Exercise - I (Objective Problems)

(A) CIRCULAR MOTION

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

(A) 800 rad (B) 400 rad
(C) 200 rad (D) 100 rad

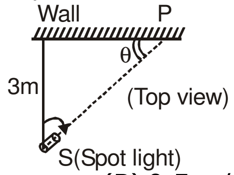
Sol.

2. 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 :

(A) 2π & 0 mm/s (B) $2\sqrt{2}\pi$ & 4.44 mm/s
(C) $2\sqrt{2}\pi$ & 2π mm/s (D) 2π & $2\sqrt{2}\pi$ mm/s

Sol.

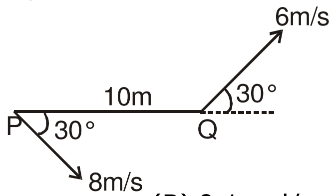
3. A spot light S rotates in a horizontal plane with a constant angular velocity of 0.1 rad/s. The spot of light p moves along the wall at a distance 3 m. What is the velocity of the spot P when $\theta = 45°$?



(A) 0.6 m/s (B) 0.5 m/s
(C) 0.4 m/s (D) 0.3 m/s

Sol.

4. Two moving particle P and Q are 10 m apart at a certain instant. The velocity of P is 8m/s making an angle 30° with the line joining P and Q and that of Q is 6m/s making an angle 30° with PQ as shown in the figure. Then angular velocity of P with respect to Q is



(A) Zero (B) 0.1 rad/sec
(C) 0.4 rad/sec (D) 0.7 rad sec

Sol.

5. The magnitude of displacement of a particle moving in a circle of radius a with constant angular speed ω varies with time t as

(A) $2\,a\,\sin\omega t$ (B) $2a\sin\frac{\omega t}{2}$

(C) $2a\,\cos\omega t$ (D) $2a\cos\frac{\omega t}{2}$

Sol.

6. Two bodies A & B rotate about an axis, such that angle θ_A (in radians) covered by first body is proportional to square of time, & θ_B (in radians) covered by second body varies linearly. At t = 0, $\theta_A = \theta_B = 0$. If A completes its first revolution in $\sqrt{\pi}$ sec. & B needs 4π sec. to complete half revolution then; angular velocity $\omega_A : \omega_B$ at t = 5 sec. are in the ratio

(A) 4 : 1 (B) 20 : 1

(C) 80 : 1 (D) 20 : 4

Sol.

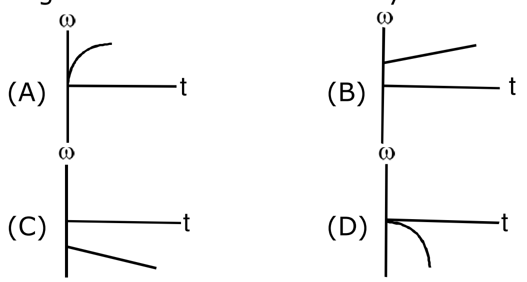
7. A particle moves along a circle of radius $\left(\frac{20}{\pi}\right)$ m with constant tangential acceleration. If the velocity of the particle is 80 m/s at the end of the second revolution after motion has begun, the tangential acceleration is :

(A) $160\,\pi$ m/s^2 (B) $40\,\pi$ m/s^2

(C) 40 m/s^2 (D) $640\,\pi$ m/s^2

Sol.

8. The graphs below show angular velocity as a function of time. In which one is the magnitude of the angular acceleration constantly decreasing?



Sol.

9. A particle moves with deaceleration along the circle of radius R so that at any moment of time its tangential and normal accelerations are equal in moduli. At the initial moment t = 0 the speed of the particle equals v_0, then :

(i) the speed of the particle as a function of the distance covered s will be

(A) $v = v_0\, e^{-s/R}$ (B) $v = v_0 e^{s/R}$

(C) $v = v_0 e^{-R/s}$ (D) $v = v_0 e^{R/s}$

(ii) the total acceleration of the particle as function of velocity and distance covered

(A) $a = \sqrt{2}\frac{v^2}{R}$ (B) $a = \sqrt{2}\frac{v}{R}$

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

Sol.

10. If angular velocity of a disc depends an angle rotated θ as $\omega = \theta^2 + 2\theta$, then its angular acceleration α at θ = 1 rad is

(A) 8 rad/sec^2 (B) 10 rad/sec^2

(C) 12 rad/sec^2 (D) None

Sol.

11. A particle moves along an arc of a circle of radius R. Its velocity depends on the distance covered as $v = a\sqrt{s}$, where a is a constant then the angle α between the vector of the total acceleration and the vector of velocity as a function of s will be

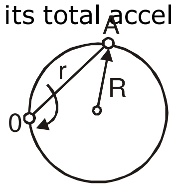
(A) $\tan\alpha = \frac{R}{2s}$ (B) $\tan\alpha = 2s / R$

(C) $\tan \alpha = \frac{2R}{s}$ (D) $\tan\alpha = \frac{s}{2R}$

Sol.

Sol.

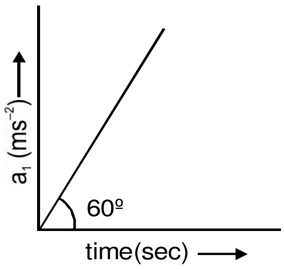
12. A particle A moves along a circle of radius R = 50 cm so that its radius vector r relative to the point O (Fig.) rotates with the constant angular velocity ω = 0.40 rad/s. Then modulus of the velocity of the particle, and the modulus of its total acceleration will be



(A) v = 0.4 m/s, a = 0.4 m/s^2
(B) v = 0.32 m/s, a = 0.32 m/s^2
(C) v = 0.32 m/s, a = 0.4 m/s^2
(D) v = 0.4 m/s, a = 0.32 m/s^2

Sol.

13. Tangential acceleration of a particle moving in a circle of radius 1 m varies with time t as (initial velocity of particle is zero). Time after which total cceleration of particle makes and angle of 30º with radial acceleration is

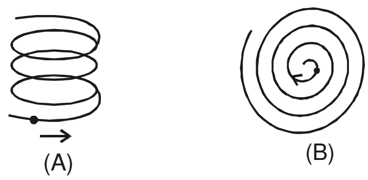


(A) 4 sec (B) 4/3 sec

(C) $2^{2/3}$ sec (D) $\sqrt{2}$ sec

Sol.

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



(A) The velocity of the particle is constant in both cases
(B) The acceleration of the particle is constant in both cases
(C) The magnitude of acceleration is constant in (A) and decreasing in (B)
(D) The magnitude of acceleration is decreasing continuously in both the cases

Sol.

15. 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 :

(A) 1 : 4 (B) 4 : 1 (C) 1 : $\sqrt{2}$ (D) $\sqrt{2}$: 1

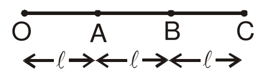
Sol.

16. A stone of mass of 16 kg is attached to a string 144 m long and is whirled in a horizontal smooth surface. The maximum tension the string can withstand is 16 newton. The maximum speed of revolution of the stone without breaking it, will be :

(A) 20 ms^{-1} (B) 16 ms^{-1} (C) 14 ms^{-1} (D) 12 ms^{-1}

Sol.

17. 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 the tensions in the three sections of the string is : (Assume that the string remains straight)



(A) 3 : 5 : 7 (B) 3 : 4 : 5

(C) 7 : 11 : 6 (D) 3 : 5 : 6

Sol.

18. A particle is kept fixed on a turntable rotating uniformly. As seen from the ground, the particle goes in a circle, its speed is 20 cm/s and acceleration is 20 cm/s^2. The particle is now shifted to a new position to make the radius half of the original value. The new values of the speed and acceleration will be

(A) 10 cm/s, 10 cm/s^2 (B) 10 cm/s, 80 cm/s^2

(C) 40 cm/s, 10 cm/s^2 (D) 40 cm/s, 40 cm/s^2

Sol.

19. A particle moving along a circular path due to a centripetal force having constant magnitude is an example of motion with :
(A) constant speed and velocity
(B) variable speed and velocity
(C) variable speed and constant velocity
(D) constant speed and variable velocity.
Sol.

20. A curved section of a road is banked for a speed v. If there is no friction between road and tyres of the car, then :
(A) car is more likely to slip at speeds higher than v than speeds lower than v
(B) car cannot remain in static equilibrium on the curved section
(C) car will not slip when moving with speed v
(D) none of the above
Sol.

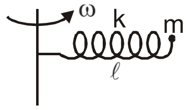
21. The kinetic energy k of a particle moving along a circle of radius R depends on the distance covered s as $k = as^2$ where a is a positive constant. The total force acting on the particle is :

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

(C) 2 as (D) $2a\frac{R^2}{S}$

Sol.

22. A particle of mass m is fixed to one end of a light spring of force constant k and unstretched length ℓ. The system is rotated about the other end of the spring with an angular velocity ω, in gravity free space. The increase in length of the spring will be



(A) $\frac{m\omega^2\ell}{k}$ (B) $\frac{m\omega^2\ell}{k-m\omega^2}$

(C) $\frac{m\omega^2\ell}{k+m\omega^2}$ (D) None of these

Sol.

23. A unifrom circular ring of mass per unit length λ and radius R is rotating with angular velocity ω about its own axis in a gravity free space. Tension in the ring is

(A) zero (B) $\frac{1}{2}\lambda R^2 \omega^2$

(C) $\lambda R^2 \omega^2$ (D) $\lambda R \omega^2$

Sol.

24. A uniform rod of mass m and length ℓ rotates in a horizontal plane with an angular velocity ω about a vertical axis passing through one end. The tension in the rod at distance x from the axis is :

(A) $\frac{1}{2}m\omega^2 x$ (B) $\frac{1}{2}m\omega^2 \frac{x^2}{\ell}$

(C) $\frac{1}{2}m\omega^2 \ell\left(1-\frac{x}{\ell}\right)$ (D) $\frac{1}{2}\frac{m\omega^2}{\ell}[\ell^2 - x^2]$

Sol.

