PRACTICE EXERCISES

SINGLE CORRECT CHOICE TYPE QUESTIONS

This section contains Single Correct Choice Type Questions. Each question has four choices (A), (B), (C) and (D), out of which ONLY ONE is correct.

1. Two equal masses are attached to the two ends of a spring of force constant k. The masses are pulled out symmetrically to stretch the spring by a length $2x_0$ over its natural length. The work done by the spring on each mass.

(A) kx_0^2 (B) $-\frac{1}{2}kx_0^2$

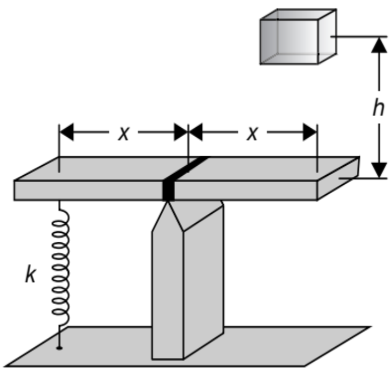
(C) $2kx_0^2$ (D) $-kx_0^2$

2. An ideal spring is hung vertically from the ceiling. Spring extends by 6 cm from its natural length when 2 kg mass is attached to it. A downward external force is now applied to the mass to extend the spring slowly by an additional 10 cm. Work done by the external force is

(A) –1.2 J (B) –1.8 J

(C) 2.4 J (D) 1.6 J

3. A crate of mass m falls from a height h onto the end of a platform, as shown in the figure. The spring is initially unstretched and the mass of the platform can be neglected. Assuming that there is no loss of energy, the maximum elongation of the spring is



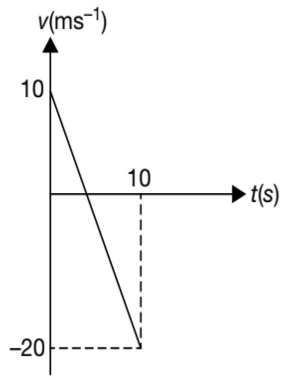
(A) $\frac{mg+\sqrt{m^2g^2+2mghk}}{k}$

(B) $\frac{mg-\sqrt{m^2g^2+2mghk}}{k}$

(C) $\frac{k}{\sqrt{m^2g^2+2mghk}}$

(D) $\frac{\sqrt{m^2g^2+2mghk}}{k}$

4. Velocity-time graph of a particle of mass 2 kg, moving in a straight line is as shown in figure. Work done by all the forces acting on the particle from $t=0$ to $t=10\text{ s}$ is



(A) 300 J (B) –300 J

(C) 400 J (D) –400 J

5. A particle moves with a velocity $\vec{v}=5\hat{i}-3\hat{j}+6\hat{k}\text{ ms}^{-1}$ under the influence of a constant force $\vec{F}=10\hat{i}+10\hat{j}+20\hat{k}\text{ N}$. The instantaneous power applied to the particle is

(A) 200 Js^{-1} (B) 40 Js^{-1}

(C) 140 Js^{-1} (D) 170 Js^{-1}

6. A ball suspended by a thread swings in a vertical plane so that its acceleration at the extreme position is equal to that at the lowest position. The thread deflection angle from the vertical in the extreme position is (Given: $\tan(26.5^\circ)=0.5$)

(A) 45° (B) 37°

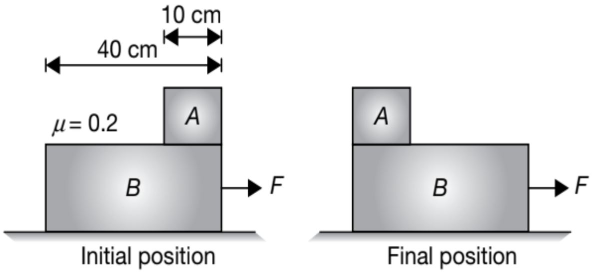
(C) 53° (D) 60°

7. A force acts on a 3 g particle in such a way that the position of the particle as a function of time is given by $x=3t-4t^2+t^3$, where x is in metre and t in second. The work done during the first 4 s is

