angle is 45º, the speed of the car is : **[AIPMT_Pre_2012]**

(1) 20 ms$_{-1}$ (2) 30 ms$_{-1}$ (3) 5 ms$_{-1}$ (4) 10 ms$_{-1}$

3. A car of mass m is moving on a level circular track of radius R. If μ_s represents the static friction between the road and tyres of the car, the maximum speed of the car in circular motion is given by : **[AIPMT 2012 (Mains)]**

(1) $\sqrt{\mu_s mRg}$ (2) $\sqrt{Rg/\mu_s}$ (3) $\sqrt{mRg/\mu_s}$ (4) $\sqrt{\mu_s Rg}$

4. Two stones of masses m and 2 m are whirled in horizontal circles the heavier one in radius $\frac{r}{2}$ and the lighter one in radius r. The tangential speed of lighter stone is n times that of the value of heavier stone when they experience same centripetal forces. The value of n is : **[AIPMT _ HZ_2015]**

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

5. The position vector of a particle $\vec{R}$ as a function of time is given by:

$\vec{R}$ = 4sin(2πt) $\hat{i}$ + 4cos(2πt) **[AIPMT_2015]**

Where R is in meters, t is seconds and $\hat{i}$ and $\hat{j}$ denote unit vectors along x-and y-directions, respectively. Which one of the following statements is wrong for the motion of particle?

(1) Magnitude of acceleration vector is $\frac{v^2}{R}$, where v is the velocity of particle

(2) Magnitude of the velocity of particle is 8 meter/second

(3) path of the particle is a circle of radius 4 meter.

(4) Acceleration vector is along - $\vec{R}$

6. What is the minimum velocity with which a body of mass m must enter a vertical loop of radius R so that it can complete the loop ? **[AIPMT_2016]**

(1) $\sqrt{5gR}$ (2) $\sqrt{gR}$ (3) $\sqrt{2gR}$ (4) $\sqrt{3gR}$

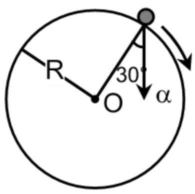
7. A particle of mass 10 g moves along a circle of radius 6.4 cm with a constant tangential acceleration. What is the magnitude of this acceleration if the kinetic energy of the particle becomes equal to 8×10^{-4} J by the end of the second revolution after the beginning of the motion ? **[AIPMT_2016]**

(1) 0.2 m/s^2 (2) 0.1 m/s^2 (3) 0.15 m/s^2 (4) 0.18 m/s^2

8. A car is negotiating a curved road of radius R. The road is banked at an angle θ. The coefficient of friction between the tyres of the care and the road is μ_s. The maximum safe velocity on this road is: **[AIPMT_2016]**

(1) $\sqrt{\frac{g}{R^2}\frac{\mu_s+\tan\theta}{1-\mu_s+\tan\theta}}$ (2) $\sqrt{gR^2\frac{\mu_s+\tan\theta}{1-\mu_s+\tan\theta}}$ (3) $\sqrt{gR\frac{\mu_s+\tan\theta}{1-\mu_s+\tan\theta}}$ (4) $\sqrt{\frac{g}{R}\frac{\mu_s+\tan\theta}{1-\mu_s+\tan\theta}}$

9. In the given figure, a = 15 m/s^2 represents the total acceleration of a particle moving in the clockwise direction in a circle of radius R = 2.5 m at a given instant of time. The speed of the particle is **[NEET 2016]**

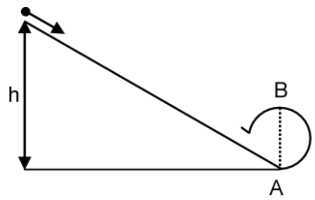


(1) 6.2 m/s (2) 4.5 m/s (3) 5.0 m/s (4) 5.7 m/s

10. One end of string of length ℓ is connected to a particle of mass 'm' and the other end is connected to a small peg on a smooth horizontal table. If the particle moves in circle with speed 'v' the net force on the particle (directed towards center) will be (T represents the tension in the string) **[NEET 2017]**