25. Water in a bucket is whirled in a vertical circle with a string attached to it. The water does not fall down even when the bucket is inverted at the top of its path. We conclude that :

(A) $mg = \frac{mv^2}{R}$ (B) $mg > \frac{mv^2}{R}$

(C) $mg < \frac{mv^2}{R}$ (D) none of these

Sol.

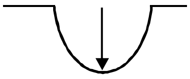
26. A man is standing on a rough ($\mu = 0.5$) horizontal disc rotating with constant angular velocity of 5 rad/sec. At what distance from centre should he stand so that he does not slip on the disc ?

(A) $R \le 0.2$ m (B) $R > 0.2$ m

(C) $R > 0.5$ m (D) $R > 0.3$ m

Sol.

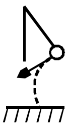
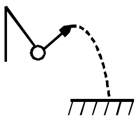
27. A car travelling on a smooth road passes through a curved portion of the road in form of an arc, of circle of radius 10m. If the mass of car is 500 kg, the reaction on car at lowest point P where its speed is 20 m/s is

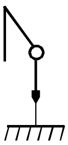
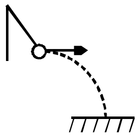


(A) 35 kN (B) 30 kN
(C) 25 kN (D) 20 kN

Sol.

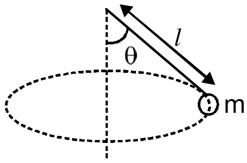
28. A pendulum bob is swinging in a vertical plane such that its angular amplitude is less than 90°. At its highest point, the string is cut. Which trajectory is possible for the bob afterwards.

(A)  (B) 

(C)  (D) 

Sol.

29. A conical pendulum is moving in a circle with angular velocity ω as shown. If tension in the string is T, which of following equations are correct ?



(A) $T = m\omega^2 l$ (B) $T\sin\theta = m\omega^2 l$
(C) $T = mg\cos\theta$ (D) $T = m\omega^2 l\sin\theta$

Sol.

30. A road is banked at an angle of 30° to the horizontal for negotiating a curve of radius $10\sqrt{3}$ m. At what velocity will a car experience no friction while negotiating the curve?

(A) 54 km/hr (B) 72 km/hr
(C) 36 km/hr (D) 18 km/hr

Sol.

31. The ratio of period of oscillation of the conical pendulum to that of the simple pendulum is : (Assume the strings are of the same length in the two cases and θ is the angle made by the string with the vertical in case of conical pendulum)

(A) $\cos\theta$ (B) $\sqrt{\cos\theta}$

(C) 1 (D) none of these

Sol.

32. A particle is moving in a circle:

(A) The resultant force on the particle must be towards the centre.

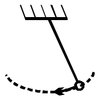
(B) The cross product of the tangential acceleration and the angular velocity will be zero.

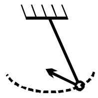
(C) The direction of the angular acceleration and the angular velocity must be the same.

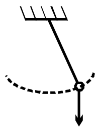
(D) The resultant force may be towards the centre.

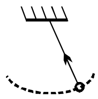
Sol.

33. Which vector in the figures best represents the acceleration of pendulum mass of the intermediate point in its swing?

(A) 

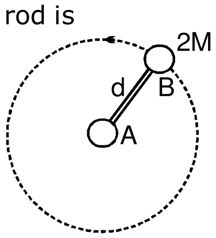
(B) 

(C) 

(D) 

Sol.

34. The dumbell is placed on a frictionless horizontal table. Sphere A is attached to a frictionless pivot so that B can be made to rotate about A with constant angular velocity. If B makes one revolution in period P, the tension in the rod is



(A) $\frac{4\pi^2 Md}{P^2}$ (B) $\frac{8\pi^2 Md}{P^2}$ (C) $\frac{4\pi^2 Md}{P}$ (D) $\frac{2Md}{P}$

Sol.

35. 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 each makes a complete circle in the same time t. The ratio of the angular speeds of the first to the second car is

(A) 1 : 1 (B) $m_1 : m_2$
(C) $r_1 : r_2$ (D) $m_1m_2 : r_1r_2$

Sol.

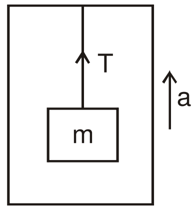
(B) WORK, POWER AND ENERGY

36. A rigid body of mass m is moving in a circle of radius r with a constant speed v. The force on the body is $\frac{mv^2}{r}$ and is directed towards the centre. What is the work done by this force in moving the body over half the cirumference of the circle.

(A) $\frac{mv^2}{\pi r^2}$ (B) Zero
(C) $\frac{mv^2}{r^2}$ (D) $\frac{\pi r^2}{mv^2}$

Sol.

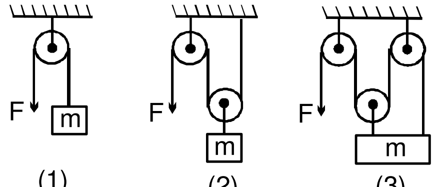
37. A block of mass m is suspended by a light thread from an elevator. The elevator is accelerating upward with uniform acceleration a. The work done by tension on the block during t seconds is :



(A) $\frac{m}{2}(g+a)at^2$ (B) $\frac{m}{2}(g-a)at^2$
(C) $\frac{m}{2}gat^2$ (D) 0

Sol.

38. Equal force F(> mg) is applied to string in all the three cases. Starting from rest, the point of application of force moves a distance of 2 m down in all cases. In which case the block has maximum kinetic energy?



(A) 1 (B) 2
(C) 3 (D) equal in all 3 cases

Sol.

39. Two springs have their force constant as k_1 and $k_2(k_1 > k_2)$. When they are stretched by the same force

(A) No work is done by this force in case of both the springs

(B) Equal work is done by this force in case of both the springs

(C) More work is done by this force in case of second spring

(D) More work is done by this force in case of first spring

Sol.

40. The work done by the frictional force on a surface in drawing a circle of radius r on the surface by a pencil of negligible mass with a normal pressing force N (coefficient of friction μ_k) is :

(A) $4\pi r^2\mu_k N$ (B) $-2\pi r^2\mu_k N$

(C) $-3\pi r^2\mu_k N$ (D) $-2\pi r\mu_k N$

Sol.

41. A body of mass m accelerates uniformly from rest to a speed v_0 in time t_0. The work done on the body till any time t is

(A) $\frac{1}{2}mv_0^2\left(\frac{t^2}{t_0^{\,2}}\right)$ (B) $\frac{1}{2}mv_0^2\left(\frac{t_0}{t}\right)$

(C) $mv_0^2\left(\frac{t}{t_0}\right)$ (D) $mv_0^2\left(\frac{t}{t_0}\right)^3$

Sol.

42. A force $\vec{F} = k[y\hat{i} + x\hat{j}]$ where k is a positive constant acts on a particle moving in x-y plane starting from the point (3, 5), the particle is taken along a straight line to (5, 7). The work done by the force is :

(A) zero (B) 35 K

(C) 20 K (D) 15 K

Sol.

43. A light spring of length 20 cm and force constant 2 kg/cm is placed vertically on a table. A small block of mass 1 kg falls on it. The length h from the surface of the table at which the ball will have the maximum velocity is -

(A) 20 cm (B) 15 cm

(C) 10 cm (D) 5 cm

Sol.

44. The work done is joules in increasing the extension of a spring of stiffness 10 N/cm from 4 cm to 6 cm is :

(A) 1 (B) 10

(C) 50 (D) 100

Sol.

45. When a conservative force does positive work on a body

(A) the potential energy increases

(B) the potential energy decreases

(C) total energy increases

(D) total energy decreases

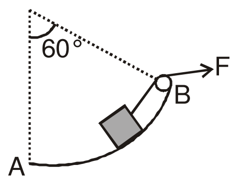
Sol.

46. The P.E. of a certain spring when stretched from natural length through a distance 0.3 m is 10 J. The amount of work in joule that must be done on this spring to stretch it through an additional distance 0.15 m will be

(A) 10 J (B) 20 J (C) 7.5 J (D) 12.5 J

Sol.

47. A 10 kg block is pulled in the vertical plane along a frictionless surface in the form of an arc of a circle of radius 10 m. The applied force is 200 N as shown in the figure. If the block started from rest at A, the velocity at B would be :



(A) 1.732 m/s (B) 17.32 m/s

(C) 173.2 m/s (D) None of these

Sol.

48. A man who is running has half the kinetic energy of the boy of half his mass. The man speeds up by 1 m/s and then has the same kinetic energy as the boy. The original speed of the man was

(A) $\sqrt{2}\,m/s$ (B) $(\sqrt{2}-1)m/s$

(C) 2 m/s (D) $(\sqrt{2}+1)m/s$

Sol.

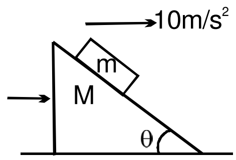
49. A particle is released from rest at origin. It moves under influence of potential field $U = x^2 - 3x$, kinetic energy at x = 2 is

(A) 2 J (B) 1 J

(C) 1.5 J (D) 0 J

Sol.

50. In the figure shown all the surfaces are frictionless, and mass of the block, m = 1kg. The block and wedge are held initially at rest. Now wedge is given a horizontal acceleration of 10 m/s^2 by applying a force on the wedge, so that the block does not slip on the wedge. Then work done by the normal force in ground frame on the block in $\sqrt{3}$ seconds is

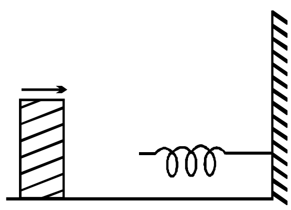


(A) 30 J (B) 60 J

(C) 150 J (D) 100 $\sqrt{3}$ J

Sol.