(A) 578 mJ (B) 528 mJ

(C) 498 mJ (D) 458 mJ

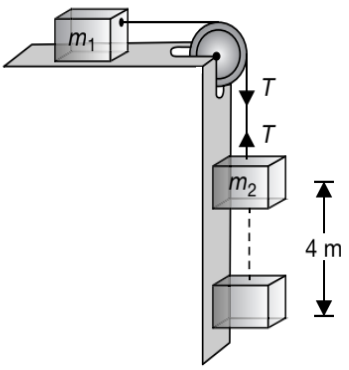
8. Block A of mass 45 kg is placed on a block B of mass 160 kg. Now block B is displaced by a force 50 cm horizontally towards right. During the same time block A just reaches the left end of block B as shown in Figure.



Work done by frictional force on block A in ground frame during this activity is

(A) -18 J (B) 18 J
(C) -45 J (D) 45 J

9. Two masses $m_1 = 10$ kg and $m_2 = 5$ kg are connected by an ideal string as shown in the figure. The coefficient of friction between m_1 and the surface is 0.2. Assuming that the system is released from rest, the velocity when m_2 has descended by 4 m is

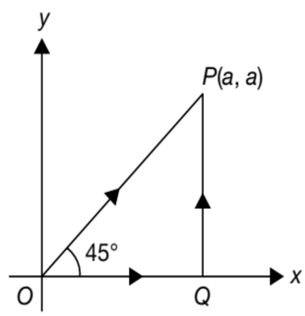


(A) $17\ \text{ms}^{-1}$ (B) $14\ \text{ms}^{-1}$
(C) $4\ \text{ms}^{-1}$ (D) $3.5\ \text{ms}^{-1}$

10. A force $\vec{F} = (2\hat{i} + 5\hat{j} + \hat{k})$ N is acting on a particle. The particle is first displaced from $(0, 0, 0)$ to $(2, 2, 0)$ m along the path $x = y$ and then from $(2, 2, 0)$ m to $(2, 2, 2)$ m along the path $x = 2$ m, $y = 2$ m. The total work done in the complete path is

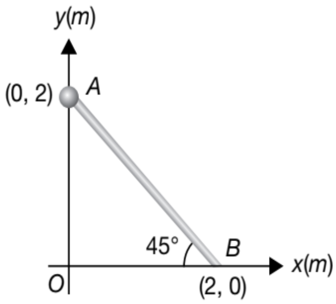
(A) 8 J (B) 10 J
(C) 12 J (D) 16 J

11. A particle is moved from $(0, 0)$ to (a, a) under a force $\vec{F} = (3\hat{i} + 4\hat{j})$ along two paths, Path 1 along OP and Path 2 along OQP. Let W_1 and W_2 be the work done by this force along these two paths. Then



(A) $W_1 = W_2$ (B) $W_1 = 2W_2$
(C) $W_2 = 2W_1$ (D) $W_2 = 4W_1$

12. In an xy horizontal plane, a force field $\vec{F} = -(40\ \text{Nm}^{-1})(y\hat{i} + x\hat{j})$ is present where x and y are the coordinates of any point lying in the plane. A smooth rod AB is fixed in the plane as shown in the figure. A particle of mass 5 kg is to be released with a velocity in this force field such that it reaches the point B. The minimum velocity that must be imparted to the particle along the rod at A such that it reaches B is

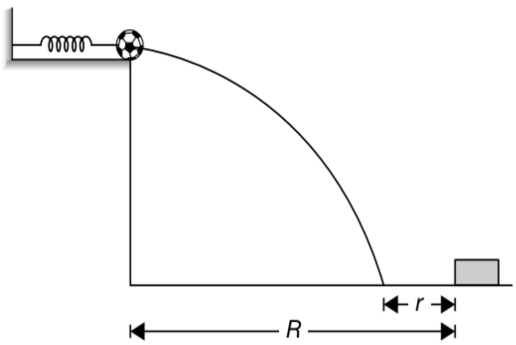


(A) $1\ \text{ms}^{-1}$ (B) $2\ \text{ms}^{-1}$
(C) $3\ \text{ms}^{-1}$ (D) $4\ \text{ms}^{-1}$

13. Work done by a force $\vec{F} = (2\hat{i} + 3\hat{j})$ N is zero, when a particle is moved along the line $3y + kx = 5$. Then k equals

(A) 2 (B) 4
(C) 6 (D) 8

14. A person wants to hit a small box on the floor with a marble as shown in Figure.



He compresses the spring by a distance d and releases but the marble falls short by a distance r from the box. How much should he compress the spring from natural length to land the ball in the box?