(1) T (2) T + $\frac{mv^2}{\ell}$ (3) T – $\frac{mv^2}{\ell}$ (4) zero

11. A body initially at rest and sliding along a frictionless track from a height h (as shown in the figure) Just-completes a vertical circle of diameter AB = D. The height h is equal to **[NEET 2018]**



(1) $\frac{3}{2}D$ (2) $\frac{5}{4}D$ (3) $\frac{7}{5}D$ (4) D

12. A mass m is attached to a thin wire and whirled in a vertical circle. The wire is most likely to break when: **[NEET_2019-I]**

(1) inclined at a angle of 60º from vertical (2) the mass is at the highest point
(2) the wire is horizontal (4) the mass is at the lowest point

13. A block of mass 10 kg in contact against the inner wall of a hollow cylindrical drum of radius 1m. The coefficient of friction between the block and the inner wall of the cylinder is 0.1. The minimum angular velocity needed for the cylinder to keep the block stationary when the cylinder is vertical and rotating about its axis, will be (g = 10 m/s²) **[NEET-2019-I]**

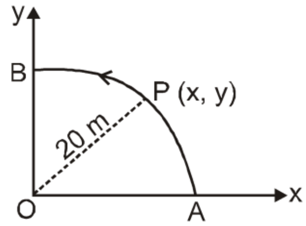
(1) 10π rad/s (2) $\sqrt{10}$ rad/s (3) $\frac{10}{2\pi}$ rad/s (4) 10 rad/s

14. A particle starting from rest, moves in a circle of radius 'r'. It attains a velocity of V_0 m/s in the n^{th} round. Its angular acceleration will be: **[NEET_2019-II]**

(1) $\frac{V_o}{n}$ rad/s² (2) $\frac{V_o^2}{2\pi nr^2}$ rad/s² (3) $\frac{V_o^2}{4\pi nr^2}$ rad/s² (4) $\frac{V_o^2}{4\pi nr}$ rad/s²

PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

1. A po1nt P moves in counter-clockwise direction on a circular path as shown in the figure. The movement of 'P' is such that it sweeps out a length $s = t^3 + 5$, where s is in metres and t is in seconds. The radius of the path is 20 m. The acceleration of 'P' when t = 2 s is nearly. **[AIEEE - 2010, 4/144]**



(1) 13 m/s² (2) 12 m/s² (3) 7.2 m/s² (4) 14 m/s²

2. For a particle in uniform circular motion, the acceleration $\vec{a}$ at a point P (R, θ) on the circle of radius R is (Here θ is measured from the x-axis) **[AIEEE - 2010, 4/144]**

(1) $-\frac{v^2}{R}\cos\theta\,\hat{i} + \frac{v^2}{R}\sin\theta\,\hat{j}$ (2) $-\frac{v^2}{R}\sin\theta\,\hat{i} + \frac{v^2}{R}\cos\theta\,\hat{j}$
(3) $-\frac{v^2}{R}\cos\theta\,\hat{i} - \frac{v^2}{R}\sin\theta\,\hat{j}$ (4) $\frac{v^2}{R}\hat{i} + \frac{v^2}{R}\hat{j}$

3. Two cars of masses m_1 and m_2 are moving in circles of radii r_1 and r_2, respectively. Their speeds are such that they make complete circles in the same time t. The ratio of their centripetal acceleration is : **[AIEEE 2012 ; 4/120, –1]**

(1) $m_1 r_1 : m_2 r_2$ (2) $m_1 : m_2$ (3) $r_1 : r_2$ (4) 1 : 1

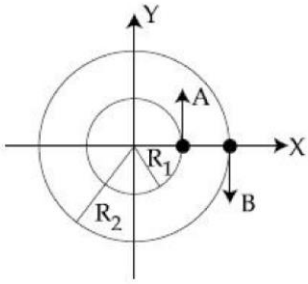
4. A particle is moving with a uniform speed in a circular orbit of radius R in a central force inversely proportional to the n^{th} power of R. If the period of rotation of the particle is T, then : **[JEE-Main-2018]**

(1) $T \alpha R^{(n+1)/2}$ (2) $T \alpha R^{n/2}$ (3) $T \alpha R^{3/2}$ For any n. (4) $T \alpha R^{\frac{n}{2}+1}$