51. A 1.0 kg block collides with a horizontal weightless spring of force constant 2.75 Nm^{-1} as shown in figure. The block compresses the spring 4.0 m from the rest position. If the coefficient of kinetic friction between the block and horizontal surface is 0.25, the speed of the block at the instant of collision is



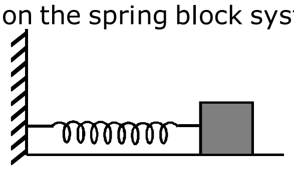
(A) 0.4 ms^{-1} (B) 4 ms^{-1} (C) 0.8 ms^{-1} (D) 8 ms^{-1}

Sol.

Question No. 52 to 53 (2 questions)

A spring block system is placed on a rough horizontal floor. The block is pulled towards right to give spring an elongation less than $\frac{2\mu mg}{K}$ but more than $\frac{\mu mg}{K}$ and released.

52. Which of the following laws/principles of physics can be applied on the spring block system



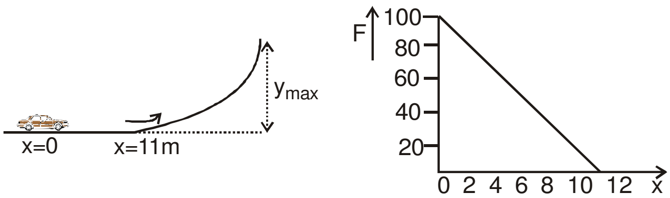
(A) conservation of mechanical energy
(B) conservation of momentum
(C) work energy principle
(D) None

Sol.

53. The correct statement is
(A) The block will cross the mean position
(B) The block come to rest when the forces acting on it are exactly balanced
(C) The block will come to rest when the work done by friction becomes equal to the change in energy stored in spring.
(D) None

Sol.

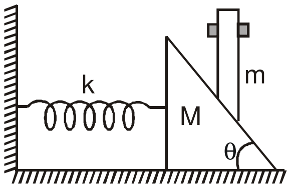
54. A toy car of mass 5 kg moves up a ramp under the influence of force F plotted against displacement x. The maximum height attained is given by



(A) y_{max} = 20 m
(B) y_{max} = 15 m
(C) y_{max} = 11 m
(D) y_{max} = 5 m

Sol.

55. A wedge of mass M fitted with a spring of stiffness 'k' is kept on a smooth horizontal surface. A rod of mass m is kept on the wedge as shown in the figure. System is in equilibrium. Assuming that all surfaces are smooth, the potential energy stored in the spring is :



(A) $\frac{mg^2 \tan^2\theta}{2K}$ (B) $\frac{m^2 g \tan^2\theta}{2K}$

(C) $\frac{m^2 g^2 \tan^2\theta}{2K}$ (D) $\frac{m^2 g^2 \tan^2\theta}{K}$

Sol.

56. A block of mass m is hung vertically from an elastic thread of force constant mg/a. Initially the thread was at its natural length and the block is allowed to fall freely. The kinetic energy of the block when it passes through the equilibrium position will be :

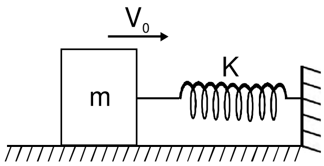
(A) mga (B) mga/2

(C) zero (D) 2mga

Sol.

Question No. 57 to 62 (6 questions)

A block of mass m moving with a velocity v_0 on a smooth horizontal surface strikes and compresses a spring of stiffness k till mass comes to rest as shown in the figure. This phenomenon is observed by two observers:



A : standing on the horizontal surface

B : standing on the block

57. To an observer A, the work done by spring force is

(A) negative but nothing can be said about its magnitude

(B) $-\frac{1}{2}mv_0^2$

(C) positive but nothing can be said about its magnitude

(D) $+\frac{1}{2}mv_0^2$

Sol.

58. To an observer A, the work done by the normal reaction N between the block and the spring on the block is

(A) zero (B) $-\frac{1}{2}mv_0^2$

(C) $+\frac{1}{2}mv_0^2$ (D) none of these

Sol.

59. To an observer A, the net work done on the block is

(A) $-mv_0^2$ (B) $+mv_0^2$

(C) $-\frac{1}{2}mv_0^2$ (D) zero

Sol.

60. According to the observer A

(A) the kinetic energy of the block is converted into the potential energy of the spring

(B) the mechanical energy of the spring-mass system is conserved

(C) the block loses its kinetic energy because of the negative work done the conservative force of spring

(D) all the above

Sol.

61. To an observer B, when the block is compressing the spring

(A) velocity of the block is decreasing

(B) retardation of the block is increasing

(C) kinetic energy of the block is zero

(D) all the above

Sol.

62. According to observer B, the potential energy of the spring increases

(A) due to the positive work done by pseudo force

(B) due to the positive work done by normal reaction between spring & wall

(C) due to the decrease in the kinetic energy of the block

(D) all the above

Sol.

63. A car of mass 'm' is driven with acceleration 'a' along a straight level road against a constant external resistive force 'R'. When the velocity of the car is 'V', the rate at which the engine of the car is doing work will be :

(A) RV (B) maV

(C) (R + ma) V (D) (ma – R)V

Sol.

64. A truck of mass 30,000 kg moves up an inclined plane of slope 1 in 100 at a speed of 30 kmph. The power of the truck is (given g = 10 ms^{-2})

(A) 25 kW (B) 10 kW

(C) 5 kW (D) 2.5 kW

Sol.

65. A particle moves with a velocity $\vec{v} = (5\hat{i} - 3\hat{j} + 6\hat{k})\,m/s$ under the influence of a constant force $\vec{F} = (10\hat{i} + 10\hat{j} + 20\hat{k})N$. The instantaneous power applied to the particle is :

(A) 200 J/s (B) 40 J/s

(C) 140 J/s (D) 170 J/s

Sol.

66. Assume the aerodynamic drag force on a car is proportional to its speed. If the power output from the engine is doubled, then the maximum speed of the car.

(A) is unchanged (B) increases by a factor of $\sqrt{2}$

(C) is also doubled (D) increases by a factor of four.

Sol.

67. A body of mass 1 kg starts moving from rest at t = 0, in a circular path of radius 8 m. Its kinetic energy varies as a function of time as : K.E. = $2t^2$ Joules, where t is in seconds. Then

(A) tangential acceleration = $4 m/s^2$

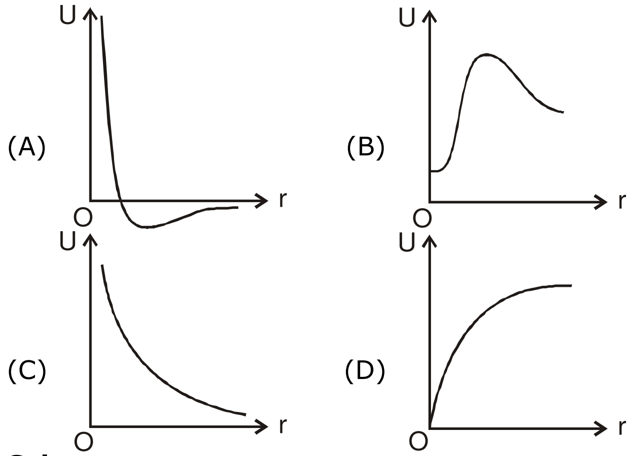
(B) power of all forces at t = 2 sec is 8 watt

(C) first round is completed in 2 sec.

(D) tangential force at t = 2 sec is 4 newton.

Sol.

68. The diagrams represent the potential energy U of a function of the inter-atomic distance r. Which diagram corresponds to stable molecules found in nature.



Sol.

69. The potential energy for a force field $\vec{F}$ is given by U(x, y) = sin (x + y). The force acting on the particle of mass m at $\left(0, \frac{\pi}{4}\right)$ is

(A) 1 (B) $\sqrt{2}$ (C) $\frac{1}{\sqrt{2}}$ (D) 0

Sol.

70. F = $2x^2 - 3x - 2$. Choose correct option

(A) x = –1/2 is position of stable equilibrium
(B) x = 2 is position of stable equilibrium
(C) x = –1/2 is position of unstable equilibrium
(D) x = 2 is position of neutral equilibrium

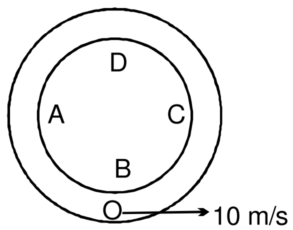
Sol.

71. A particle originally at rest 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 = R/3
(C) h = R/2 (D) h = 2R

Sol.

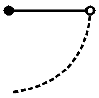
72. A ball whose size is slightly smaller than width of the tube of radius 2.5 m is projected from bottommost point of a smooth tube fixed in a vertical plane with velocity of 10 m/s. If N_1 and N_2 are the normal reactions exerted by inner side and outer side of the tube on the ball

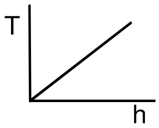


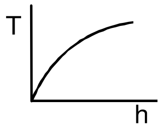
(A) $N_1 > 0$ for motion in ABC, $N_2 > 0$ for motion in CDA
(B) $N_1 > 0$ for motion in CDA, $N_2 > 0$ for motion in ABC
(C) $N_2 > 0$ for motion in ABC & part of CDA
(D) N_1 is always zero.

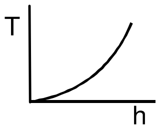
Sol.

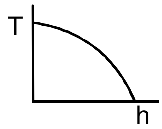
73. A bob attached to a string is held horizontal and released. The tension and vertical distance from point of suspension can be represented by.