(A) $\dfrac{d^2}{R-r}$ (B) $\dfrac{d(R-r)}{R}$

(C) $\dfrac{d(R-r)}{R+r}$ (D) $\dfrac{Rd}{R-r}$

15. An object of mass m slides down a hill of height h of arbitrary shape and after travelling a certain horizontal path stops because of friction. The friction coefficient is different for different segments for the entire path but is independent of the velocity and direction of motion. The work that a force must perform to return the object to its initial position along the same path is

(A) mgh (B) $2mgh$
(C) $4mgh$ (D) $-mgh$

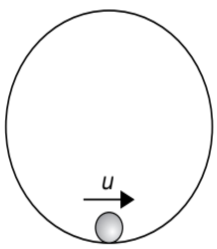
16. A horizontal force in the positive direction of x-axis is applied to a 1.5 kg block initially at rest on a horizontal frictionless surface. The force is given by $\vec{F} = (4 - x^2)\hat{i}$ N, where x is in metre and the initial position of the block is $x = 0$. The maximum kinetic energy of the block between $x = 0$ and $x = 2$ m is

(A) 2.33 J (B) 8.67 J
(C) 5.33 J (D) 6.67 J

17. In PROBLEM 24, the maximum positive displacement x is

(A) $2\sqrt{3}$ m (B) 2 m
(C) 4 m (D) $\sqrt{2}$ m

18. A particle is given an initial speed u inside a smooth spherical shell so that it is just able to complete the circle. Acceleration of the particle, when its velocity is vertical will be

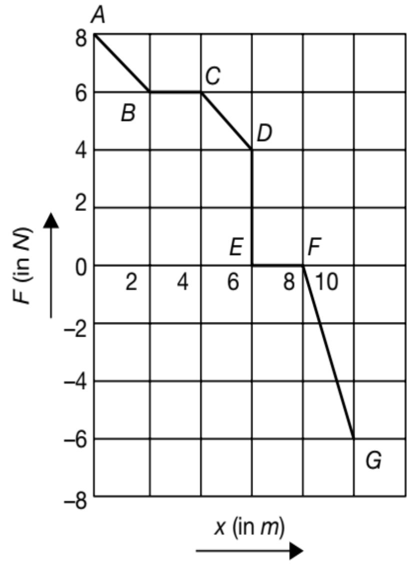


(A) $3g$ (B) g
(C) $\sqrt{10}g$ (D) $\sqrt{6}g$

19. The work done in moving a particle from a point $(1, 1)$ to $(2, 3)$ in a plane and in a force field with potential $u = \lambda(x + y)$ is

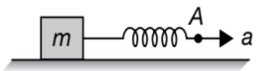
(A) 3λ (B) -3λ
(C) 0 (D) λ

20. A 1.0 kg block moves in a straight line on a horizontal frictionless surface under the influence of a force that varies with position as shown in the figure. The work done by the force as it moves from the origin to a point $x = 10$ m is



(A) 5 J (B) 30 J
(C) –10 J (D) 22 J

21. A block of mass m is attached with a spring in its natural length, of spring constant k. The other end A of spring is moved with a constant acceleration a away from the block as shown in the figure. The maximum extension in the spring is (Assume that initially block and spring both are at rest w.r.t. ground frame)



(A) $\frac{ma}{k}$ (B) $\frac{1}{2}\frac{ma}{k}$
(C) $\frac{2ma}{k}$ (D) $\frac{4ma}{k}$

