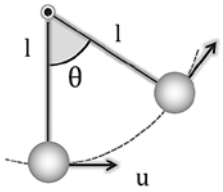
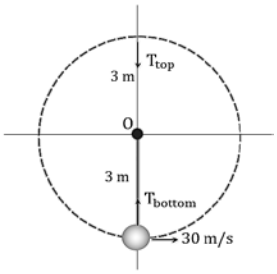
**Tension in string**

**Q.1** In the figure shown below, $u = \sqrt{7gl}$ and mass of the bob is 3 kg. Find the value of tension in the string when angle $\theta = 180°$ [Takeg $= 10\ m/s^2$]



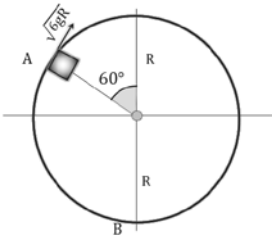

**(A)**40 N **(B)**30 N **(C)**0 N **(D)**60 N

**Q.2** A ball of mass 2 kg is tied to a string 3 m long and is rotated at a constant speed of 30 m/s in a vertical circle. The ratio of the tensions at the top and bottom is (Take $g = 10\ m/s^2$)



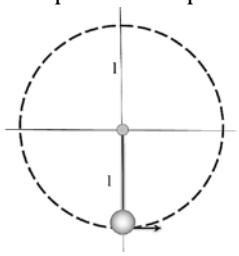

**(A)**$\frac{39}{41}$ **(B)**$\frac{11}{18}$ **(C)**$\frac{39}{31}$ **(D)**$\frac{29}{31}$

**Q.3** Figure shows a smooth vertical circular track of radius R. A block slides along the surface AB when it is given a velocity equal to $\sqrt{6gR}$ at point A. The ratio of the force exerted by the track on the block at point A to that at point B is.




**(A)**0.25 **(B)**0.35 **(C)**0.45 **(D)**0.55

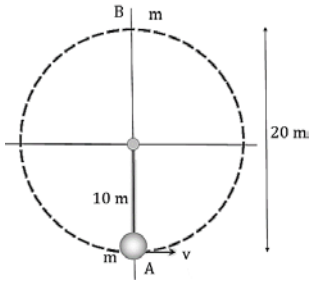
**Q.4** A particle of mass m is fixed to one end of a light rigid rod of length l and rotated in a vertical circular path about its other end. The minimum speed of the particle at its highest point must be:



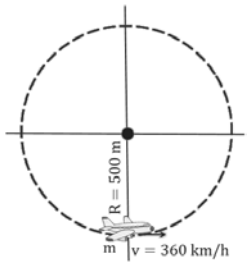

**(A)**Zero **(B)**$\sqrt{gl}$ **(C)**$\sqrt{1.5gl}$ **(D)**$\sqrt{2gl}$

**Q.5** What horizontal speed should be given to a particle of mass m attached to a rigid rod of length 10 m so that it describes a complete vertical circular motion?

**(A)** 22.36 m/s **(B)** 10 m/s
**(C)** 20 m/s **(D)**Depend upon the mass of particle

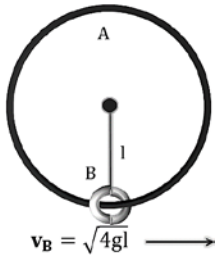



**Q.6** An aircraft executes a vertical turn of radius R = 500 m with a constant velocity v = 360 km/h. The normal reaction on the pilot of mass m = 70 kg at the lower, upper and middle points of the loop will respectively be:



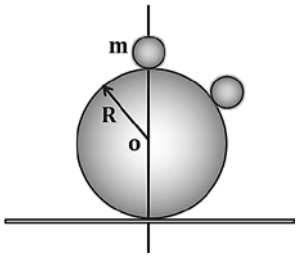

**(A)** 210 N, 700 N, 1400 N **(B)** 1400 N, 700 N, 2100 N
**(C)** 700 N, 1400 N, 2100 N **(D)** 2100 N, 700 N, 1400 N

**Q.7** A small ring is attached to the vertical ring as shown in figure. The small ring is given velocity $v_B = \sqrt{4gl}$ by a sharp hit where l is radius of the vertical ring. Find the normal force acting on the small ring at the topmost point, if the mass of the small ring is m and mass of the vertical ring is M.