(A) 

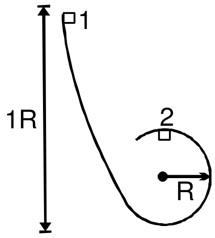
(B) 

(C) 

(D) 

Sol.

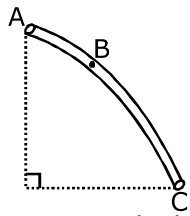
74. A small cube with mass M starts at rest point 1 at a height 4R, where R is the radius of the circular part of the track. The cube slides down the frictionless track and around the loop. The force that the track exerts on the cube at point 2 is nearly _________ times the cube's weight Mg.



(A) 1 (B) 2 (C) 3 (D) 4

Sol.

75. 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. B 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

Sol.

76. A particle is rotated in a vertical circle by connecting it to a light rod of length l and keeping the other end of the rod fixed. The minimum speed of particle when the light rod is horizontal for which the particle will complete the circle is

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

(C) $\sqrt{3gl}$ (D) none

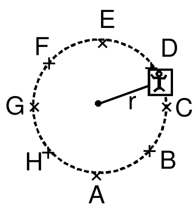
Sol.

Exercise - II (Multiple Correct Problems)

(A) CIRCULAR MOTION

1. A person applies a constant force $\vec{F}$ on a particle of mass m and finds that the particle moves in a circle of radius r with a uniform speed v as seen (in the plane of motion) from an inertial frame of reference.
(A) This is not possible.
(B) There are other forces on the particle.
(C) The resultant of the other forces is $\frac{mv^2}{r}$ towards the centre.
(D) The resultant of the other forces varies in magnitude as well as in direction.
Sol.

2. A machine, in an amusement park, consists of a cage at the end of one arm, hinged at O. The cage revolves along a vertical circle of radius r (ABCDEFGH) about its hinge O, at constant linear speed v = $\sqrt{gr}$. The cage is so attached that the man of weight 'w' standing on a weighing machine, inside the cage, is always vertical. Then which of the following is correct



(A) the reading of his weight on the machine is the same at all positions
(B) the weight reading at A is greater than the weight reading at E by 2 w.
(C) the weight reading at G = w
(D) the ratio of the weight reading at E to that at A = 0
(E) the ratio of the weight reading at A to that at C = 2

Sol.

3. A simple pendulum of length l and mass (bob) M is oscillating in a plane about a vertical line between angular limits $-\phi$ and ϕ. For an angular displacement θ, $[|\theta| < \phi]$ the tension in the string and velocity of the bob are T and v respectively. The following relations hold good under the above conditions :
(A) $T \cos\theta = Mg$
(B) $T - Mg\cos\theta = \frac{Mv^2}{L}$
(C) Tangential acc. = $g \sin\theta$
(D) $T = Mg\cos\theta$
Sol.

(B) W.P.E

4. No work is done by a force on an object if
(A) the force is always perpendicular to its velocity
(B) the force is always perpendicular to its acceleration
(C) the object is stationary but the point of application of the force moves on the object.
(D) the object moves in such a way that the point of application of the force remains fixed.

Sol.

5. One end of a light spring of spring constant k is fixed to a wall and the other end is tied to a block placed on a smooth horizontal surface. In a displacement, the work done by the spring is $\frac{1}{2}kx^2$.

The possible cases are :

(A) the spring was initially compressed by a distance x and was finally in its natural length

(B) it was initially stretched by a distance x and finally was in its natural length

(C) it was initially in its natural length and finally in a compressed position.

(D) it was initially in its natural length and finally in a stretched position.

Sol.

6. Work done by force of friction

(A) can be zero

(B) can be positive

(C) can be negative

(D) information insufficient

Sol.

7. When total work done on a particle is positive

(A) KE remains constant (B) Momentum increases

(C) KE decreases (D) KE increases

Sol.

8. A particle with constant total energy E moves in one dimension in a region where the potential energy is U(x). The speed of the particle is zero where

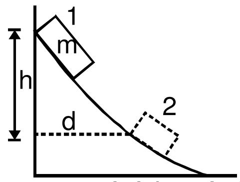
(A) U(x) = E (B) U(x) = 0

(C) $\frac{dU(x)}{dx} = 0$ (D) $\frac{d^2U(x)}{dx^2} = 0$

Sol.

9. A block of mass m slides down a plane inclined at an angle θ. Which of the following will NOT increase the energy lost by the block due to friction ?
(A) Increasing the angle of inclination
(B) Increasing the distance that the block travels
(C) Increasing the acceleration due to gravity
(D) Increasing the mass of the block
Sol.

10. A box of mass m is released from rest at position on the frictionless curved track shown. It slides a distance d along the track in time t to reach position 2, dropping a vertical distance h. Let v and a be the instantaneous speed and instantaneous acceleration, respectively, of the box at position 2. Which of the following equations is valid for this situation?



(A) $h = vt$ (B) $h = (1/2)gt^2$

(C) $d = (1/2)at^2$ (D) $mgh = (1/2)mv^2$
Sol.

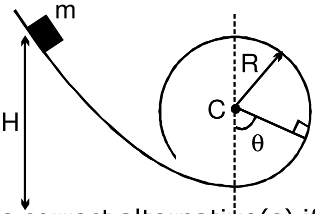
11. A ball of mass m is attached to the lower end of light vertical spring of force constant k. The upper end of the spring is fixed. The ball is released from rest with the spring at its normal (unstreched) length, comes to rest again after descending through a distance x.
(A) $x = mg/k$ (B) $x = 2\ mg/k$
(C) The ball will have no acceleration at the position where it has descended through x/2.
(D) The ball will have an upward acceleration equal to g at its lowermost position.
Sol.

12. A cart moves with a constant speed along a horizontal circular path. From the cart, a particle is thrown up vertically with respect to the cart
(A) The particle will land somewhere on the circular path
(B) The particle will land outside the circular path
(C) The particle will follow an elliptical path
(D) The particle will follow a parabolic path
Sol.

13. The potential energy in joules of a particle of mass 1 kg moving in a plane is given by $U = 3x + 4y$, the position coordinates of the point being x and y, measured in meters. If the particle is initially at rest at (6, 4), then
(A) its acceleration is of magnitude 5 m/s^2
(B) its speed when it crosses the y-axis is 10 m/s
(C) it crosses the y-axis (x = 0) at y = –4
(D) it moves in a straight line passing through the origin (0, 0)
Sol.

Question No. 14 to 16 (3 questions)

A particle of mass m is released from a height H on a smooth curved surface which ends into a vertical loop of radius R, as shown



14. Choose the correct alternative(s) if H = 2R
(A) The particle reaches the top of the loop with zero velocity
(B) The particle cannot reach the top of the loop
(C) The particle breaks off at a height H = R from the base of the loop
(D) The particle break off at a height R < H < 2R

Sol.

15. If θ is instantaneous angle which the line joining the particle and the centre of the loop makes with the vertical, then identify the correct statement(s) related to the normal reaction N between the block and the surface

(A) The maximum value N occurs at $\theta = 0$

(B) The minimum value of N occurs at $N = \pi$ for $H > 5R/2$

(C) The value of N becomes negative for $\pi/2 < \theta < 3\pi/2$

(D) The value of N becomes zero only when $\theta \geq \pi/2$

Sol.

16. The minimum value of H required so that the particle makes a complete vertical circle is given by

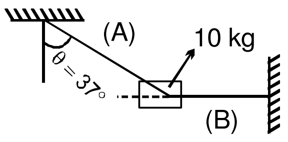
(A) 5 R (B) 4 R (C) 2.5 R (D) 2 R

Sol.

Exercise - III (Subjective Problems)

(A) CIRCULAR MOTION

1. The 10 kg block is in equilibrium.



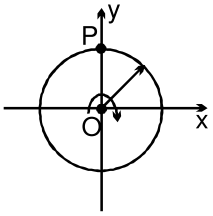
(i) Find the tension in string A.
(ii) Find the tension in string A just after the string B is cut?
Sol.

2. A particle moves in the x-y plane with the velocity $\vec{v} = a\hat{i} + bt\hat{j}$. At the instant $t = a\sqrt{3}/b$ the magnitude of tangential, normal and total acceleration are ________________, _______ & __________.
Sol.

3. A particle moves clockwise in a circle of radius 1 m with centre at (x, y) = (1m, 0). It starts at rest at the origin at time t = 0. Its speed increases at the constant rate of $\left(\frac{\pi}{2}\right)$ m/s^2. (a) How long does it take to travel halfway around the circle ? (b) What is the speed at that time ?
Sol.

4. A point moves along a circle having a radius 20 cm with a constant tangential acceleration 5 cm/s^2. How much time is needed after motion begins for the normal acceleration of the point to be equal to tangential acceleration?
Sol.

5. A ring rotates about z axis as shown in figure. The plane of rotation is xy. At a certain instant the acceleration of a particle P (shown in figure) on the ring is $(6\hat{i} - 8\hat{j})$ m/s^2. find the angular acceleration of the ring & the angular velocity at that instant. Radius of the ring is 2m.



Sol.

6. A particle is revolving in a circle of radius 1m with an angular speed of 12 rad/s. At t = 0, it was subjected to a constant angular acceleration α and its angular speed increased to $(480/\pi)$ rpm in 2 sec. Particle then continues to move with attained speed. Calculate

(a) angular acceleration of the particle,

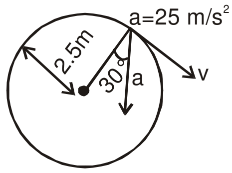
(b) tangential velocity of the particle as a function of time.

(c) acceleration of the particle at t = 0.5 second and at t = 3 second

(d) angular displacement at t = 3 second.

Sol.