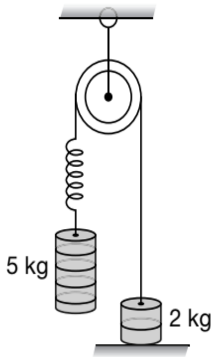
22. A particle moves in the x-y plane with velocity $\vec{v} = \alpha\hat{i} + \beta t\hat{j}$. The magnitude of tangential, normal and total accelerations at $t = \frac{\alpha\sqrt{3}}{\beta}$ are

(A) $\frac{\sqrt{3}}{2}\beta$, $\frac{\beta}{2}$ and β respectively
(B) $\frac{\beta}{2}$, $\frac{\beta}{2}$ and β respectively
(C) $\sqrt{2}\beta$, $\sqrt{2}\beta$ and β respectively
(D) None of the above

23. A body of mass 0.5 kg is taken up an inclined plane of length 10 m and height 5 m and then allowed to slide down to the bottom again. The coefficient of friction between the body and the plane is 0.1. The work done by the frictional force over the round trip is $(g = 10\ \text{ms}^{-2})$

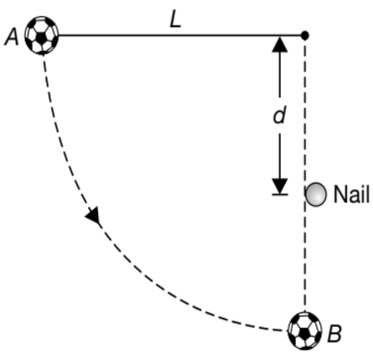
(A) 5 J (B) $5\sqrt{3}$ J
(C) –5 J (D) $-5\sqrt{3}$ J

24. In the system shown the 5 kg block is released from rest. The pulley and spring are massless and friction is absent everywhere. The force constant of spring is $40\ \text{Nm}^{-1}$. The speed of 5 kg block when 2 kg block leaves contact with ground is (Take $g = 10\ \text{ms}^{-2}$)



(A) $\sqrt{2}\ \text{ms}^{-1}$ (B) $2\sqrt{2}\ \text{ms}^{-1}$
(C) $2\ \text{ms}^{-1}$ (D) $4\sqrt{2}\ \text{ms}^{-1}$

25. In the given system, when the ball of mass m is released from position A, it swings down the dotted arc. A nail is located at a distance d below the point of suspension such that the ball just swings completely around a circle centered on the nail. Then minimum value of d possible is



(A) 0.6 L (B) 0.4 L
(C) 0.5 L (D) 0.3 L

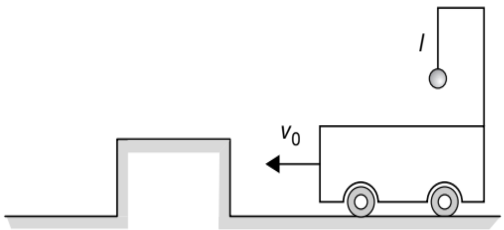
26. A 60 g bullet is fired through a stack of fibre board sheets 200 mm thick. If the bullet approaches the stack with a velocity of $600\ \text{ms}^{-1}$ and emerges out with a velocity of $300\ \text{ms}^{-1}$, the average resistance offered to the bullet is

(A) 40.5 kN (B) 2 kN
(C) 20.25 kN (D) 10 kN

27. A particle of mass m begins to slide down a fixed smooth sphere from the top. What is its tangential acceleration when it leaves contact with the sphere?

(A) $\frac{2g}{3}$ (B) $\frac{\sqrt{5}}{3}g$
(C) g (D) $\frac{g}{3}$

28. A bob is suspended from a crane by a cable of length $l = 5$ m. The crane and load are moving at a constant speed v_0. The crane is stopped by an obstacle such that the bob on the cable swings out an angle of 60°. The initial speed v_0 is $\left(g = 9.8\ \text{ms}^{-2}\right)$



(A) $10\ \text{ms}^{-1}$ (B) $7\ \text{ms}^{-1}$
(C) $4\ \text{ms}^{-1}$ (D) $2\ \text{ms}^{-1}$