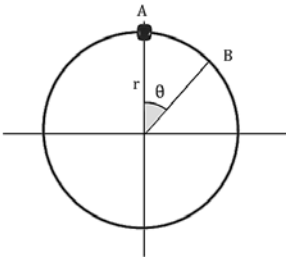

**(A)** 2 mg **(B)** 2 Mg **(C)** mg **(D)** Mg

**Q.8** A spherical ball of mass m begins to slide down a fixed smooth sphere from the top with negligible initial velocity. What is its tangential acceleration when it breaks off the sphere?



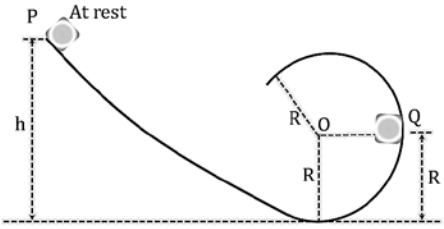

**(A)** $\frac{2g}{3}$ **(B)** $\frac{g}{3}$
**(C)** $\frac{\sqrt{5}}{3}$ **(D)** Ball never leaves contact

**Q.9** A bead can slide on a smooth circular wire frame of radius r which is fixed in the vertical plane. The bead is displaced slightly from the highest point of the wire frame. The speed of the bead subsequently as a function of the angle θ made by the bead with the vertical line is.




**(A)** $\sqrt{2grsin\theta}$ **(B)** $\sqrt{2gr(1-sin\theta)}$ **(C)** $\sqrt{2gr(1-cos\theta)}$ **(D)** $\sqrt{2grcos\theta}$

**Q.10** A small block of mass m slides along a smooth frictionless track as shown in the figure. If the block starts from rest at P at height h from the bottom, then which of the following statements are true?




**(A)** The resultant force acting on the block at Q is $\sqrt{75}$mg.

**(B)** If the force exerted by the block against the track at the top of the loop equals its weight, then h $= 3R$.

**(C)** The resultant force acting on the block at Qis $\sqrt{65}$mg.

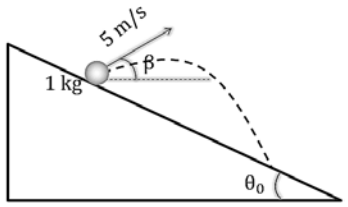
**(D)** If the block should not fall off at the top of the circular track, it must be released from a minimum height h $= \frac{5R}{2}$

WORK SHEET

**Q.11** Two forces whose magnitudes are in the ratio 3: 5 give a resultant of 28 N. If the angle of their inclination is 60°, find the magnitude of the larger force.

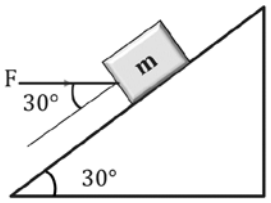
**(A)**24 N **(B)**28 N **(C)**32 N **(D)**20 N

**Q.12** An inclined plane makes as angle $\theta_0 = 30°$ with the horizontal. A particle is projected from this plane with a speed of 5 m/s at an angle of elevation $\beta = 30°$ with the horizontal as shown in the figure. Find the range of the particle on the plane when it strikes the plane. (Assume the incline is long enough and $g = 10\ m/s^2$)



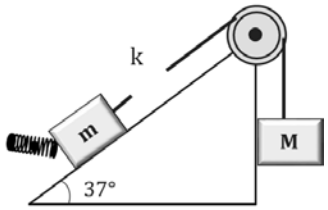

**(A)**3.5 m **(B)**4 m **(C)**4.2 m **(D)**5 m

**Q.13** A block of mass m is in equilibrium on an inclined plane as shown. Find out the normal force acting on the block.