7. Figure shows the total acceleration and velocity of a particle moving clockwise in a circle of radius 2.5 m at a given instant of time. At this instant, find :



(a) the radial acceleration,

(b) the speed of the particle and

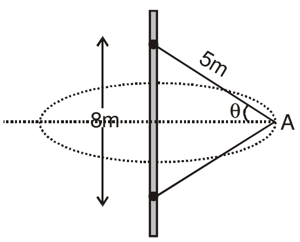
(c) its tangential acceleration

Sol.

8. A stone is launched upward at 45° with speed v_0. A bee follows the trajectory of the stone at a constant speed equal to the initial speed of the stone.
(a) Find the radius of curvature at the top point of the trajectory.
(b) What is the acceleration of the bee at the top point of the trajectory? For the stone, neglect the air resistance.
Sol.

9. A particle moves in circle of radius R with a constant speed v. Then, find the magnitude of average acceleration during a time interval $\frac{\pi R}{2v}$.
Sol.

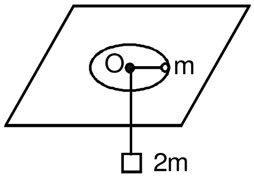
10. A 4 kg block is attached to a vertical rod by means of two strings of equal length. When the system rotaes about the axis of the rod, the strings are extended as shown in figure.
(a) How many revolutions per minute must the system make in order for the tension in the upper chord to be 20 kgf?
(b) What is the tension in the lower chord?



Sol.

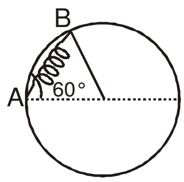
11. A rod of length 1 m is being rotated about its end in a gravity free space with a constant angular acceleration of 5 rad/s^2 starting from rest. A sleeve is fitted on the rod at a distance of 0.5 m from the centre. The coefficient of friction between the rod and the sleeve is 0.05. Find the time after which sleeve will start slipping on the rod.
Sol.

12. A mass m rotating freely in a horizontal circle of radius 1 m on a frictionless smooth table supports a stationary mass 2m, attached to the other end of the string passing through smooth hole O in table, hanging vertically. Find the angular velocity of rotation.



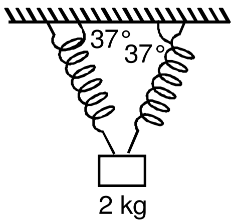
Sol.

13. A beam of mass m is attached to one end of a spring of natural length $\sqrt{3}R$ and spring constant $k = \frac{(\sqrt{3}+1)mg}{R}$. The other end of the spring is fixed at point A on a smooth fixed vertical ring of radius R as shown in the figure. What is the normal reaction at B just after the bead is released?



Sol.

14. The blocks are of mass 2 kg shown is in equilibrium. At t = 0 right spring in fig. (i) and right string in fig. (ii) breaks. Find the ratio of instantaneous acceleration of blocks ?



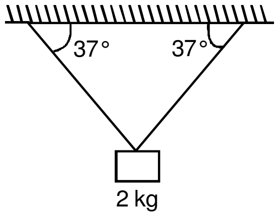


figure (ii)

Sol.

(B) WORK, POWER AND ENERGY

15. A block of mass m is pulled on a rough horizontal surface which has a friction coefficient μ. A force F isapplied which is capable of moving the body uniformly with speed v. Find the work done on the block in time t by (a) weight of the block, (b) Normal reaction by surface on the block, (c) friction, (d) F.

Sol.

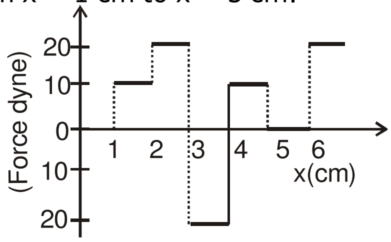
16. Calculate the work done against gravity by a coolie in carrying a load of mass 10 kg on his head when he walks uniformly a distance of 5 m in the (i) horizontal direction (ii) vertical direction. (Take g = 10 m/s^2)

Sol.

17. A body is constrained to move in the y-direction. It is subjected to a force $(-2\hat{i}+15\hat{j}+6\hat{k})$ newton. What is the work done by this force in moving the body through a distance of 10 m ?

Sol.

18. The relationship between force and position is shown in the figure given (in one dimensional case). What will be the work done by the force in displacing a body from x = 1 cm to x = 5 cm.



Sol.

19. It is well known that a raindrop or a small pebble falls under the influence of the downward gravitational force and the opposing resistive force. The latter is known to be proportional to the speed of the drop but is otherwise undetermined. Consider a drop or small pebble of 1 g falling from a cliff of height 1.00 km. It hits the ground with a speed of 50.0 m s^{-1}. What is the work done by the unknown resistive force ?

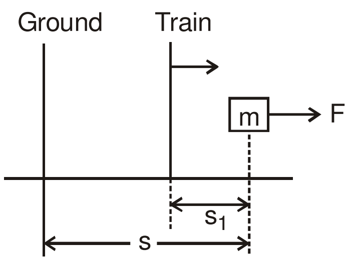
Sol.

20. A rigid body of mass 2 kg initially at rest moves under the action of an applied horizontal force 7 N on a table with coefficient of kinetic friction = 0.1. Calculate the
(a) work done by the applied force on the body in 10 s.
(b) work done by friction on the body in 10 s.
(c) work done by the net force on the body in 10 s.
(d) change in kinetic energy of the body is 10 s.
Sol.

21. A rigid body of mass 0.3 kg is taken slowly up an inclined plane of length 10 m and height 5 m, and then allowed to slide down to the bottom again. The co-efficient of friction between the body and the plane is 0.15. Using g = 9.8 m/s^2 find the

(a) work done by the gravitational force over the round trip.
(b) work done by the applied force (assuming it to be parallel to the inclined plane) over the upward journey
(c) work done by frictional force over the round trip.
(d) kinetic energy of the body at the end of the trip?
Sol.

22. A block of mass m sits at rest on a frictionless table in a rail car that is moving with speed v_c along a straight horizontal track (fig.) A person riding in the car pushes on the block with a net horizontal force F for a time t in the direction of the car's motion.



(a) What is the final speed of the block according to a person in the car ?

Sol.

(b) According to a person standing on the ground outside the train?
Sol.

(c) How much did K of the block change according to the person in the car ?
Sol.

(d) According to the person on the ground ?
Sol.

(e) In terms of F, m, & t, how far did the force displace the object according to the person in car ?
Sol.

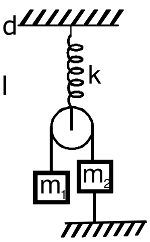
(f) According to the person on the ground ?
Sol.

(g) How much work does each say the force did ?
Sol.

(h) Compare the work done to the K gain according to each person.
Sol.

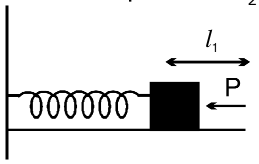
(i) What can your conclude from this computation?
Sol.

23. In the figure shown, pulley and spring are ideal. Find the potential energy stored in the spring ($m_1 > m_2$)



Sol.

24. A block of mass m placed on a smooth horizontal surface is attached to a spring and is held at rest by a force P as shown. Suddenly the force P changes its direction opposite to the previous one. How many times is the maximum extension l_2 of the spring longer compared to its initial compression l_2 ?



Sol.

25. (a) Power applied to a particle varies with time as P = $(3t^2 - 2t + 1)$ watt, where t is in second. Find the change in its kinetic energy between time t = 2 s and t = 4 s.
Sol.

(b) The potential function for a conservative force is given by U = k(x + y). Find the work done by the conservative force in moving a particle from the point A(1, 1) to point B (2, 3).
Sol.

26. A labourer lifts 100 stones to a height of 6 metre in two minute. If mass of each stone be one kilogram, calculate the average power. Given : g = 10 ms^{-2}.
Sol.

27. An engine develops 10 kW of power. How much time will it take to lift a mass of 200 kg through a height of 40 m? Given : g = 10 ms^{-2}
Sol.

28. Two trains of equal masses are drawn along smooth level lines by engines; one of then X exerts a constant force while the other Y works at a constant rate. Both start from rest & after a time t both again have the same velocity v. Find the ratio of travelled distance during the interval.
Sol.

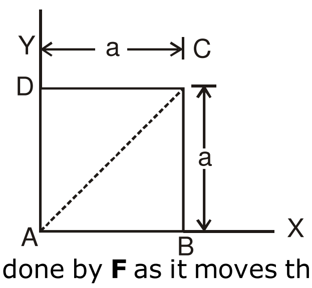
29. Water is pumped from a depth of 10m and delivered through a pipe of cross section $10^{-2}m^2$ upto a height of 10m. If it is needed to deliver a volume 0.2 m^3 per second, find the power required. [Use g = 10 m/s^2]

Sol.

30. A particle moves along a straight line. A force acts on the particle which produces a constant power. It starts with initial velocity 3 m/s and after moving a distance 252 m its velocity is 6 m/s. Find the time taken.

Sol.

31. A force F = $x^2y^2\mathbf{i} + x^2y^2\mathbf{j}$ (N) acts on a particle which moves in the XY plane.

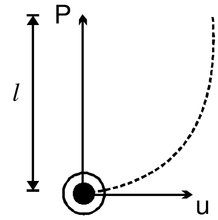


Find the work done by **F** as it moves the particle from A to C (fig.) along each of the paths ABC, ADC, and AC.

Sol.

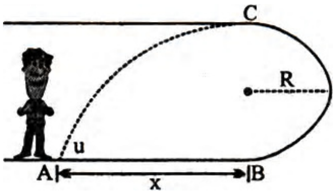
32. Calculate the forces F(y) associated with the following one-dimensional potential energies :
(a) $U = -\omega y$ (b) $U = ay^3 - by^2$
(c) $U = U_0 \sin \beta y$
Sol.

33. Consider the shown arrangement when a is bob of mass 'm' is suspended by means of a string connected to peg P. If the bob is given a horizontal velocity $\vec{u}$ having magnitude $\sqrt{3gl}$, find the minimum speed of the bob in subsequent motion.