29. A chain of length l and mass m lies on the surface of a smooth sphere of radius $R(R > l)$ with one end tied on the top of the sphere. Then the gravitational potential energy of the chain with reference level at the centre of sphere is given by

(A) $\frac{mR^2g}{l}\sin\left(\frac{l}{R}\right)$ (B) $\frac{mR^2g}{l}\cos\left(\frac{l}{R}\right)$
(C) $\frac{mR^2g}{l}\cot\left(\frac{R}{l}\right)$ (D) $\frac{mR^2g}{l}\tan\left(\frac{R}{l}\right)$

30. A particle of mass m attached to a string of length l is describing circular motion on a smooth plane inclined that makes an angle α with the horizontal. For the particle to reach the highest point its minimum velocity at the lowest point should be

(A) $\sqrt{5gl}$ (B) $\sqrt{5gl(\cos\alpha + 1)}$
(C) $\sqrt{5gl\tan\alpha}$ (D) $\sqrt{5gl\sin\alpha}$

31. A block is attached to a spring of stiffness k. The other end of the spring is attached to a fixed wall. The entire system lie on a horizontal surface and the spring is in natural state. The natural length of the spring is l_0. If the block is slowly lifted up vertically to a height $\frac{5}{12}l_0$ from its initial position. The work done by the

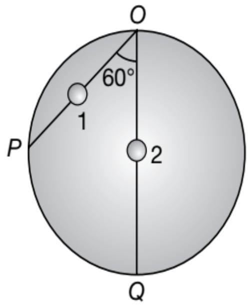
(A) lifting force is $\frac{kl_0^2}{288} + \frac{5}{12}mgl_0$

(B) lifting force is $-\frac{5}{12}mgl_0 + \frac{kl_0^2}{288}$

(C) gravity is $\frac{5}{12}mgl_0$

(D) spring force is $\frac{kl_0^2}{288}$

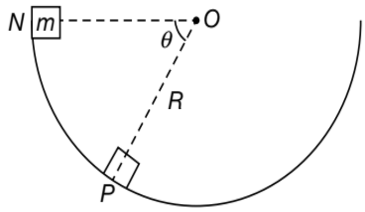
32. Two particles 1 and 2 are descending on two frictionless chords OP and OQ. The ratio of the speeds of the particles 1 and 2 respectively, when they reach the circumference is



(A) $\frac{1}{4}$ (B) $\frac{1}{2\sqrt{2}}$

(C) $\frac{1}{2}$ (D) 1

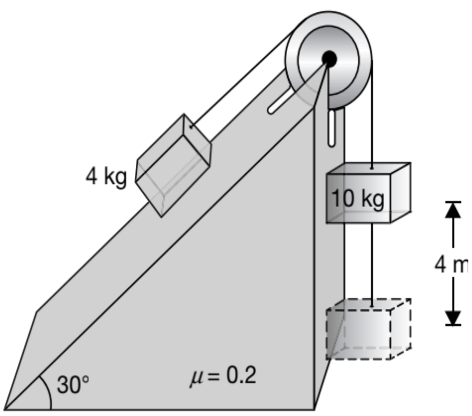
33. An object of mass m is released from rest at N to move along the fixed smooth circular track of radius R as shown in figure. The ratio of magnitudes of centripetal force and normal reaction of the track on the object at the point P is



(A) $\frac{2}{3}\sin\theta$ (B) $\frac{2}{3}\cos\theta$

(C) $\frac{2}{3}$ (D) $\frac{3}{2}$

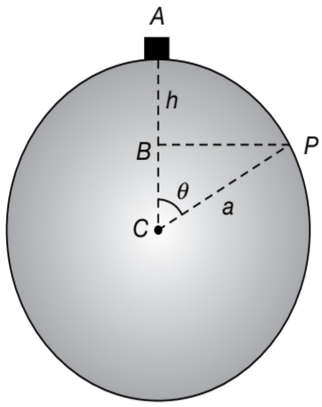
34. Two blocks of masses 10 kg and 4 kg are connected by a flexible inextensible string as shown in the figure. The pulley is assumed to be frictionless. The coefficient of friction between the inclined surface and the 4 kg block is 0.2 and angle of inclination of the plane is 30°. Assuming that the system is released from rest, the velocity of 10 kg block when it has moved 4 m down is



