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CIRCULAR MOTION

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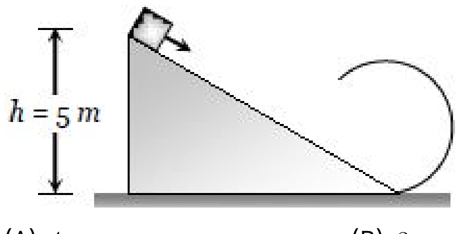
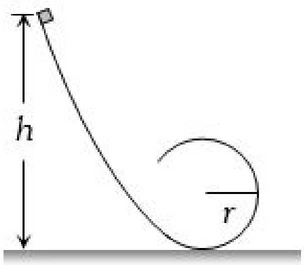
1. The coordinates of a moving particle at any time $'t'$ are given by $x = \alpha t^3$ and $y = \beta t^3$. The speed of the particle at time $'t'$ is given by
   (A) $\sqrt{\alpha^2 + \beta^2}$ (B) $3\,t\sqrt{\alpha^2 + \beta^2}$
   (C) $3\,t^2\sqrt{\alpha^2 + \beta^2}$ (D) $t^2\sqrt{\alpha^2 + \beta^2}$
2. If the radius of curvature of the path of two particles of same masses are in the ratio $1 : 2$, then in order to have constant centripetal force, their velocity, should be in the ratio of
   (A) $1 : 4$ (B) $4 : 1$
   (C) $\sqrt{2} : 1$ (D) $1 : \sqrt{2}$
3. A wheel completes 2000 revolutions to cover the $9.5\,km$. distance. then the diameter of the wheel is
   (A) $1.5\,m$ (B) $1.5\,cm$
   (C) $7.5\,cm$ (D) $7.5\,m$
4. 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 .... m
   (A) 14 (B) 28
   (C) 35 (D) 7
5. The string of pendulum of length l is displaced through 90^o from the vertical and released. Then the minimum strength of the string in order to withstand the tension, as the pendulum passes through the mean position is
   (A) mg (B) $3mg$
   (C) $5\,mg$ (D) $6\,mg$
6. A particle of mass M is moving in a horizontal circle of radius R with uniform speed V. When it moves from one point to a diametrically opposite point, its
   (A) Kinetic energy changes by $MV^2/4$ (B) Momentum does not change
   (C) Momentum changes by $2MV$ (D) Kinetic energy changes by MV^2
7. What is the angular velocity of earth
   (A) $\frac{2\pi}{86400} rad/\sec$ (B) $\frac{2\pi}{3600} rad/\sec$
   (C) $\frac{2\pi}{24} rad/\sec$ (D) $\frac{2\pi}{6400} rad/\sec$
8. If a particle covers half the circle of radius R with constant speed then
   (A) Momentum change is mvr (B) Change in $K.E.$ is $1/2mv^2$
   (C) Change in $K.E.$ is mv^2 (D) Change in $K.E.$ is zero
9. A body of mass $1\,kg$ tied to one end of string is revolved in a horizontal circle of radius $0.1\,m$ with a speed of 3 revolution/sec, assuming the effect of gravity is negligible, then linear velocity, acceleration and tension in the string will be
   (A) $1.88\ m/s,\ 35.5\ m/s^2,\ 35.5\ N$ (B) $2.88\ m/s,\ 45.5\ m/s^2,\ 45.5\ N$
   (C) $3.88\ m/s,\ 55.5\ m/s^2,\ 55.5\ N$ (D) None of these
10. 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 .... $\sec$
    (A) 1 (B) 10
    (C) 8 (D) 4
11. A coin, placed on a rotating turn-table slips, when it is placed at a distance of $9\,cm$ from the centre. If the angular velocity of the turn-table is trippled, it will just slip, if its distance from the centre is .... cm.
    (A) 27 (B) 9
    (C) 3 (D) 1
12. If the length of the second's hand in a stop clock is $3\,cm$ the angular velocity and linear velocity of the tip is
    (A) $0.2047\,rad/sec, 0.0314\,m/sec$ (B) $0.2547\,rad/sec, 0.314\,m/sec$
    (C) $0.1472\,rad/sec, 0.06314\,m/sec$ (D) $0.1047\,rad/sec, 0.00314\,m/sec$
13. 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
    (A) $1 : 1$ (B) $1 : 2$
    (C) $2 : 1$ (D) $4 : 1$
14. A bob of mass $10\,kg$ is attached to wire $0.3\,m$ long. Its breaking stress is $4.8 \times 10^7 N/m^2$. The area of cross section of the wire is $10^{-6} m^2$. The maximum angular velocity with which it can be rotated in a horizontal circle .... rad/sec
    (A) 8 (B) 4
    (C) 2 (D) 1
15. The maximum velocity at the lowest point, so that the string just slack at the highest point in a vertical circle of radius l
    (A) $\sqrt{gl}$ (B) $\sqrt{3gl}$
    (C) $\sqrt{5gl}$ (D) $\sqrt{7gl}$
16. A $1\,kg$ stone at the end of $1\,m$ long string is whirled in a vertical circle at constant speed of $4\,m/sec$. The tension in the string is $6\,N$, when the stone is at
    (A) Top of the circle (B) Bottom of the circle
    (C) Half way down (D) None of the above
17. A weightless thread can support tension upto $30\,N$. A stone of mass $0.5\,kg$ is tied to it and is revolved in a circular path of radius $2\,m$ in a vertical plane. If $g = 10 m/s^2$, then the maximum angular velocity of the stone will be .... rad/s
    (A) 5 (B) $\sqrt{30}$
    (C) $\sqrt{60}$ (D) 10
18. As per given figure to complete the circular loop what should be the radius if initial height is $5\,m$ .... m.



    (A) 4 (B) 3
    (C) 2.5 (D) 2

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



(A) $h < 5r/2$
(B) $h > 5r/2$
(C) $h = 5r/2$
(D) $h \geq 5r/2$

20. 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
(A) T_0
(B) $T_0/2$
(C) $4T_0$
(D) $8T_0$

21. The ratio of angular speeds of minute hand and hour hand of a watch is
(A) $1:12$
(B) $6:1$
(C) $12:1$
(D) $1:6$

22. 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 .... ^{o}.
(A) 30
(B) 45
(C) 60
(D) 90

23. If a particle of mass m is moving in a horizontal circle of radius r with a centripetal force $(-k/r^2)$, the total energy is
(A) $-\dfrac{k}{2r}$
(B) $-\dfrac{k}{r}$
(C) $-\dfrac{2k}{r}$
(D) $-\dfrac{4k}{r}$

24. A particle is moving in a vertical circle. The tensions in the string when passing through two positions at angles 30^o and 60^o from vertical (lowest position) are $T_1 and T_2$ respectively. then
(A) $T_1 = T_2$
(B) $T_2 > T_1$
(C) $T_1 > T_2$
(D) Tension in the string always remains the same

25. A stone ties to the end of a string $1\,m$ long is whirled in a horizontal circle with a constant speed. If the stone makes 22 revolution in 44 seconds, what is the magnitude and direction of acceleration of the stone
(A) $\dfrac{\pi^2}{4}ms^{-2}$ and direction along the radius towards the centre
(B) $\pi^2 ms^{-2}$ and direction along the radius away from the centre
(C) $\pi^2 ms^{-2}$ and direction along the radius towards the centre
(D) $\pi^2 ms^{-2}$ and direction along the tangent to the circle