Sol.

34. A person rolls a small ball with speed u along the floor from point A. If x = 3R, determine the required speed u so that the ball returns to A after rolling on the circular surface in the vertical plane from B to C and becoming a projectile at C. What is the minimum value of x for which the game could be played if contact must be maintained to point C ? Neglect friction.



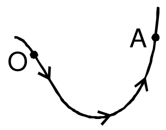
Sol.

35. A toy rocket of mass 1 kg has a small fuel of mass 0.02 kg which it burns out in 3 s. Starting from rest on a horizontal smooth track, it gets a speed of 20 ms^{-1} after the fuel is burnt out. What is the average thrust of the rocket? What is the energy content per unit mass of the fuel? (Ignore the small mass variation of the rocket during fuel burning).

Sol.

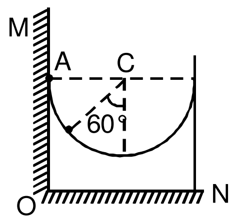
Exercise - IV (Tough Subjective Problems)

Q.1 A particle which moves along the curved path shown passes point O with a speed of 12 m/s and slows down to 5m/s at point A in a distance of 18 m measured along the curve from O. The deceleration measured along the curve it proportional to distance from O. If the total acceleration of the particle is 10 m/s^2 on it passes A. Find the radius of curvature of A.



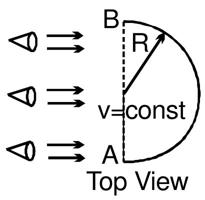
Sol.

Q.2 A ball of mass 1 kg is released from position A inside a wedge with a hemispherical cut of radius 0.5 m as shown in the figure. Find the force exerted by the vertical wall OM on wedge, when the ball is in position B. (neglect friction everywhere) Take (g = $10m/s^2$)



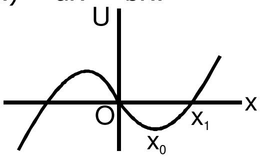
Sol.

Q.3 A small is block can move in a straight horizontal line a along AB. Flash lights from one side projects its shadow on a vertical wall which has horizontal cross section as a circle. Find tangential & normal acceleration of shadow of the block on the wall as a function of time if the velocity of the block is constant (v).



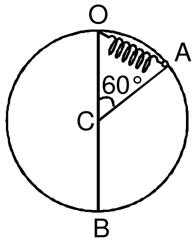
Sol.

Q.4 A particle is confined to move along the +x axis under the ac tion of a force F(x) that is derivable from thePotential $U(x) = ax^3 - bx$.



(a) Find the expression for F(x)
(b) When the total energy of the particle is zero, the particle can be trapped with in the interval x = 0 to x = x_1. For this case find the values of x_1.
(c) Determine the maximum kinetic energy that the trapped particle has in its motion. Express all answers in terms a and b.
Sol.

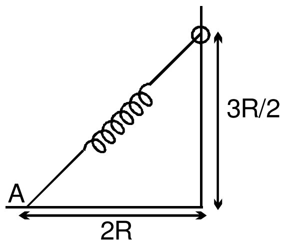
Q.5 A particle of mass 5 kg is free to slide on a smooth ring of radius r = 20 cm fixed in a vertical plane. The particle is attached to one end of a spring whose other end is fixed to the top point O of the ring. Initially the particle is at rest at a point A of the ring such that ∠OCA = 60º, C being the centre of the ring. The natural length of the spring is also equal to r = 20 cm. After the particle is released and slides down the ring the contact force between the particle & the ring becomes zero when it reaches the lowest position B. Determine the force constant of the spring.



Sol.

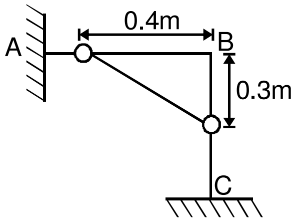
Q.6 Two blocks of mass m_1 = 10kg and m_2 = 5kg connected to each other by a massless inextensible string of length 0.3 m are placed along a diameter of a turn table. The coefficient of friction between the table and m_1 is 0.5 while there is no friction between m_2 and the table. The table is rotating with an angular velocity of 10 rad/sec about a vertical axis passing through its centre. The masses are placed along the diameter of the table on either side of the centre O such that m_1 is at a distance of 0.124 m from O. The masses are observed to be at rest with respect to an observer on the turn table.
(i) Calculate the frictional force on m_1
(ii) What should be the minimum angular speed of the turn table so that the masses will slip from this position
(iii) How should the masses be placed with the string remaining taut, so that there is no frictional force acting on the mass m_1.
Sol.

Q.7 A ring of mass m can slide over a smooth vertical rod. The ring is connected to a spring of force constant $K = \frac{4mg}{R}$ where 2R is the natural length of the spring. The other end of the spring is fixed to the ground at a horizontal distance 2R from the base of the rod. The mass is released at a height of 1.5 R from ground



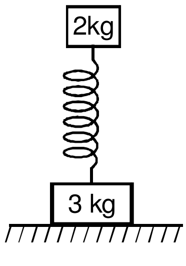
(a) calculate the work done by the spring
(b) calculate the velocity of the ring as it reaches the ground.
Sol.

Q.8 Two identical beads of mass 1 kg each are connected by an inextensible massless string & they can slide along the two arms AB and BC of a rigid smooth wire frame in vertical plane. If the system is released from rest, find the speeds of the particles when they have moved by a dis tance of 0.1 m. Also find tension in the string.



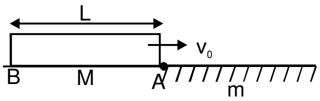
Sol.

Q.9 The ends of spring are attached to blocks of mass 3 kg and 3 kg. The 3 kg block rests on a horizontal surface and the 2 kg block which is vertically above it is in equilibrium producing a compression of 1cm of the spring. The 2kg mass must be compressed further by at least ________, so that when it is released, the 3 kg block may be lifted off the ground.



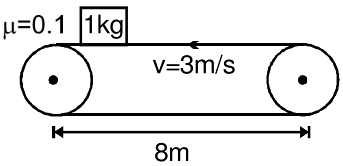
Sol.

Q.10 A uniform rod of mass m length L is sliding along its length on a horizontal table whose top is partly smooth & rest rough with friction coefficient μ. If the rod after moving through smooth part, enters the rough with velocity v_0.
(a) What will be the magnitude of the friction force when its x length (< L) lies in the rough part during sliding.
(b) Determine the minimum velocity v_0 with which it must enter so that it lies completely in rough region before coming to rest.
(c) If the velocity is double the minimum velocity as calculated in part (a) then what distance does its front end A would have travelled in rough region before rod comes to rest.



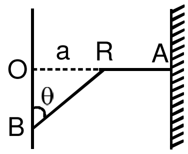
Sol.

Q.11 Find the velocity with which a block of mass 1 kg must be horizontally projected on a conveyer belt moving uniformly at a velocity of 3 m/s so that maximum heat is liberated. Take coefficient of friction of 0.1. Also find the corresponding amount of heat liberated. What happens when belt velocity is 5 m/s ?



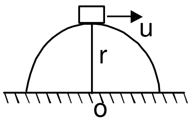
Sol.

Q.12 A small bead of mass m is free to slide on a fixed smooth vertical wire, as indicated in the diagram. One end of a light elastic string, of unstretched length a and force constant 2 mg/a is attached to B. The string passes through a smooth fixed ring R and the other end of the string is attached to the fixed point A, AR being horizontal. The point O on the wire is at same horizontal level as R, and AR = RO = a.
(i) In the equilibrium, find OB
(ii) The bead B is raised to a point C of the wire above O, where OC = a, and is released from rest. Find the speed of the bead as it passes O, and find the greatest depth below O of the bead in the subsequent motion.



Sol.

Q.13 A small block of mass m is projected horizontally from the top the smooth hemisphere of radius r with speed u as shown. For values of $u \geq u_0$, it does not slide on the hemisphere (i.e. leaves the surface at the top itself)
(a) For $u = 2u_0$ it lands at point P on ground Find OP.
(b) For $u = u_0/3$, Find the height from the ground at which it leaves the hemisphere.
(c) Find its net acceleration at the instant it leaves the hemisphere.



Sol.

Exercise - V JEE-Problems

Q.1 A force $\vec{F} = -K(y\hat{i} + x\hat{j})$ where K is a positive constant, acts on a particle moving in the x-y plane. Starting from the origin, the particle is taken along the positive x-axis to the point (a, 0) and then parallel to the y-axis to the point (a, a). The total work done by the force $\vec{F}$ on the particle is **[JEE-98]**

(A) $-2Ka^2$ (B) $2Ka^2$
(C) $-Ka^2$ (D) Ka^2

Sol.

Q.2 A stone is tied to a string of length l is whirled in a vertical circle with the other end of the string at 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 its velocity at it reaches a position where the string is horizontal is

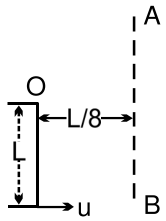
[JEE-98]

(A) $\sqrt{(u^2 - 2gl)}$ (B) $\sqrt{2gl}$
(C) $\sqrt{(u^2 - gl)}$ (D) $\sqrt{2(u^2 - gl)}$

Sol.

Q.3 A particle is suspended vertically from a point O by an inextensible massless string of length L. A vertical line AB is at a distance L/8 from O as shown. The object given a horizontal velocity u. At some point, its motion ceases to be circular and eventually the object passes through the line AB. At the instant of crossing AB, its velocity is horizontal. Find u.

[JEE-99]



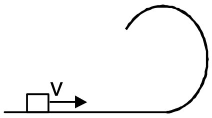
Sol.