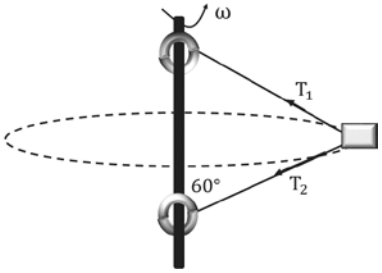

**(A)**$\frac{2mg}{\sqrt{3}}$ **(B)**$\frac{4mg}{\sqrt{3}}$ **(C)**$\frac{\sqrt{3}\,mg}{4}$ **(D)**$\frac{mg}{2\sqrt{3}}$

**Q.14** A block of mass m is attached with a massless spring of force constantk. The block is placed over a rough inclined surface for which the coefficient of friction is 0.5. M is released from rest when the spring was unscratched. The minimum value of M required to move the block m up the plane is (neglect mass of string and pulley and friction in pulley)



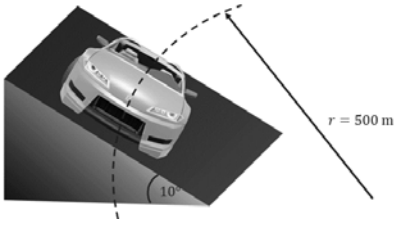

**(A)**$\frac{m}{2}$ **(B)**$\frac{m}{3}$ **(C)**$\frac{m}{4}$ **(D)**None of these

**Q.15** A small block is connected to one end of two identical massless strings of length $16\frac{2}{3}$cm each with their other ends fixed to a vertical rod. If the ratio of tensions $\frac{T_1}{T_2}$is 4: 1, then what will be the angular velocity of the block? [Take $g = 9.8\ ms^{-2}$]



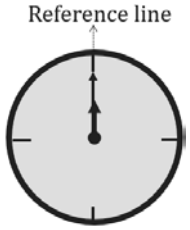

**(A)**7 rad/s **(B)**8.5 rad/s **(C)**11 rad/s **(D)**14 rad/s

**Q.16** A circular road course track has a radius of 500 m and is banked to 10°. If the coefficient of friction between the road and tyre is 0.25, compute (i) the maximum speed to avoid slipping (ii) optimum speed to avoid wear and tear of the tires. [Taketan $10° = 0.1763$]



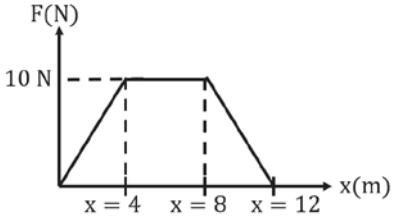

**(A)**46.74 m/s, 29.39 m/s **(B)**30 m/s, 24 m/s
**(C)**74.46 m/s, 23.39 m/s **(D)**50 m/s, 44 m/s

**Q.17** Find the time period of meeting of the minute hand and second hand of a clock. (initial positions are shown in the figure below)




**(A)** $\frac{59}{60}$ min **(B)** $\frac{60}{59}$ min **(C)** $\frac{3}{4}$ min **(D)** $\frac{3}{8}$ min

**Q.18** A particle of mass 0.1 kg is subjected to a force which varies with distance as shown. If it starts its journey from rest at $x = 0$, then its velocity at $x = 12$ m is.

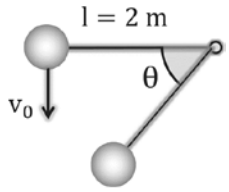



**(A)**10 m/s **(B)**20 m/s **(C)**$20\sqrt{3}$ m/s **(D)**40 m/s

**Q.19** Two blocks of masses $m_1$ and $m_2$ interconnected by a spring of stiffness k are placed on a horizontal surface. If a constant horizontal force F acts on the block $m_1$ it slides through a distance x whereas $m_2$ remains stationary. If the coefficient of friction between all contacting surfaces is μ, find the speed of the block $m_1$ as a function of x.