26. A body of mass $0.4\,kg$ is whirled in a vertical circle making $2\,rev/sec$. If the radius of the circle is $2\,m$, then tension in the string when the body is at the top of the circle, is .... N
(A) 41.56
(B) 89.86
(C) 109.86
(D) 115.86

27. A body of mass m hangs at one end of a string of length l, the other end of which is fixed. It is given a horizontal velocity so that the string would just reach where it makes an angle of 60° with the vertical. The tension in the string at mean position is
(A) $2\,mg$
(B) mg
(C) $3\,mg$
(D) $\sqrt{3}\,mg$

28. A $2\,kg$ stone at the end of a string $1\,m$ long is whirled in a vertical circle at a constant speed. The speed of the stone is $4\,m/sec$. The tension in the string will be $52\,N$, when the stone is
(A) At the top of the circle
(B) At the bottom of the circle
(C) Halfway down
(D) None of the above

29. A bucket full of water is revolved in vertical circle of radius $2\,m$. What should be the maximum time-period of revolution so that the water doesn't fall off the bucket .... $\sec$.
(A) 1
(B) 2
(C) 3
(D) 4

30. A pendulum bob on a $2\,m$ string is displaced 60° from the vertical and then released. What is the speed of the bob as it passes through the lowest point in its path .... m/s
(A) $\sqrt{2}$
(B) $\sqrt{9.8}$
(C) 4.43
(D) $1/\sqrt{2}$

31. 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)
(A) 18
(B) 12
(C) 36
(D) 48

32. The length of second's hand in a watch is $1\,cm$. The change in velocity of its tip in $15\,seconds$ is
(A) Zero
(B) $\dfrac{\pi}{30\sqrt{2}}cm/\sec$
(C) $\dfrac{\pi}{30}cm/\sec$
(D) $\dfrac{\pi\sqrt{2}}{30}cm/\sec$

33. A cycle wheel of radius 0.4 m completes one revolution in one second then the acceleration of a point on the cycle wheel will be
(A) $0.8m/s^2$
(B) $0.4m/s^2$
(C) $1.6\,\pi^2\,m/s^2$
(D) $0.4\,\pi^2\,m/s^2$

34. A proton of mass $1.6\,\times 10^{-27}kg$ goes round in a circular orbit of radius $0.10\,m$ under a centripetal force of $4\,\times 10^{-13}\,N$. then the frequency of revolution of the proton is about
(A) $0.08\,\times 10^8$cycles per sec
(B) $4\,\times 10^8$cycles per sec
(C) $8\,\times 10^8$cycles per sec
(D) $12\,\times 10^8$cycles per sec

35. A particle describes a horizontal circle in a conical funnel whose inner surface is smooth with speed of $0.5\,m/s$. What is the height of the plane of circle from vertex of the funnel .... cm
(A) 0.25
(B) 2
(C) 4
(D) 2.5

36. A bucket tied at the end of a $1.6\,m$ long string is whirled in a vertical circle with constant speed. What should be the minimum speed so that the water from the bucket does not spill, when the bucket is at the highest position .... m/sec (Take $g = 10\,m/\sec^2$)
(A) 4
(B) 6.25
(C) 16
(D) None of the above

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

38. A sphere is suspended by a thread of length l. What minimum horizontal velocity has to be imparted the ball for it to reach the height of the suspension
(A) gl
(B) $2gl$
(C) $\sqrt{gl}$
(D) $\sqrt{2gl}$

39. A fighter plane is moving in a vertical circle of radius $'r'$. Its minimum velocity at the highest point of the circle will be
(A) $\sqrt{3\,g\,r}$
(B) $\sqrt{2\,g\,r}$
(C) $\sqrt{g\,r}$
(D) $\sqrt{gr/2}$

40. A particle is tied to $20\,cm$ long string. It performs circular motion in vertical plane. What is the angular velocity of string when the tension in the string at the top is zero .... rad/sec

(A) 5 (B) 2
(C) 7.5 (D) 7

41. 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]

(A) $v=\sqrt{2gR}$ (B) $v=\sqrt{gR}$
(C) $v=\dfrac{g}{R}$ (D) $v=\sqrt{g^2R}$

42. A fan is making 600 revolutions per minute. If after some time it makes 1200 revolutions per minute, then increase in its angular velocity is

(A) $10\,\pi\,rad/\sec$ (B) $20\,\pi\,rad/\sec$
(C) $40\,\pi\,rad/\sec$ (D) $60\,\pi\,rad/\sec$

43. A car is moving with speed $30\ m/\sec$ on a circular path of radius $500\,m$. Its speed is increasing at the rate of $2m/\sec^2$, What is the acceleration of the car .... m/sec^2

(A) 2 (B) 2.7
(C) 1.8 (D) 9.8

44. A car is moving on a circular path and takes a turn. If R_1 and R_2 be the reactions on the inner and outer wheels respectively, then

(A) $R_1=R_2$ (B) $R_1<R_2$
(C) $R_1>R_2$ (D) $R_1\geq R_2$

45. A cyclist riding the bicycle at a speed of $14\sqrt{3}\ ms^{-1}$takes a turn around a circular road of radius $20\sqrt{3}$ m without skidding. Given $g=9.8ms^{-2}$, what is his inclination to the vertical .... ^{o}

(A) 30 (B) 90
(C) 45 (D) 60

46. A particle moves in a circle of radius $25\,cm$ at two revolutions per second. The acceleration of the particle in m/s^2 is

(A) π^2 (B) $8\pi^2$
(C) $4\pi^2$ (D) $2\pi^2$

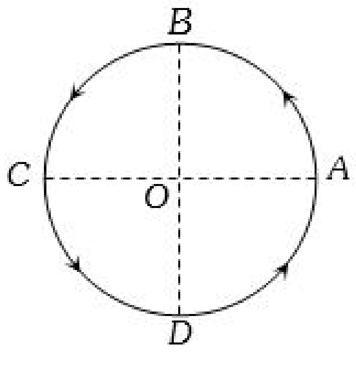
47. The maximum and minimum tension in the string whirling in a circle of radius $2.5\,m$ with constant velocity are in the ratio $5:3$ then its velocity is

(A) $\sqrt{98}\ m/s$ (B) $7\ m/s$
(C) $\sqrt{490}\ m/s$ (D) $\sqrt{4.9}$

48. A hollow sphere has radius $6.4\,m$. Minimum velocity required by a motor cyclist at bottom to complete the circle will be .... m/s

(A) 17.7 (B) 10.2
(C) 12.4 (D) 16.0

49. Figure shows a body of mass m moving with a uniform speed v along a circle of radius r. The change in velocity in going from A to B is



(A) $v\sqrt{2}$ (B) $v/\sqrt{2}$
(C) v (D) zero

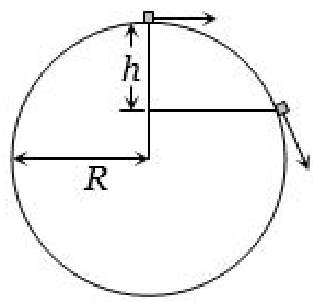
50. A wheel is subjected to uniform angular acceleration about its axis. Initially its angular velocity is zero. In the first 2 sec, it rotates through an angle θ_1. In the next 2 sec, it rotates through an additional angle θ_2. The ratio of $\frac{\theta_2}{\theta_1}$ is