(A) 5.6 ms^{-1} (B) 6.5 ms^{-1}

(C) 41.8 ms^{-1} (D) 13 ms^{-1}

35. A small body A starts sliding off the top of a smooth sphere of radius a. The angle θ corresponding to the point P at which the body breaks off the sphere is



(A) $\cos^{-1}\left(\frac{h}{a}\right)$ (B) $\cos^{-1}\left(\frac{2h}{a}\right)$

(C) $\cos^{-1}\left(\frac{a}{h}\right)$ (D) $\cos^{-1}\left(\frac{a}{2h}\right)$

36. A body is displaced from $(0,\ 0)$ to $(1,\ 1)$ m along the path $x = y$ by a force $\vec{F} = \left(x^2\hat{j} + y\hat{i}\right)$ N. The work done by this force is

(A) $\frac{4}{3}$ J (B) $\frac{5}{6}$ J

(C) $\frac{3}{2}$ J (D) $\frac{7}{5}$ J

37. A dam is situated at a height of 550 metre above sea level and supplies water to a power house which is at a height of 50 metre above sea level. 2000 kg of water passes through the turbines per second. The maximum electrical power output of the power house if the whole system were 80% efficient is

(A) 8 MW (B) 10 MW

(C) 12.5 MW (D) 16 MW

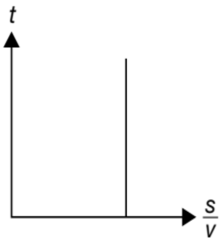
38. A particle of mass m attached to an inextensible light string is moving in a vertical circle of radius r. Velocity at the highest point is v_0 and is just sufficient to complete the vertical circle. Tension in the string when it becomes horizontal is

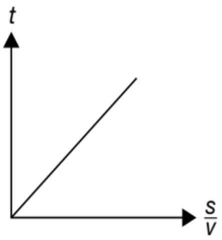
a. $\frac{3mv_0^2}{r}$ b. $\frac{9mv_0^2}{r}$ c. $3mg$

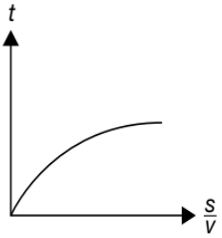
(A) a only (B) b only

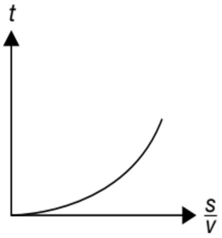
(C) Both b and c (D) Both a and c

39. A body is moved from rest along a straight line by a machine delivering constant power. The ratio of displacement and velocity, $\left(\frac{s}{v}\right)$ varies with time t as

(A)


(B)


(C)


(D)


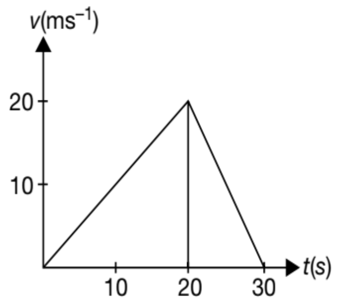
40. A particle suspended from a fixed point, by a light inextensible thread of length L is projected horizontally from its lowest position with velocity $\sqrt{\frac{7gL}{2}}$. The string will slack after swinging through an angle θ, such that θ equals

(A) 30° (B) 135°
(C) 120° (D) 150°

41. A man pulls a bucket of water from a depth of h from a well. If the mass of the rope and that of bucket full of water are m and M respectively, the work done by the man is

(A) $(M+m)gh$ (B) $\left(M+\frac{m}{2}\right)gh$
(C) $\left(\frac{M+m}{2}\right)gh$ (D) $\left(\frac{M}{2}+m\right)gh$

42. v-t graph of an object of mass 2 kg is shown. Select the incorrect statement



(A) The average acceleration of the object is zero
(B) The average velocity of the object is zero
(C) The average force on the object is zero
(D) Work done on the object in 30 s is zero