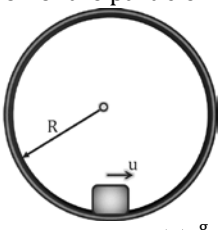

**(A)** $v = \sqrt{(\frac{F}{m_1} - 2\mu g)x - \frac{k}{m_1}x^2}$ **(B)** $v = \sqrt{2(\frac{F}{m_1} - \mu g)x - \frac{2k}{m_1}x^2}$
**(C)** $v = \sqrt{(\frac{F}{m_1} - \mu g)x - \frac{k}{m_1}x^2}$ **(D)** $v = \sqrt{2(\frac{F}{m_1} - \mu g)x - \frac{k}{m_1}x^2}$

**Q.20** A small sphere is given vertical velocity of magnitude $v_0 = 5\ ms^{-1}$ and it swings in a vertical plane about the end of a massless string. The angle θ with the vertical at which the string will break, given that it can withstand a maximum tension equal to twice the weight of the sphere, is.



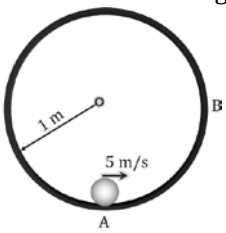

**(A)** $\cos^{-1}\frac{2}{3}$ **(B)** $\cos^{-1}\frac{1}{4}$ **(C)** $60°$ **(D)** $30°$

**Q.21** A particle is given an initial speed u inside a smooth spherical shell of radius R = 1 m and it is just able to complete the circle. Acceleration of the particle when its velocity is vertical is:



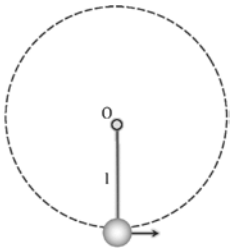

**(A)** $g\sqrt{10}$ **(B)** g. **(C)** $\frac{g}{\sqrt{2}}$ **(D)** $\frac{g}{\sqrt{6}}$

**Q.22** A ball of mass 1 kg moves inside a smooth fixed spherical shell of radius 1 m with an initial velocity v = 5 m/s from the bottom. What is the total force acting on the particle at pointB?




**(A)** 10 N **(B)** 25 N **(C)** $5\sqrt{5}$ N **(D)** 5 N

**Q.23** A ball at the end of a string is being swing in a vertical circle at a constant velocity. Which of these statements about the forces acting on the ball and the acceleration of the ball are true?

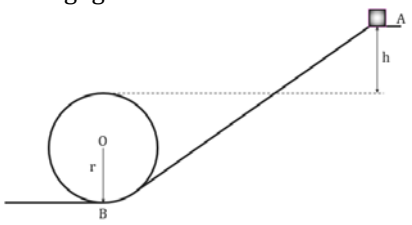



**(A)** The tension in the string at the top of its circular path and the bottom of its circular path are equal in magnitude.
**(B)** At the bottom of the circular path, the tension in the string acts up while the acceleration of the ball is down.
**(C)** The string is perfectly horizontal two times in the circular path, once on the way up and once on the way down. The only difference in the net force between these situations is the direction of the tension force.
**(D)** At the top of its circular path, the tension in the string acts down while the acceleration of the ball is up.

**Q.24** A small ring is connected to another larger ring of radius 5 m. The small ring is given an initial velocity of 10 m/s at the bottom of the larger ring. Will the small ring complete a loop around the larger ring? If not, how high will the small ring rise? Assume that there is no friction between the surfaces. [Take $g = 10\ m/s^2$]

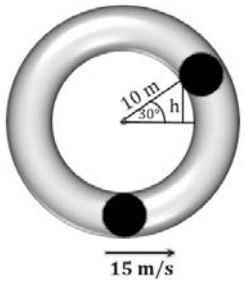
**(A)** The smaller ring rises to a height of 5 m above the initial position.
**(B)** The smaller ring completes a circle around the larger ring.
**(C)** The smaller ring rises to a height of 7.5 m above the initial position.
**(D)** The smaller ring rises to a height of 10 m above the initial position.