(A) 1 (B) 2
(C) 3 (D) 5

51. 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 $10m/sec^2$. In order to avoid skidding, he must not bend with respect to the vertical plane by an angle greater than

(A) $\theta=\tan^{-1}6$ (B) $\theta=\tan^{-1}2$
(C) $\theta=\tan^{-1}25.92$ (D) $\theta=\tan^{-1}4$

52. A particle originally at rest at the highest point of a smooth vertical circle is slightly displaced. It will leave the circle at a vertical distance h below the highest point such that



(A) $h=R$ (B) $h=\dfrac{R}{3}$
(C) $h=\dfrac{R}{2}$ (D) $h=\dfrac{2R}{3}$

53. 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

(A) $\dfrac{Ml}{M+m}$ (B) $\dfrac{ml}{M+m}$
(C) $\dfrac{M+m}{M}l$ (D) $\dfrac{M+m}{m}l$

54. An athlete completes one round of a circular track of radius $10\,m$ in $40\,sec$. The distance covered by him in $2\,min\ 20\,sec$ is .... m

(A) 70 (B) 140
(C) 110 (D) 220

55. A stone of mass m is tied to a string and is moved in a vertical circle of radius r making n revolutions per minute. The total tension in the string when the stone is at its lowest point is

(A) mg (B) $m(g+\pi\,n\,r^2)$
(C) $m(g+\pi\,n\,r)$ (D) $m\{g+(\pi^2\,n^2\,r)/900\}$

56. A body crosses the topmost point of a vertical circle with critical speed. Its centripetal acceleration, when the string is horizontal will be

(A) $6\,g$ (B) $3\,g$
(C) $2\,g$ (D) g

57. A person with his hands in his pockets is skating on ice at the velocity of $10\,m/s$ and describes a circle of radius $50\,m$. What is his inclination with vertical

(A) $\tan^{-1}\left(\dfrac{1}{10}\right)$ (B) $\tan^{-1}\left(\dfrac{3}{5}\right)$
(C) $\tan^{-1}(1)$ (D) $\tan^{-1}\left(\dfrac{1}{5}\right)$

58. A ball is moving to and fro about the lowest point A of a smooth hemispherical bowl. If it is able to rise up to a height of $20\,cm$ on either side of A, its speed at A must be .... m/s (Take = $10m/s^2$, mass of the body $5\,g$)

(A) 0.2 (B) 2
(C) 4 (D) 4.5

59. A ball of mass $0.1\,Kg.$ is whirled in a horizontal circle of radius $1\,m.$ by means of a string at an initial speed of $10\,R.P.M.$ Keeping the radius constant, the tension in the string is reduced to one quarter of its initial value. The new speed is .... $r.p.m.$

(A) 5 (B) 10
(C) 20 (D) 14

60. A cyclist goes round a circular path of circumference $34.3\,m$ in $\sqrt{22}$ sec. the angle made by him, with the vertical, will be ...... ^{o}

(A) 45 (B) 40
(C) 42 (D) 48

ANSWER KEY

PHYSICS

1 - C	2 - D	3 - A	4 - C	5 - B	6 - C	7 - A	8 - D	9 - A	10 - D
11 - D	12 - D	13 - B	14 - B	15 - C	16 - A	17 - A	18 - D	19 - D	20 - D
21 - C	22 - D	23 - A	24 - C	25 - C	26 - D	27 - A	28 - B	29 - C	30 - C
31 - B	32 - D	33 - C	34 - A	35 - D	36 - A	37 - A	38 - D	39 - C	40 - D
41 - B	42 - B	43 - B	44 - B	45 - D	46 - C	47 - A	48 - A	49 - A	50 - C
51 - B	52 - B	53 - B	54 - D	55 - D	56 - B	57 - D	58 - B	59 - A	60 - A

SOLUTION

PHYSICS

1. The coordinates of a moving particle at any time $'t'$ are given by $x = \alpha t^3$ and $y = \beta t^3$. The speed of the particle at time $'t'$ is given by

(A) $\sqrt{\alpha^2+\beta^2}$ (B) $3\,t\sqrt{\alpha^2+\beta^2}$

(C) ✓$3\,t^2\sqrt{\alpha^2+\beta^2}$ (D) $t^2\sqrt{\alpha^2+\beta^2}$

Sol : (c) $x = \alpha t^3$ and $y = \beta t^3$(given)

$v_x = \dfrac{dx}{dt} = 3\alpha t^2$ and $v_y = \dfrac{dy}{dt} = 3\beta t^2$

Resultant velocity $= v = \sqrt{v_x^2+v_y^2} = 3t^2\sqrt{\alpha^2+\beta^2}$

2. If the radius of curvature of the path of two particles of same masses are in the ratio $1\ :\ 2$, then in order to have constant centripetal force, their velocity, should be in the ratio of

(A) $1:4$ (B) $4:1$

(C) $\sqrt{2}:1$ (D) ✓$1\ :\ \sqrt{2}$

Sol : (d) The centripetal force, $F = \dfrac{mv^2}{r}$

$\Rightarrow r = \dfrac{mv^2}{F}$

$\Rightarrow r \propto v^2$ or $v \propto \sqrt{r}$ (If m and F are constant),

$\Rightarrow \dfrac{v_1}{v_2} = \sqrt{\dfrac{r_1}{r_2}} = \sqrt{\dfrac{1}{2}}$

3. A wheel completes 2000 revolutions to cover the $9.5\,km$. distance. then the diameter of the wheel is

(A) ✓$1.5\,m$ (B) $1.5\,cm$

(C) $7.5\,cm$ (D) $7.5\,m$

Sol : (a) Distance covered in 'n' revolution $= n2\pi\,r = n\pi\,D$

$\Rightarrow 2000\,\pi\,D = 9500$ [As $n = 2000$, distance $= 9500\,m$]

$\Rightarrow D = \dfrac{9500}{2000\times\pi} = 1.5\,m$

4. 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 .... m

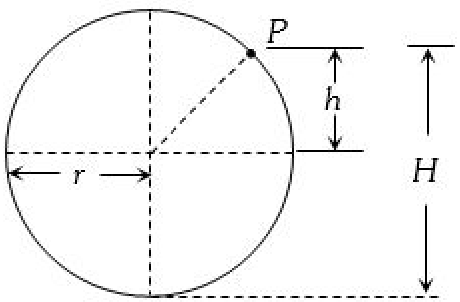
(A) 14 (B) 28

(C) ✓35 (D) 7

Sol : (c) As we know for hemisphere the particle will leave the sphere at height $h = 2r/3$

$h = \dfrac{2}{3}\times 21 = 14\,m$

but from the bottom $H = h + r = 14 + 21 = 35\,metre$



5. The string of pendulum of length l is displaced through 90^o from the vertical and released. Then the minimum strength of the string in order to withstand the tension, as the pendulum passes through the mean position is

(A) mg (B) ✓$3mg$

(C) $5\,mg$ (D) $6\,mg$

Sol : (b) $T = mg + \dfrac{mv^2}{l} = mg + 2mg = 3mg$

where $v = \sqrt{2gl}$ from $\dfrac{1}{2}mv^2 = mgl$

6. A particle of mass M is moving in a horizontal circle of radius R with uniform speed V. When it moves from one point to a diametrically opposite point, its