43. A body of mass 2 kg, initially at rest, is acted upon simultaneously by two forces, one of 4 N and the other of 3 N, acting at right angles to each other. The kinetic energy of the body after 20 s is

(A) 500 J (B) 1250 J
(C) 2500 J (D) 5000 J

44. Power supplied to a particle of mass 2 kg varies with time t (in second) as $P = \frac{3t^2}{2}$ W. If velocity of particle at $t = 0$ is $v = 0$. The velocity of particle at time $t = 2$ s will be

(A) 1 ms^{-1} (B) 2 ms^{-1}
(C) $2\sqrt{2}$ ms^{-1} (D) 4 ms^{-1}

45. A particle of mass m is projected with velocity u at an angle α with horizontal. During the period when the particle descends from highest point to the position where its velocity vector makes an angle $\frac{\alpha}{2}$ with horizontal. Work done by gravity force is

(A) $\frac{1}{2}mu^2\tan^2\alpha$ (B) $\frac{1}{2}m^2\tan^2\frac{\alpha}{2}$
(C) $\frac{1}{2}mu^2\cos^2\alpha\tan^2\frac{\alpha}{2}$ (D) $\frac{1}{2}mu^2\cos^2\frac{\alpha}{2}\sin^2\alpha$

46. A uniform rod of length 1 m and mass 100 g is pivoted at one end and is hanging vertically. It is displaced through 60° from the vertical. The increase in its potential energy is $\left(g = 10\ ms^{-2}\right)$

(A) 0.25 J (B) 0.5 J
(C) 0.75 J (D) 1.0 J

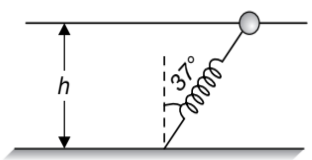
47. A running man has half the kinetic energy of a boy of half his mass. The man speeds up by 1.0 ms^{-1} and then has the same kinetic energy as the boy. The original speed of the boy was

(A) 2.4 ms^{-1} (B) 9.6 ms^{-1}
(C) 4.8 ms^{-1} (D) 7.2 ms^{-1}

48. A body of mass m accelerates uniformly from rest to a velocity v_0 in time t_0. The instantaneous power delivered to the body at any time t is

(A) $\frac{mv_0t}{t_0}$ (B) $\frac{m{v_0}^2t}{t_0}$
(C) $\frac{mv_0t^2}{t_0}$ (D) $\frac{mv_0^2}{t_0^2}t$

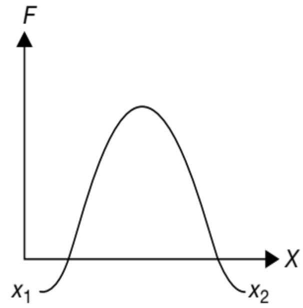
49. One end of a spring of natural length h and spring constant k is fixed at the ground and the other is fitted with a smooth ring of mass m which is allowed to slide on a horizontal rod fixed at a height h. Initially the spring makes an angle of 37° with the vertical when the system is released from rest. The speed of the ring when the spring becomes vertical is



(A) $\sqrt{\frac{k}{m}}$ (B) $\frac{h}{2}\sqrt{\frac{k}{m}}$

(C) $\frac{h}{3}\sqrt{\frac{k}{m}}$ (D) $\frac{h}{4}\sqrt{\frac{k}{m}}$

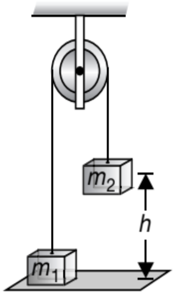
50. The force acting on a particle moving along x-axis varies with the position of the particle as shown in the figure. The particle is in stable equilibrium at



(A) $x = x_1$ (B) $x = x_2$

(C) both x_1 and x_2 (D) neither x_1 nor x_2

51. Two masses m_1 and $m_2\left(m_2 > m_1\right)$ are positioned as shown in figure, m_1 being on the ground and m_2 at a height h above the ground. When m_2 is released, the speed at which it hits the ground will be