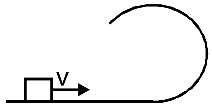
Q.4 A long horizontal rod has bead which can slide along its length, and initially placed at a distance L from one end of A of the rod. The rod is set in angular motion about A with constant angular acceleration α. If the coefficient of friction between the rod and the bead is μ and gravity is neglected, then the time after which is bead starts slipping is **[JEE-2000]**

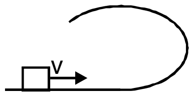
(A) $\sqrt{\frac{\mu}{\alpha}}$ (B) $\frac{\mu}{\sqrt{\alpha}}$ (C) $\frac{1}{\sqrt{\mu\alpha}}$ (D) infinitesimal

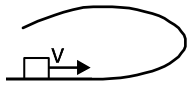
Sol.

Q.5 A small block is shot into each of the four tracks as shown below. Each of the tracks risks 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 **[JEE-2001]**

(A) 

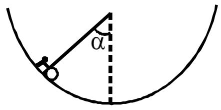
(B) 

(C) 

(D) 

Sol.

Q.6 An insect crawls up a hemispherical surface very slowly (see the figure). The coefficient of friction between the insect and the surface is 1/3. If the line joining the centre of the hemispherical surface to the insect makes an angle α with the vertical, the maximum possible value of α is given by **[JEE(Scr.)-2001]**



(A) $\cot\alpha = 3$ (B) $\tan\alpha = 3$
(C) $\sec\alpha = 3$ (D) $\operatorname{cosec}\alpha = 3$

Sol.

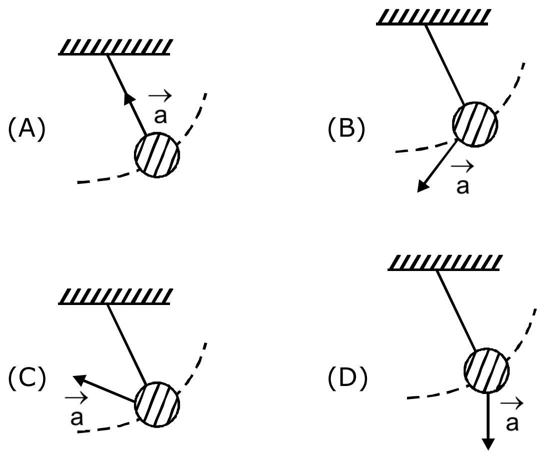
Q.7 A small ball of mass 2×10^{-3} Kg having a charge of $1\mu c$ is suspended by a string of length 0.8m. Another identical ball having the same charge is kept at the point of suspension. Determine the minimum horizontal velocity which should be imparted to the lower ball so that it can make complete revolution.

[JEE-2001]

Sol.

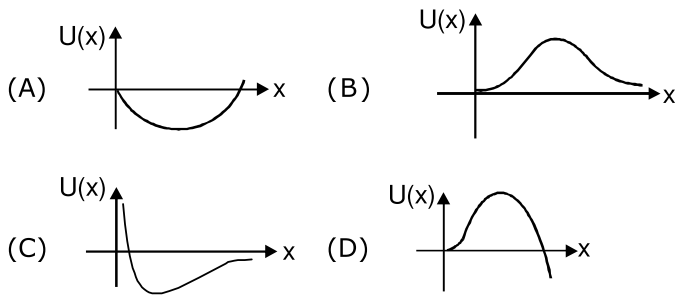
Q.8 A simple pendulum is oscillating without damping. When the displacement of the bob is less that maximum, its acceleration vector $\vec{a}$ is correctly shown in

[JEE(Scr.)-2002]



Sol.

Q.9 A particle, which is constrained to move along the x-axis, is subjected to a force in the same direction which varies with the distance x of the particle x of the particle from the origin as $F(x) = -kx + ax^2$. Here k and a are positive constants. For $x \geq 0$, the functional form of the potential energy U(x) of the particle is **[JEE(Scr.)-2002]**



Sol.

Q.10 An ideal spring with spring-constant k is hung from the ceiling and a block of mass M is attached to its lower end. The mass is released with the spring initially unstretched. Then the maximum extension in the spring is **[JEE(Scr.)-2002]**

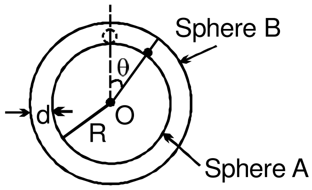
(A) 4 Mg/k (B) 2 Mg/k

(C) Mg/k (D) Mg/2k

Sol.

Q.11 A spherical ball of mass m is kept at the highest point in the space between two fixed, concentric spheres A and B (see figure.) The smaller sphere A has a radius R and the space between the two spheres has a width d. The ball has a diameter very slightly less than d. All surfaces are frictionless. The ball is given a gentle push (towards the right in the figure). The angle made by the radius vector of the ball with the upward vertical is denoted by θ (shown in the figure) **[JEE-2002]**

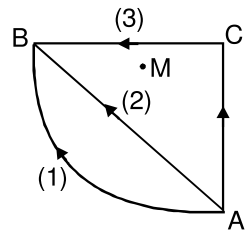
(a) Express the total normal reaction force exerted by the spheres on the ball as a function of angle θ.



(b) Let N_A and N_B denote the magnitudes of the normal reaction force on the ball exerted by the spheres A and B, respectively. Sketch the variations of N_A and N_B as functions of $\cos\theta$ in the range $0 \le \theta \le \pi$ by drawing two separate graphs in your answer book, taking $\cos\theta$ on the horizontal axes.

Sol.

Q.12 In a region of only gravitational field of mass 'M' a particle is shifted from A to B via three different paths in the figure. The work done in different paths are W_1, W_2, W_3 respectively then **[JEE(Scr.)-2003]**



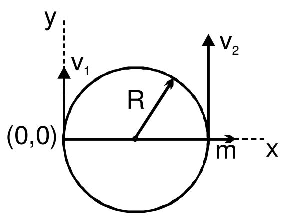
(A) $W_1 = W_2 = W_3$ (B) $W_1 = W_2 > W_3$

(C) $W_1 > W_2 > W_3$ (D) $W_1 < W_2 < W_3$

Sol.

Q.13 A particle of mass m, moving in a circular path of radius R with a constant speed v_2 is located at point (2R, 0) at time t = 0 and a man starts moving with velocity v_1 along the +ve y-axis from origin at time t = 0. Calculate the linear momentum of the particle w.r.t. the man as a function of time.

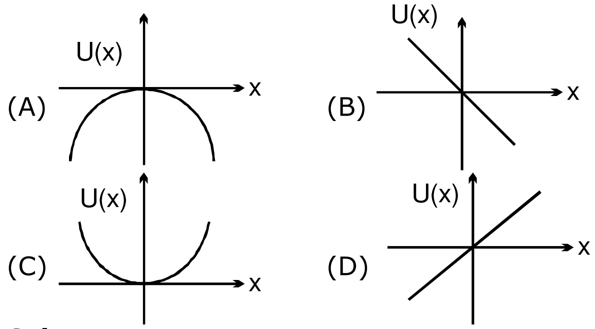
[JEE-2003]



Sol.

Q.14 A particle is placed at the origin and a force F = kx is acting on it (where k is a positive constant). If U(0) = 0, the graph of U(x) versus x will be (where U is the potential energy function)

[JEE(Scr.)-2004]



Sol.

Q.15 STATEMENT-1

A block of mass m starts moving on a rough horizontal surface with a velocity v. It stops due to friction between the block and the surface after moving through a certain distance. The surface is now tilted to an angle of 30º with the horizontal and the same block is made to go up on the surface with the same initial velocity v. The decrease in the mechanical energy in the second situation is smaller than that in the first situation.

because

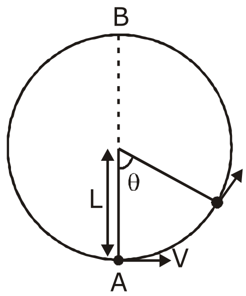
STATEMENT-2

The coefficient of friction between the block and the surface decreases with the increase in the angle of inclination. **[JEE-2007]**

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

Sol.

16. 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 **[JEE 2008]**

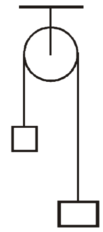


(A) $\theta = \frac{\pi}{4}$ (B) $\frac{\pi}{4} < \theta < \frac{\pi}{2}$

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

Sol.

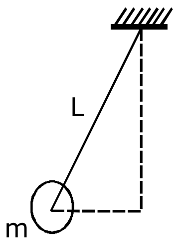
17. A light inextensible string that goes over a smooth fixed pulley as shown in the figure connects two blocks of masses 0.36 kg and 0.72 kg. Taking g = 10 m/s^2, find the work done (in joules) by the string on the block of mass 0.36 kg during the first second after the system is released from rest.



[JEE 2009]

Sol.

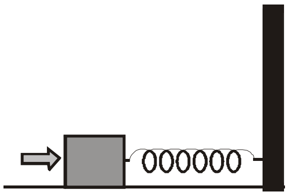
18. A ball of mass (m) 0.5 kg is attached to the end of a string having length (L) 0.5 m. The ball is rotated on a horizontal circular path about vertical axis. The maximum tension that the string can bear is 324 N. the maximum possible value of angular velocity of ball (in radian/s) is **[JEE-2011]**



(A) 9 (B) 18 (C) 27 (D) 36

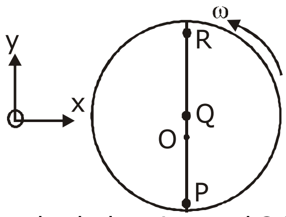
Sol.

19. A block of mass 0.18 kg is attached to a spring of force-constant 2 N/m. The coefficient of friction between the block and the floor is 0.1. Initially the block is at rest and the spring is un-stretched. An impulse is given to the block as shown in the figure. The block slides a distance of 0.06 m and comes to rest for the first time. The initial velocity of the block in m/s is V = N/10. Then N is **[JEE-2011]**



Sol.