(A) Kinetic energy changes by $MV^2/4$ (B) Momentum does not change

(C) ✓Momentum changes by $2MV$ (D) Kinetic energy changes by MV^2

Sol : (c) On the diametrically opposite points, the velocities have same magnitude but

opposite directions. Therefore change in momentum is

$\mathrm{Mv} - (-\mathrm{Mv}) = 2\mathrm{Mv}$

7. What is the angular velocity of earth

(A) ✓$\dfrac{2\pi}{86400}rad/\sec$ (B) $\dfrac{2\pi}{3600}rad/\sec$

(C) $\dfrac{2\pi}{24}rad/\sec$ (D) $\dfrac{2\pi}{6400}rad/\sec$

Sol : (a)Angular velocity $= \dfrac{2\pi}{T} = \dfrac{2\pi}{24}rad/hr = \dfrac{2\pi}{86400}rad/s$

8. If a particle covers half the circle of radius R with constant speed then

(A) Momentum change is mvr (B) Change in $K.E.$ is $1/2mv^2$

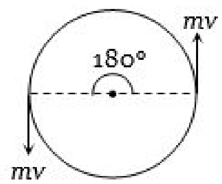
(C) Change in $K.E.$ is mv^2 (D) ✓Change in $K.E.$ is zero

Sol : (d) As momentum is vector quantity

change in momentum ΔP= $2mv\sin(\theta/2)$

=$2mv\sin(90) = 2mv$

But kinetic energy remains always constant so change in kinetic energy is zero.



9. A body of mass $1\,kg$ tied to one end of string is revolved in a horizontal circle of radius $0.1\,m$ with a speed of 3 revolution/sec, assuming the effect of gravity is negligible, then linear velocity, acceleration and tension in the string will be

(A) ✓$1.88\ m/s,\ 35.5\ m/s^2,\ 35.5\ N$ (B) $2.88\ m/s,\ 45.5\ m/s^2,\ 45.5\ N$

(C) $3.88\ m/s,\ 55.5\ m/s^2,\ 55.5\ N$ (D) None of these

Sol : (a) Linear velocity, $v = \omega r = 2\pi nr = 2\times 3.14\times 3\times 0.1 = 1.88\,m/s$

Acceleration, $a = \omega^2 r = (6\pi)^2\times 0.1 = 35.5\,m/s^2$

Tension in string, $T = m\omega^2 r = 1\times(6\pi)^2\times 0.1 = 35.5\,N$

10. 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 .... sec

(A) 1 (B) 10

(C) 8 (D) ✓4

Sol : (d) For critical condition at the highest point $\omega = \sqrt{g/R}$

$\Rightarrow T = \dfrac{2\pi}{\omega} = 2\pi\sqrt{R/g} = 2\times 3.14\sqrt{4/9.8}$

$= 4\,sec.$

11. A coin, placed on a rotating turn-table slips, when it is placed at a distance of $9\,cm$ from the centre. If the angular velocity of the turn-table is trippled, it will just slip, if its distance from the centre is .... $cm.$

(A) 27 (B) 9

(C) 3 (D) ✓1

Sol : (d) In the given condition friction provides the required centripetal force and that is constant. i.e. $mw^2r =$constant

$\Rightarrow r \propto \frac{1}{\omega^2} \Rightarrow r_2 = r_1\left(\frac{\omega_1}{\omega_2}\right)^2 = 9\left(\frac{1}{3}\right)^2 = 1\,cm$

12. If the length of the second's hand in a stop clock is $3\,cm$ the angular velocity and linear velocity of the tip is

(A) $0.2047\,rad/sec, 0.0314\,m/sec$
(B) $0.2547\,rad/sec, 0.314\,m/sec$
(C) $0.1472\,rad/sec, 0.06314\,m/sec$
(D) ✓$0.1047\,rad/sec, 0.00314\,m/sec$

Sol : (d) $\omega = \frac{2\pi}{T} = \frac{2\pi}{60} = 0.1047\,rad/s$

and $v = \omega r = 0.1047 \times 3 \times 10^{-2} = 0.00314\,m/s$

13. 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

(A) $1:1$
(B) ✓$1:2$
(C) $2:1$
(D) $4:1$

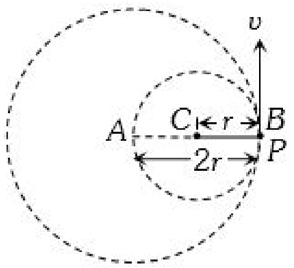
Sol : (b)Angular velocity of particle P about point A,

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

Angular velocity of particle P about point C,

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

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



14. A bob of mass $10\,kg$ is attached to wire $0.3\,m$ long. Its breaking stress is $4.8 \times 10^7 N/m^2$. The area of cross section of the wire is $10^{-6}m^2$. The maximum angular velocity with which it can be rotated in a horizontal circle .... rad/sec

(A) 8
(B) ✓4
(C) 2
(D) 1

Sol : (b) Centripetal force $=$ breaking force

$\Rightarrow\ m\omega^2 r =$ breaking stress $\times$ cross sectional area

$\Rightarrow\ m\omega^2 r = p \times A$

$\Rightarrow\ \omega = \sqrt{\frac{p \times A}{mr}} = \sqrt{\frac{4.8 \times 10^7 \times 10^{-6}}{10 \times 0.3}}$

$\omega = 4\,rad/\mathrm{sec}$

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

(A) $\sqrt{gl}$
(B) $\sqrt{3gl}$
(C) ✓$\sqrt{5gl}$
(D) $\sqrt{7gl}$

Sol : (c) $T + mg = \frac{mv_1^2}{l}$v

There is certain velocity so called as critical velocity/minimum velocity (v) of object at highest point below which string become slack Ie. tension T vanishes (T=0).

$mg = \frac{mv_1^2}{l}$

$v_1 = \sqrt{gl}$

The decrease in potential energy between top $-$position and bottom position is

$mgl - (-mgl) = 2mgl$

This must be equal to the increase in kinetic energy, when particle move from highest point

i.e.

$\frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$

Using law of conservation of energy.

$2mgl = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$

$2mgl = \frac{1}{2}mv_2^2 - \frac{1}{2}mgl$

$4mgl = mv_2^2 - mgl$

$v_2^2 = 5gl$

$v_2 = \sqrt{5gl}$

16. A $1\,kg$ stone at the end of $1\,m$ long string is whirled in a vertical circle at constant speed of $4\,m/sec$. The tension in the string is $6\,N$, when the stone is at

(A) ✓Top of the circle
(B) Bottom of the circle
(C) Half way down
(D) None of the above

Sol : (a) $mg = 1 \times 10 = 10N$, $\frac{mv^2}{r} = \frac{1 \times (4)^2}{1} = 16$

Tension at the top of circle = $\frac{mv^2}{r} - mg = 6N$

Tension at the bottom of circle = $\frac{mv^2}{r} + mg = 26N$

17. A weightless thread can support tension upto $30\,N$. A stone of mass $0.5\,kg$ is tied to it and is revolved in a circular path of radius $2\,m$ in a vertical plane. If $g = 10m/s^2$, then the maximum angular velocity of the stone will be .... rad/s

(A) ✓5
(B) $\sqrt{30}$
(C) $\sqrt{60}$
(D) 10

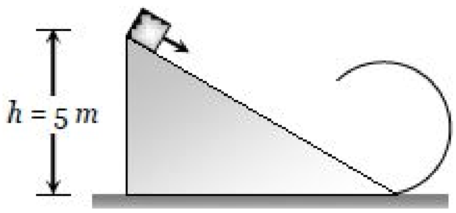
Sol : (a) $T_{\max} = m\omega_{\max}^2 r + mg$

$\Rightarrow \frac{T_{\max}}{m} = \omega^2 r + g$

$\Rightarrow \frac{30}{0.5} - 10 = \omega^2{}_{\max} r$

$\Rightarrow \omega_{\max} = \sqrt{\frac{50}{r}} = \sqrt{\frac{50}{2}} = 5\,rad/s$

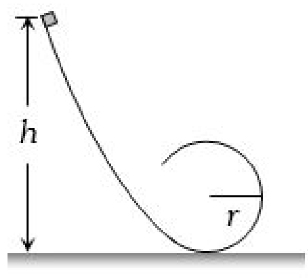
18. As per given figure to complete the circular loop what should be the radius if initial height is $5\,m$ .... m.