5. A particle is moving along a circular path with a constant speed of 10 ms^{-1}. What is the magnitude of the change is velocity of the particle, when it moves through an angle of 60° around the centre of the circle? **[JEE-MAIN-2019]**

(1) Zero (2) 10 m/s (3) $10\sqrt{2}$ m/s (4) $10\sqrt{3}$ m/s

6. Two particles A, B are moving on two concentric circles of radii R_1 and R_2 with equal angular speed ω. At t = 0, their positions and direction of motion are shown in figure. **[JEE-MAIN-2019]**



The relative velocity $\vec{v}_A - \vec{v}_B$ at t = $\frac{\pi}{2\omega}$ is

(1) $\omega(R_2 - R_1)\hat{i}$ (2) $\omega(R_1 - R_2)\hat{i}$ (3) $-\omega(R_1 + R_2)\hat{i}$ (4) $\omega(R_1 + R_2)\hat{i}$

Answers

EXERCISE # 1

SECTION (A) :

1.	(1)	**2.**	(3)	**3.**	(4)	**4.**	(1)	**5.**	(1)	**6.**	(3)	**7.**	(4)
8.	(1)	**9.**	(4)	**10.**	(4)	**11.**	(4)	**12.**	(1)	**13.**	(3)	**14.**	(1)
15.	(4)	**16.**	(1)	**17.**	(2)	**18.**	(2)	**19.**	(3)	**20.**	(3)	**21.**	(3)
22.	(4)												

SECTION (B) :

1.	(3)	**2.**	(3)	**3.**	(2)	**4.**	(2)	**5.**	(3)	**6.**	(3)	**7.**	(3)
8.	(2)	**9.**	(2)	**10.**	(3)	**11.**	(4)	**12.**	(3)	**13.**	(4)	**14.**	(3)

SECTION (C) :

1.	(1)	**2.**	(4)	**3.**	(2)	**4.**	(2)	**5.**	(1)	**6.**	(4)	**7.**	(2)
8.	(3)	**9.**	(2)	**10.**	(3)	**11.**	(3)	**12.**	(1)	**13.**	(4)	**14.**	(3)
15.	(4)	**16.**	(1)	**17.**	(3)	**18.**	(2)	**19.**	(2)	**20.**	(1)	**21.**	(4)
22.	(2)	**23.**	(3)	**24.**	(2)	**25.**	(2)	**26.**	(1)	**27.**	(4)		

SECTION (D) :

1.	(1)	**2.**	(3)	**3.**	(1)	**4.**	(1)

SECTION (E) :

1.	(3)	**2.**	(1)	**3.**	(4)	**4.**	(3)	**5.**	(2)	**6.**	(2)	**7.**	(1)
8.	(4)	**9.**	(1)	**10.**	(2)	**11.**	(3)	**12.**	(4)	**13.**	(1)	**14.**	(4)
15.	(3)	**16.**	(1)	**17.**	(3)	**18.**	(3)	**19.**	(4)	**20.**	(3)	**21.**	(4)
22.	(1)	**23.**	(1)	**24.**	(4)	**25.**	(2)	**26.**	(1)	**27.**	(1)	**28.**	(3)

SECTION (F) :

1.	(2)	**2.**	(2)	**3.**	(1)	**4.**	(1)	**5.**	(4)	**6.**	(1)	**7.**	(1)
8.	(4)	**9.**	(2)										

EXERCISE # 2

1.	(2)	**2.**	(2)	**3.**	(2)	**4.**	(3)	**5.**	(3)	**6.**	(1)	**7.**	(2)
8.	(2)	**9.**	(4)	**10.**	(4)	**11.**	(4)	**12.**	(1)				

EXERCISE # 3

PART - I

1.	(4)	**2.**	(2)	**3.**	(4)	**4.**	(4)	**5.**	(2)	**6.**	(1)	**7.**	(2)
8.	(3)	**9.**	(4)	**10.**	(1)	**11.**	(2)	**12.**	(4)	**13.**	(4)	**14.**	(3)

PART - II

1.	(4)	**2.**	(3)	**3.**	(3)	**4.**	(1)	**5.**	(2)	**6.**	(1)