20. Consider a disc rotating in the horizontal plane with a constant angular speed ω about its centre O. The disc has a shaded region on one side of the diameter and an unshaded region on the other side as shown in the figure. When the disc is in the orientation as shown, two pebbles P and Q are simultaneously projected at an angle towards R. The velocity of projection is in the y-z plane and is same for both pebbles with respect to the disc. Assume that (i) they land back on the disc before the disc has completed 1/8 rotation, (ii) their range is less than half the disc radius, and (iii) ω remains constant throughout. Then

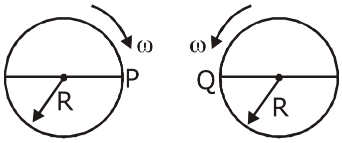


(A) P lands in the shaded region and Q in the unshaded region
(B) P lands in the unshaded region and Q in the shaded region
(C) Both P and Q land in the unshaded region
(D) Both P and Q land in the shaded region

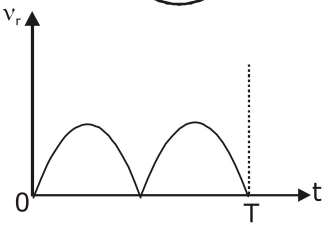
[JEE-2012]

Sol.

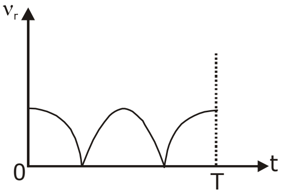
21. Two identical discs of same radius R are rotating about their axes in opposite directions with the same constant angular speed ω. The discs are in the same horizontal plane At time t = 0, the points P and Q are facing each other as shown in the figure. The relative speed between the two points P and Q is ν_r.In one time period (T) of rotation of the discs, ν_r as a function of time is best represented by **[JEE-2012]**



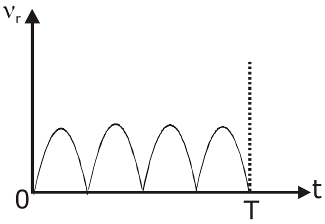
(A)



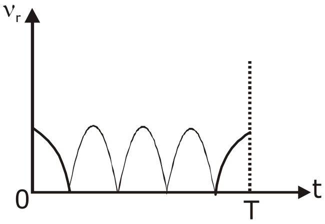
(B)



(C)



(D)



Sol.

Exercise-I

(A) CIRCULAR MOTION

1.	C	**2.**	D	**3.**	A	**4.**	D	**5.**	B	**6.**	C	**7.**	C
8.	A	**9.**	(i) A (ii) A	**10.**	C	**11.**	B	**12.**	D	**13.**	C	**14.**	C
15.	C	**16.**	D	**17.**	D	**18.**	A	**19.**	D	**20.**	C	**21.**	B
22.	B	**23.**	C	**24.**	D	**25.**	C	**26.**	A	**27.**	C	**28.**	C
29.	A	**30.**	C	**31.**	B	**32.**	D	**33.**	B	**34.**	B	**35.**	A

(B) WORK, POWER AND ENERGY

36.	B	**37.**	A	**38.**	C	**39.**	C	**40.**	D	**41.**	A	**42.**	C
43.	B	**44.**	A	**45.**	B	**46.**	D	**47.**	B	**48.**	D	**49.**	A
50.	C	**51.**	D	**52.**	C	**53.**	C	**54.**	C	**55.**	C	**56.**	B
57.	B	**58.**	B	**59.**	C	**60.**	D	**61.**	C	**62.**	B	**63.**	C
64.	A	**65.**	C	**66.**	B	**67.**	B	**68.**	A	**69.**	A	**70.**	A
71.	B	**72.**	C	**73.**	A	**74.**	C	**75.**	C	**76.**	B		

Exercise-II

(A) CIRCULAR MOTION

1. B,D **2.** B,C,D,E **3.** B,C

(B) WORK, POWER AND ENERGY

4. A,C,D **5.** A,B **6.** A,B,C **7.** B,D **8.** A **9.** A **10.** D

11. B,C,D **12.** B,D **13.** A,B,C **14.** B,D **15.** A,B,D **16.** C

Exercise-III

(A) CIRCULAR MOTION

1. (i) 125 N, (ii) 80 N **2.** $\sqrt{3}b/2$, b/2, b **3. (a)** t = 2s, **(b)** 3.14 m/s **4.** 2 sec

5. $-3\hat{k}\ rad/s^2, -2\hat{k}\ rad/s$ **6.** (a) 2 rad/s^2, (b) 12 + 2t for t ≤ 2s, 16 for t ≥ 2s, (c) $\sqrt{28565} \approx 169$, 256 m/s^2 (d) 44 rad

7. (a) $25\frac{\sqrt{3}}{2} m/s^2$ **(b)** $\left(125\frac{\sqrt{3}}{4}\right)^{1/2}$ m/s **(c)** 25/2 m/s^2 **8.** (a) $v_0^2/2g$, (b) 2g **9.** $2\sqrt{2}\frac{v^2}{\pi R}$

10. (a) $\frac{30}{\pi}\sqrt{\frac{35}{2}}$ per min., (b) 150 N **11.** 0.1 sec. **12.** $\sqrt{2}g$ rad/s **13.** $(1-\sqrt{3}/2)mg$ **14.** $\frac{25}{24}$

(B) WORK, POWER AND ENERGY

15. (a) Zero, (b) Zero, (c) $-\mu mgvt$ (d) $\mu mgvt$ **16.** (i) Zero, (ii) 500 J **17.** 150 J

18. 20 Ergs **19.** –8.75 J

20. (a) 875 Joule (b) –250 joule (c) 625 joule.

(d) Change in kinetic energy of the body is equal to the work done by the net force in 10 second. This is in accordance with work-energy theorem

21. (a) Since the gravitational force is a conservative force therefore the work done in round trip is zero.

(b) 18.5 J (c) –7.6 J (d) 10.9 J

22. **(a)** $a_1 = F/m$, so $v_1 = a_1t = Ft/m$ **(b)** Since velocities and, $v = v_c + v_1 = v_c + Ft/m$

(c) $\Delta K_1 = \frac{m(v_1)^2}{2} = \frac{F^2t^2}{2m}$ **(d)** $\Delta K = \frac{m(v_c+v_1)^2}{2} - \frac{mv_c^2}{2}$ **(e)** s_1 is $\frac{a_1t^2}{2} = \frac{Ft^2}{2m}$ **(f)** $s_1 + v_ct$

(h) Compare W and W_1 and ΔK and ΔK_1, they are respectively equal.

(i) The work-energy theorem holds for moving observers.

23. $\frac{2m_1^2g^2}{k}$ **24.** 3 **25. (a)** 46 J, (b) –3k **26.** 50 W **27.** 8 s **28.** 3/4 **29.** 80 KW

30. 54 sec. **31.** $W_{ABC} = W_{ADC} = \frac{a^5}{3}$ (J), $W_{AC} = \frac{2a^5}{5}$(J)

32. (a) $F = -\frac{dU}{dy} = \omega$ (b) $F = -\frac{dU}{dy} = -3ay^2 + 2by$ (c) $F = -\frac{dU}{dy} = -\beta U_0 \cos\beta y$

33. $\frac{1}{3}\sqrt{\frac{gl}{3}}$ **34.** $\frac{5}{2}\sqrt{gR}, x_{min} = 2R$ **35.** 20/3 N, 10000 J kg^{-1}

Exercise-IV

1. 3.3 m **2.** $\frac{15\sqrt{3}}{2}$N **3.** $a_N = \frac{vR}{(2Rt - vt^2)}, a_t = \frac{R(vt-R)v^{1/2}}{(2Rt-vt^2)^{3/2}}$ **4.** $F = -3ax^2 + b$, $x = \sqrt{\frac{b}{a}}$, $KE_{max} = \frac{2b}{3\sqrt{3}}\sqrt{\frac{b}{a}}$ **5.** 500 N/m **6.** (i) 36 N, (ii) 11.66 rad/sec, (iii) 0.1 m, 0.2m **7.** $mgR/2, 2\sqrt{gR}$

8. $\frac{4\sqrt{2}}{5}, \frac{3\sqrt{2}}{5}$ $3a_1 = 4a_2 + 20$, T = 12 N **9.** 2.5 cm **10.** (a) $f = -\frac{\mu m}{\ell}xg$; (b) $\sqrt{\mu g \ell}$; (c) $\frac{5\ell}{2}$

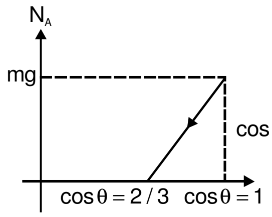
1. 4 m/s, 24.5J, 40 J **12.** (i) $\frac{a}{2}$, (ii) $2\sqrt{ag}, 2a$ **13.** (a) $2\sqrt{2}r$ (b) $h = \frac{19r}{27}$, (c) g

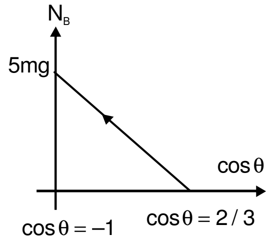
Exercise-V

1. C **2.** D **3.** $u=\sqrt{gL\left(\frac{3\sqrt{3}}{2}+2\right)}$ **4.** A **5.** A **6.** A **7.** 5.79 m/s

8. C **9.** D **10.** B

11. (a) N = 3mg cos θ – 2mg, (b)





12. A **13.** $\vec{P}_{PM}=m\bar{v}_{PM}=-mv_2\sin\omega t\hat{i}+m(v_2\cos\omega t-v_1)\hat{j}$ **14.** A **15.** C **16.** D

17. Work = T.S. = 4.8 × 10/6 = 8N **18.** D **19.** 4 **20.** C **21.** A