(A) 4
(B) 3
(C) 2.5
(D) ✓2

Sol : (d) $h = \frac{5}{2}r \Rightarrow r = \frac{2}{5} \times h = \frac{2}{5} \times 5 = 2\,metre$

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



(A) $h < 5r/2$
(B) $h > 5r/2$
(C) $h = 5r/2$
(D) ✓$h \geq 5r/2$

Sol : (d) In order to complete a full circle, the normal force when the block is at the highest point of circular ramp should be greater than zero,

SO

if value of point $B = v_B$ Then,

At point $B, mg + N = \frac{mv_B^2}{R}$

$\text{AS} N > 0$

$\Rightarrow v_B^2 > mgR$

At point $-A$

$\frac{mv_A^2}{2} - \frac{mv_B^2}{2} = mg(2R)[As \Delta KE = -\Delta PE]$

$\frac{mv_A^2}{2} = 2mgR + \frac{mv_B^2}{2}$

As $v_B^2 > mgR$

$\Rightarrow \frac{mv_A^2}{2} > 2mgR + \frac{mgR}{2} \Rightarrow \frac{mv_A^2}{2} > \frac{5mgR}{2}$

Also, $\frac{mv_A^2}{2} - 0 = mgh$

$\text{As}, mv_A^2 > 5mgR \Rightarrow mgh > \frac{5mgR}{2}$

$\Rightarrow h > 5r/2$

20. 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

(A) T_0 (B) $T_0/2$

(C) $4T_0$ (D) $\checkmark 8T_0$

Sol : (d) Tension in the string $T_0 = mR\omega_0^2$

In the second case $T = m(2R)(4\omega_0^2) = 8mR\omega_0^2 = 8T_0$

21. The ratio of angular speeds of minute hand and hour hand of a watch is

(A) $1:12$ (B) $6:1$

(C) $\checkmark 12:1$ (D) $1:6$

Sol : (c) $\omega_{\min} = \frac{2\pi}{60} \frac{Rad}{min}$ and $\omega_{hr} = \frac{2\pi}{12 \times 60} \frac{Rad}{min}$

$\frac{\omega_{\min}}{\omega_{hr}} = \frac{2\pi/60}{2\pi/12 \times 60}$

22. 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 .... ^{o}.

(A) 30 (B) 45

(C) 60 (D) $\checkmark 90$

Sol : (d) Tension at mean position, $mg + \frac{mv^2}{r} = 3\,mg$

$v = \sqrt{2gl}. . . (i)$

and if the body displaces by angle θ with the vertical then

$v = \sqrt{2gl(1-\cos\theta)}. . . (ii)$

Comparing (i) and (ii), $\cos\theta = 0$

$\Rightarrow \theta = 90°$

23. If a particle of mass m is moving in a horizontal circle of radius r with a centripetal force $(-k/r^2)$, the total energy is

(A) $\checkmark -\frac{k}{2r}$ (B) $-\frac{k}{r}$

(C) $-\frac{2k}{r}$ (D) $-\frac{4k}{r}$

Sol : (a) $\frac{mv^2}{r} = \frac{k}{r^2} \Rightarrow mv^2 = \frac{k}{r}$

$\therefore K.E.$ = $\frac{1}{2}mv^2 = \frac{k}{2r}$

$P.E. = \int F\,dr = \int \frac{k}{r^2}dr = -\frac{k}{r}$

Total energy $= K.E. + P.E. = \frac{k}{2r} - \frac{k}{r} = -\frac{k}{2r}$

24. A particle is moving in a vertical circle. The tensions in the string when passing through two positions at angles 30^o and 60^o from vertical (lowest position) are $T_1 and T_2$ respectively. then

(A) $T_1 = T_2$ (B) $T_2 > T_1$

(C) $\checkmark T_1 > T_2$

(D) Tension in the string always remains the same

Sol : (c) Tension, $T = \frac{mv^2}{r} + mg\cos\theta$

For, $\theta = 30°, T_1 = \frac{mv^2}{r} + mg\cos 30°$

$\theta = 60°, T_2 = \frac{mv^2}{r} + mg\cos 60°$

$\therefore T_1 > T_2$

25. A stone ties to the end of a string $1\,m$ long is whirled in a horizontal circle with a constant speed. If the stone makes 22 revolution in 44 seconds, what is the magnitude and direction of acceleration of the stone

(A) $\frac{\pi^2}{4} ms^{-2}$ and direction along the radius towards the centre

(B) $\pi^2 ms^{-2}$ and direction along the radius away from the centre

(C) $\checkmark \pi^2 ms^{-2}$ and direction along the radius towards the centre

(D) $\pi^2 ms^{-2}$ and direction along the tangent to the circle

Sol : (c) $a = \frac{v^2}{r} = \omega^2 r = 4\pi^2 n^2 r = 4\pi^2 \left(\frac{22}{44}\right)^2 \times 1 = \pi^2\,m/s^2$

and its direction is always along the radius and towards the centre.

26. A body of mass $0.4\,kg$ is whirled in a vertical circle making $2\,rev/sec$. If the radius of the circle is $2\,m$, then tension in the string when the body is at the top of the circle, is .... N

(A) 41.56 (B) 89.86

(C) 109.86 (D) $\checkmark 115.86$

Sol : (d) Tension at the top of the circle,$T = m\omega^2 r - mg$

$T = 0.4 \times 4\pi^2 n^2 \times 2 - 0.4 \times 9.8 = 115.86\,N$

27. A body of mass m hangs at one end of a string of length l, the other end of which is fixed. It is given a horizontal velocity so that the string would just reach where it makes an angle of $60°$ with the vertical. The tension in the string at mean position is

(A) $\checkmark 2\,mg$ (B) mg

(C) $3\,mg$ (D) $\sqrt{3}\,mg$

Sol : (a) When body is released from the position p (inclined at angle θ from vertical) then velocity at mean position

$v = \sqrt{2gl(1-\cos\theta)}$

Tension at the lowest point = $mg + \frac{mv^2}{l}$

$= mg + \frac{m}{l}[2gl(1-\cos 60)] = mg + mg = 2\,mg$

28. A $2\,kg$ stone at the end of a string $1\,m$ long is whirled in a vertical circle at a constant speed. The speed of the stone is $4\,m/sec$. The tension in the string will be $52\,N$, when the stone is

(A) At the top of the circle (B) $\checkmark$At the bottom of the circle

(C) Halfway down (D) None of the above

Sol : (b) $mg = 20N$ and $\frac{mv^2}{r} = \frac{2 \times (4)^2}{1} = 32N$

It is clear that $52\,N$ tension will be at the bottom of the circle. Because we know that

$T_{\text{Bottom}} = mg + \frac{mv^2}{r}$

29. A bucket full of water is revolved in vertical circle of radius $2\,m$. What should be the maximum time-period of revolution so that the water doesn't fall off the bucket .... sec.