**Q.25** Figure shows a loop track of radius r. A box starts sliding from a platform at a distance (h) above the top of the loop and goes around the loop without falling off the track. Find the minimum value of h for a successful looping. Friction is negligible at all surfaces.



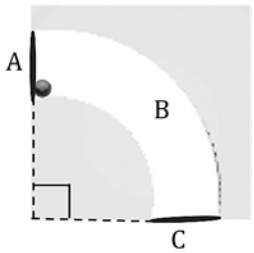

**(A)** 2 r **(B)** r **(C)** $\frac{r}{2}$ **(D)** $\frac{3r}{2}$

**Q.26** A metal bead of mass 500 g placed inside a hollow circular tube of radius 10 m is initially at rest at the bottom-most point. It is given an initial velocity of 15 m/s such that it moves along the hollow circular tube. Can the metal bead subtend an angle of 30° with the positive horizontal axis? If yes, what is the kinetic energy at this point? [Take $g = 10\ m/s^2$]




**(A)** The kinetic energy at this point is 56.25 J.
**(B)** It cannot subtend an angle of 30° with the positive horizontal axis.
**(C)** The kinetic energy at this point is 18.75 J.
**(D)** The kinetic energy at this point is 75 J.

**Q.27** The tube AC forms a quarter circle in a vertical plane. The ball B has an area of cross-section slightly smaller than that of the tube, and can move without friction through it. Ball is placed at A and displaced slightly. It will



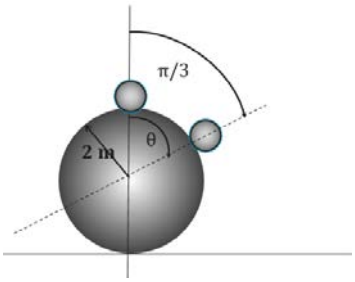

**(A)** Always be in contact with the inner wall of the tube
**(B)** Always be in contact with the outer wall of the tube.
**(C)** Initially be in contact with the inner wall and later with the outer wall.
**(D)** Initially be in contact with the outer wall and later with the inner wall.

**Q.28** A small box of mass m is placed on the outer surface of a smooth fixed sphere of radius R at a point where the radius makes an angle $\phi$ with the vertical. The box is released from this position. Find the distance travelled by the box before it leaves contact with the sphere.

**(A)** $R\left[\cos^{-1}\left(\frac{2}{3}\sin\theta\right)-\phi\right]$ **(B)** $R\left[\cos^{-1}\left(\frac{2}{3}\cos\phi\right)-\phi\right]$

**(C)** $R\left[\cos^{-1}\left(\frac{1}{3}\sin\theta\right)-\phi\right]$ **(D)** $R\left[\cos^{-1}\left(\frac{1}{3}\cos\phi\right)-\phi\right]$

**Q.29** A particle placed on top of a smooth sphere of radius 2 m slides through a distance of $\frac{\pi}{3}$ m and falls off the sphere. What is the velocity of the particle when it is about to drop off the surface of the sphere?




**(A)** 0 m/s **(B)** 5.16 m/s **(C)** 4.16 m/s **(D)** 10 m/s

**Q.30** The bike of a stunt driver can achieve a maximum instantaneous velocity of 40 m/s. He starts at the base of a vertical circular track and intends to complete the vertical circle. What is the maximum radius of the track to ensure the safety of the driver?


**ANSWER KEY**

| Q. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Sol. | (D) | (D) | (D) | (A) | (C) | (D) | (C) | (C) | (C) | (B,C,D) |
| WORK SHEET | | | | | | | | | | |
| Q. | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| Sol. | (D) | (D) | (A) | (A) | (D) | (A) | (B) | (D) | (D) | (B) |
| Q. | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| Sol. | (A) | (C) | (C) | (A) | (C) | (C) | (C) | (B) | (C) | 32 m |