(A) 1 (B) 2

(C) $\checkmark 3$ (D) 4

Sol : (c) Minimum angular velocity $\omega_{\min} = \sqrt{g/R}$

$\therefore\ T_{\max} = \dfrac{2\pi}{\omega_{\min}} = 2\pi\sqrt{\dfrac{R}{g}}$

$= 2\pi\sqrt{\dfrac{2}{10}} = 2\sqrt{2} \cong 3\,s$

30. A pendulum bob on a $2\,m$ string is displaced 60° from the vertical and then released. What is the speed of the bob as it passes through the lowest point in its path .... m/s

(A) $\sqrt{2}$ (B) $\sqrt{9.8}$

(C) $\checkmark 4.43$ (D) $1/\sqrt{2}$

Sol : (c)$v = \sqrt{2gl(1-\cos\theta)} = \sqrt{2\times 9.8\times 2(1-\cos 60^\circ)} = 4.43\,m/s$

31. 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)

(A) 18 (B) $\checkmark 12$

(C) 36 (D) 48

Sol : (b) By using equation $\omega^2 = \omega_0^2 - 2\alpha\theta$

$\left(\dfrac{\omega_0}{2}\right)^2 = \omega_0^2 - 2\alpha(2\pi n)$

$\Rightarrow \alpha = \dfrac{3}{4}\dfrac{\omega_0^2}{4\pi\times 36}, (n=36)..(i)$

Now let fan completes total n' revolution from the starting to come to rest

$0 = \omega_0^2 - 2\alpha(2\pi n') \Rightarrow n' = \dfrac{\omega_0^2}{4\alpha\pi}$

substituting the value of from equation (i)

$n' = \dfrac{\omega_0^2}{4\pi}\dfrac{4\times 4\pi\times 36}{3\omega_0^2} = 48$ revolution

Number of rotation $= 48 - 36 = 12$

32. The length of second's hand in a watch is $1\,cm$. The change in velocity of its tip in $15\,seconds$ is

(A) Zero (B) $\dfrac{\pi}{30\sqrt{2}}cm/\sec$

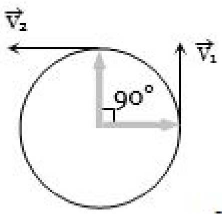
(C) $\dfrac{\pi}{30}cm/\sec$ (D) $\checkmark \dfrac{\pi\sqrt{2}}{30}cm/\sec$

Sol : (d) In $15\,second's$ hand rotate through 90°.

Change in velocity $\left|\overrightarrow{\Delta v}\right| = 2v\sin(\theta/2)$

$= 2(r\omega)\sin(90^\circ/2) = 2\times 1\times\dfrac{2\pi}{T}\times\dfrac{1}{\sqrt{2}}$

$= \dfrac{4\pi}{60\sqrt{2}} = \dfrac{\pi\sqrt{2}}{30}\dfrac{cm}{\sec}$ [As $T = 60\,sec$]



33. A cycle wheel of radius 0.4 m completes one revolution in one second then the acceleration of a point on the cycle wheel will be

(A) $0.8m/s^2$ (B) $0.4m/s^2$

(C) $\checkmark 1.6\,\pi^2\,m/s^2$ (D) $0.4\,\pi^2\,m/s^2$

Sol : (c) Centripetal acceleration $= 4\pi^2 n^2 r = 4\pi^2\times(1)\times 0.4 = 1.6\pi^2$

34. A proton of mass $1.6\ \times 10^{-27}kg$ goes round in a circular orbit of radius $0.10\,m$ under a centripetal force of $4\ \times 10^{-13}\,N$. then the frequency of revolution of the proton is about

(A) $\checkmark 0.08\ \times 10^8$cycles per sec (B) $4\ \times 10^8$cycles per sec

(C) $8\ \times 10^8$cycles per sec (D) $12\ \times 10^8$cycles per sec

Sol : (a) $m\,4\pi^2 n^2 r = 4\times 10^{-13} \Rightarrow n = 0.08\times 10^8\,cycles/\sec$.

35. A particle describes a horizontal circle in a conical funnel whose inner surface is smooth with speed of $0.5\,m/s$. What is the height of the plane of circle from vertex of the funnel .... cm

(A) 0.25 (B) 2

(C) 4 (D) $\checkmark 2.5$

Sol : (d) The particle is moving in circular path

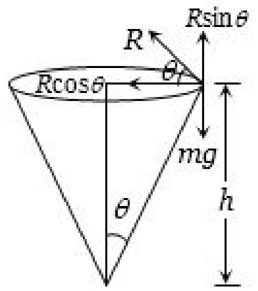
From the figure, $mg = R\sin\theta\ .\ .\ .\ (i)$

$\dfrac{mv^2}{r} = R\cos\theta\ .\ .\ .\ (ii)$

From equation (i) and (ii) we get

$\tan\theta = \dfrac{rg}{v^2}$ but $\tan\theta = \dfrac{r}{h}$

$h = \dfrac{v^2}{g} = \dfrac{(0.5)^2}{10} = 0.025m = 2.5\,cm$



36. A bucket tied at the end of a $1.6\,m$ long string is whirled in a vertical circle with constant speed. What should be the minimum speed so that the water from the bucket does not spill, when the bucket is at the highest position .... m/sec (Take $g = 10\,m/\sec^2$)

(A) $\checkmark 4$ (B) 6.25

(C) 16 (D) None of the above

Sol : (a) Critical velocity at highest point$= \sqrt{gR} = \sqrt{10\times 1.6} = 4\,m/s$

37. A weightless thread can bear tension upto $3.7\,kgwt$. A stone of mass $500\,gms$ is tied to it and revolved in a circular path of radius $4m$ in a vertical plane. If $g = 10\,ms^{-2}$, then the maximum angular velocity of the stone will be .... $rad/\sec$

(A) $\checkmark 4$ (B) 16

(C) $\sqrt{21}$ (D) 2

Sol : (a) Max. tension that string can bear = $3.7\,kgwt = 37\,N$

Tension at lowest point of vertical $\text{loop} = mg + m\omega^2 r$

= $0.5\times 10 + 0.5\times\omega^2\times 4 = 5 + 2\omega^2$

$37 = 5 + 2\,\omega^2$

$\Rightarrow \omega = 4\,rad/s.$

38. A sphere is suspended by a thread of length l. What minimum horizontal velocity has to be imparted the ball for it to reach the height of the suspension

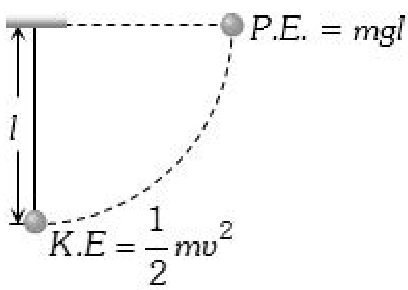
(A) gl (B) $2gl$

(C) $\sqrt{gl}$ (D) $\checkmark \sqrt{2gl}$

Sol : (d) Kinetic energy given to a sphere at lowest point = potential energy at the height of suspension

$\Rightarrow \dfrac{1}{2}mv^2 = mgl$

$v = \sqrt{2gl}$



39. A fighter plane is moving in a vertical circle of radius $'r'$. Its minimum velocity at the highest point of the circle will be

(A) $\sqrt{3\,g\,r}$ (B) $\sqrt{2\,g\,r}$

(C) ✓ $\sqrt{g\,r}$ (D) $\sqrt{gr/2}$

Sol : (c) Minimum velocity at the highest point of vertical circle $VA = \sqrt{gr}$

40. A particle is tied to $20\,cm$ long string. It performs circular motion in vertical plane. What is the angular velocity of string when the tension in the string at the top is zero .... rad/sec

(A) 5 (B) 2

(C) 7.5 (D) ✓7

Sol : (d)$\omega = \sqrt{\frac{g}{r}} = \sqrt{\frac{9.8}{0.2}} = 7\,rad/s$

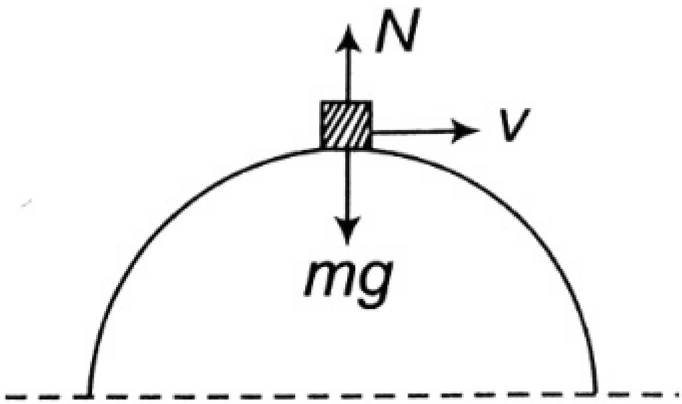
41. A small disc is on the top of a hemisphere of radius R. What is the smallest horizontal velocity v that should be given to the disc for it to leave the hemisphere and not slide down it ? [There is no friction]

(A) $v = \sqrt{2gR}$ (B) ✓$v = \sqrt{gR}$

(C) $v = \frac{g}{R}$ (D) $v = \sqrt{g^2R}$

Sol : (b) $mg - N = \frac{mv^2}{R}$

$N = 0 \Rightarrow v = \sqrt{gR}$



42. A fan is making 600 revolutions per minute. If after some time it makes 1200 revolutions per minute, then increase in its angular velocity is

(A) $10\,\pi\,rad/\sec$ (B) ✓$20\,\pi\,rad/\sec$

(C) $40\,\pi\,rad/\sec$ (D) $60\,\pi\,rad/\sec$

Sol : (b) Increment in angular velocity $\omega = 2\pi(n_2 - n_1)$

$\omega = 2\pi(1200 - 600)\frac{rad}{min} = \frac{2\pi \times 600}{60}\frac{rad}{s} = 20\pi\frac{rad}{s}$

43. A car is moving with speed $30\,m/\sec$ on a circular path of radius $500\,m$. Its speed is increasing at the rate of $2m/\sec^2$, What is the acceleration of the car .... m/sec^2

(A) 2 (B) ✓2.7

(C) 1.8 (D) 9.8

Sol : (b) Net acceleration in nonuniform circular motion,

$$a = \sqrt{a_t^2 + a_c^2} = \sqrt{(2)^2 + \left(\frac{900}{500}\right)^2} = 2.7\,m/s^2$$

a_t =tangential acceleration

a_c =centripetal acceleration $= \frac{v^2}{r}$

44. A car is moving on a circular path and takes a turn. If R_1 and R_2 be the reactions on the inner and outer wheels respectively, then

(A) $R_1 = R_2$ (B) ✓$R_1 < R_2$

(C) $R_1 > R_2$ (D) $R_1 \geq R_2$

Sol : (b) Reaction on inner wheel $R_1 = \frac{1}{2}M\left[g - \frac{v^2h}{ra}\right]$

Reaction on outer wheel $R_2 = \frac{1}{2}M\left[g + \frac{v^2h}{ra}\right]$

where, r = radius of circular path, $2a$ = distance between two wheels and h = height of centre of gravity of car.

45. A cyclist riding the bicycle at a speed of $14\sqrt{3}\ ms^{-1}$takes a turn around a circular road of radius $20\sqrt{3}$ m without skidding. Given $g = 9.8ms^{-2}$, what is his inclination to the vertical .... ^{o}

(A) 30 (B) 90

(C) 45 (D) ✓60

Sol : (d)$\theta = \tan^{-1}\left(\frac{v^2}{rg}\right) = \tan^{-1}\left[\frac{(14\sqrt{3})^2}{20\sqrt{3} \times 9.8}\right] =$ $\tan^{-1}[\sqrt{3}] = 60°$

46. A particle moves in a circle of radius $25\,cm$ at two revolutions per second. The acceleration of the particle in m/s^2 is

(A) π^2 (B) $8\pi^2$

(C) ✓$4\pi^2$ (D) $2\pi^2$

Sol : (c) Since $n = 2$, $\omega = 2\pi \times 2 = 4\pi\,rad/s^2$

So acceleration $= \omega^2 r = (4\pi)^2 \times \frac{25}{100}m/s^2 = 4\pi^2$

47. The maximum and minimum tension in the string whirling in a circle of radius $2.5\,m$ with constant velocity are in the ratio $5:3$ then its velocity is

(A) ✓$\sqrt{98}\ m/s$ (B) $7\ m/s$

(C) $\sqrt{490}\ m/s$ (D) $\sqrt{4.9}$

Sol : (a) In this problem it is assumed that particle although moving in a vertical loop but its speed remain constant.

Tension at lowest point $T_{\max} = \frac{mv^2}{r} + mg$

Tension at highest point $T_{\min} = \frac{mv^2}{r} - mg$

$$\frac{T_{\max}}{T_{\min}} = \frac{\frac{mv^2}{r} + mg}{\frac{mv^2}{r} - mg} = \frac{5}{3}$$

by solving we get,$v = \sqrt{4gr} = \sqrt{4 \times 9.8 \times 2.5} = \sqrt{98}\,m/s$

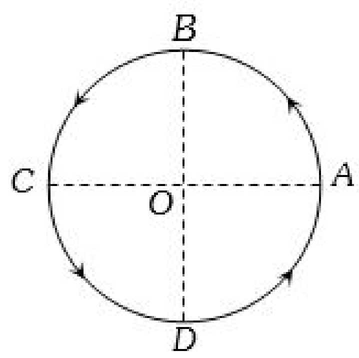
48. A hollow sphere has radius $6.4\,m$. Minimum velocity required by a motor cyclist at bottom to complete the circle will be .... m/s

(A) ✓17.7 (B) 10.2

(C) 12.4 (D) 16.0

Sol : (a)$v_{\min} = \sqrt{5\,gr} = 17.7\,m/\sec$

49. Figure shows a body of mass m moving with a uniform speed v along a circle of radius r. The change in velocity in going from A to B is



(A) ✓$v\sqrt{2}$ (B) $v/\sqrt{2}$

(C) v (D) zero

Sol : (a)$\left|\overrightarrow{\Delta v}\right| = 2v\sin(\theta/2) = 2v\sin\left(\frac{90}{2}\right) = 2v\sin 45 = v\sqrt{2}$

50. 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

(A) 1 (B) 2

(C) ✓3 (D) 5

Sol : (c) Using relation $\theta=\omega_0 t+\frac{1}{2}at^2$

$\theta_1=\frac{1}{2}(\alpha)(2)^2=2\alpha...(i)$ (As $\omega_0=0, t=2$ sec)

Now using same equation for $t=4\,sec$, $\omega_0=0$

$\theta_1+\theta_2=\frac{1}{2}\alpha(4)^2=8\alpha...(ii)$

From (i) and (ii),

$\theta_1=2\alpha$and$\theta_2=6\alpha \ \ \frac{\theta_2}{\theta_1}=3$

51. 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 $10m/sec^2$. In order to avoid skidding, he must not bend with respect to the vertical plane by an angle greater than

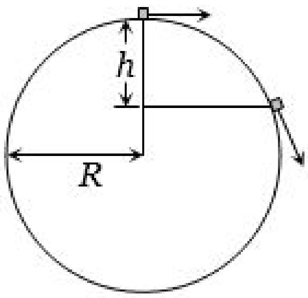
(A) $\theta=\tan^{-1}6$ (B) $\checkmark\theta=\tan^{-1}2$

(C) $\theta=\tan^{-1}25.92$ (D) $\theta=\tan^{-1}4$

Sol : (b)$v=72\,km/hour=20\,m/\sec$

$\theta=\tan^{-1}\left(\frac{v^2}{rg}\right)=\tan^{-1}\left(\frac{20\times 20}{20\times 10}\right)=\tan^{-1}(2)$

52. A particle originally at rest at the highest point of a smooth vertical circle is slightly displaced. It will leave the circle at a vertical distance h below the highest point such that



(A) $h=R$ (B) $\checkmark h=\frac{R}{3}$

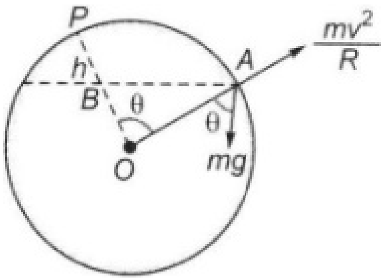
(C) $h=\frac{R}{2}$ (D) $h=\frac{2R}{3}$

Sol : $h=R-R\cos\theta, v=\sqrt{2gh}=\sqrt{2gR(1-\cos\theta)}$

$mg\cos\theta-N=\frac{mv^2}{R}$

When it leaves circle: $N=0 \ mg\cos\theta=\frac{mv^2}{R}\Rightarrow\cos\theta=\frac{2}{3}$

$h=R-R\cos\theta=\frac{R}{3}$



53. 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

(A) $\frac{Ml}{M+m}$ (B) $\checkmark\frac{ml}{M+m}$

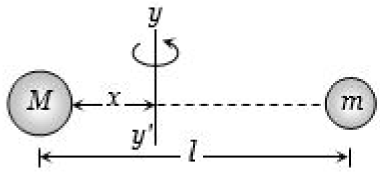
(C) $\frac{M+m}{M}l$ (D) $\frac{M+m}{m}l$

Sol : (b)If the both mass are revolving about the axis yy' and tension in both the threads are equal then

$M\omega^2x=m\omega^2(l-x)$

$\Rightarrow Mx=m(l-x)$

$\Rightarrow x=\frac{ml}{M+m}$



54. An athlete completes one round of a circular track of radius $10\,m$ in $40\,sec$. The distance covered by him in $2\,min\ 20\,sec$ is .... m

(A) 70 (B) 140

(C) 110 (D) $\checkmark 220$

Sol : (d) Time period $=40\,sec$

No. of revolution $=\frac{\text{Totaltime}}{\text{Timeperiod}}=\frac{140\text{ sec}}{40\text{ sec}}=3.5\,Rev.$

So, distance $=3.5\times 2\pi R=3.5\times 2\pi\times 10=220\,m.$

55. A stone of mass m is tied to a string and is moved in a vertical circle of radius r making n revolutions per minute. The total tension in the string when the stone is at its lowest point is

(A) mg (B) $m(g+\pi\,n\,r^2)$

(C) $m(g+\pi\,n\,r)$ (D) $\checkmark m\{g+(\pi^2\,n^2\,r)/900\}$

Sol : (d) $T=mg+m\omega^2r=m\{g+4\pi^2n^2r\}$

$=m\left\{g+\left(4\pi^2\left(\frac{n}{60}\right)^2r\right)\right\}$

$=m\left\{g+\left(\frac{\pi^2n^2r}{900}\right)\right\}$

56. A body crosses the topmost point of a vertical circle with critical speed. Its centripetal acceleration, when the string is horizontal will be

(A) $6\,g$ (B) $\checkmark 3\,g$

(C) $2\,g$ (D) g

Sol : (b)$v=\sqrt{3gr}$ and $a=\frac{v^2}{r}=\frac{3gr}{r}=3g$

57. A person with his hands in his pockets is skating on ice at the velocity of $10\,m/s$ and describes a circle of radius $50\,m$. What is his inclination with vertical

(A) $\tan^{-1}\left(\frac{1}{10}\right)$ (B) $\tan^{-1}\left(\frac{3}{5}\right)$

(C) $\tan^{-1}(1)$ (D) $\checkmark\tan^{-1}\left(\frac{1}{5}\right)$

Sol : (d) The inclination of person from vertical is given by,

$\tan\theta=\frac{v^2}{rg}=\frac{(10)^2}{50\times 10}=\frac{1}{5}$

$\Rightarrow\theta=\tan^{-1}(1/5)$

58. A ball is moving to and fro about the lowest point A of a smooth hemispherical bowl. If it is able to rise up to a height of $20\,cm$ on either side of A, its speed at A must be .... m/s (Take = $10m/s^2$, mass of the body $5\,g$)

(A) 0.2 (B) $\checkmark 2$

(C) 4 (D) 4.5

Sol : (b)$v=\sqrt{2gh}=\sqrt{2\times 10\times 0.2}=2\,m/s$

59. A ball of mass $0.1\,Kg.$ is whirled in a horizontal circle of radius $1\,m.$ by means of a string at an initial speed of $10\,R.P.M.$ Keeping the radius constant, the tension in the string is reduced to one quarter of its initial value. The new speed is .... $r.p.m.$

(A) $\checkmark 5$ (B) 10

(C) 20 (D) 14

Sol : (a) $T=m\omega^2r\Rightarrow\omega\propto\sqrt{T}$

$\therefore\frac{\omega_2}{\omega_1}=\sqrt{\frac{1}{4}}\Rightarrow\omega_2=\frac{\omega_1}{2}=5\,rpm$

60. A cyclist goes round a circular path of circumference $34.3\,m$ in $\sqrt{22}$ sec. the angle made by him, with the vertical, will be .... ^{o}

(A) $\checkmark 45$ (B) 40

(C) 42 (D) 48

Sol : (a) $2\pi r=34.3\Rightarrow r=\frac{34.3}{2\pi}$ and $v=\frac{2\pi r}{T}=\frac{2\pi r}{\sqrt{22}}$

Angle of binding $\theta=\tan^{-1}\left(\frac{v^2}{rg}\right)=45°$