(A) $\sqrt{\frac{2ghm_1}{m_2}}$ (B) $\sqrt{\frac{2gh(m_1 - m_2)}{(m_1 + m_2)}}$

(C) $\sqrt{\frac{2gh(m_1 + m_2)}{(m_1 - m_2)}}$ (D) $\sqrt{\frac{2gh(m_2 - m_1)}{(m_1 + m_2)}}$

52. A block of mass m slides down a rough inclined plane of inclination θ with horizontal with zero initial velocity. The coefficient of friction between the block and the plane is μ with $\theta > \tan^{-1}(\mu)$. The rate of work done by the force of friction at time t is

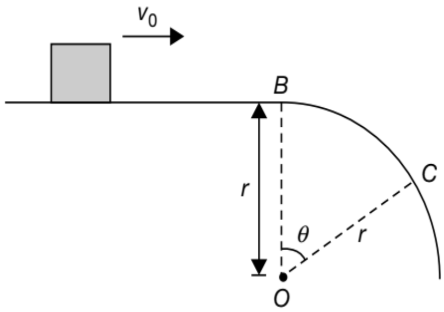
(A) $\mu mg^2 t\sin\theta$

(B) $mg^2 t(\sin\theta - \mu\cos\theta)$

(C) $\mu mg^2 t\cos\theta(\sin\theta - \mu\cos\theta)$

(D) $\mu mg^2 t\cos\theta$

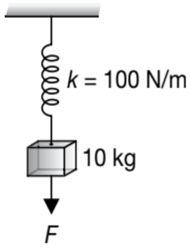
53. A small block slides with velocity $v_0 = \frac{1}{2}\sqrt{gr}$ on the horizontal frictionless surface as shown in the figure. The block leaves the surface at point C. The angle θ in the figure is



(A) $\cos^{-1}\left(\frac{4}{9}\right)$ (B) $\cos^{-1}\left(\frac{3}{4}\right)$

(C) $\cos^{-1}\left(\frac{1}{2}\right)$ (D) None of the above

54. A vertical spring of force constant $100\ \text{Nm}^{-1}$ is attached with a hanging mass of $10\ \text{kg}$. Now an external force is applied slowly on the mass so that the spring is stretched by additional $2\ \text{m}$. The work done by the force F is $\left(\text{Take } g = 10\ \text{ms}^{-2}\right)$



(A) 200 J (B) 400 J

(C) 450 J (D) 600 J

55. A child on a swing is 1 m above the ground at the lowest point and 6 m above the ground at the highest point. The horizontal speed of the child at the lowest point of the swing is approximately

(A) $8\ \text{ms}^{-1}$ (B) $10\ \text{ms}^{-1}$

(C) $12\ \text{ms}^{-1}$ (D) $14\ \text{ms}^{-1}$

56. A force F acting on a body depends on its displacement x as $F \propto x^{-\frac{1}{3}}$. The power delivered by F will depend on displacement as

(A) $x^{\frac{2}{3}}$ (B) $x^{-\frac{5}{3}}$

(C) $x^{\frac{1}{2}}$ (D) x^0

57. Two conservative forces $\vec{F}_1$ and $\vec{F}_2$ act on an object. The relation between W_1 and W_2, where $W_1 = \oint(\vec{F}_1 + \vec{F}_2)\cdot d\vec{l}$ and $W_2 = \oint(\vec{F}_1 - \vec{F}_2)\cdot d\vec{l}$

(A) $W_1 > W_2$ (B) $W_1 = W_2 \neq 0$
(C) $W_1 = W_2 = 0$ (D) $W_1 < W_2$

58. A smooth sphere of radius R is made to translate in a straight line with a constant acceleration whose magnitude is equal to the value of acceleration due to gravity. A particle kept on the top of the sphere is released from there with zero velocity with respect to the sphere. The speed of particle with respect to the sphere as a function of angle θ with the vertical, as it slides down is

(A) $\frac{\sqrt{Rg(\sin\theta + \cos\theta)}}{2}$

(B) $\sqrt{Rg(1 + \cos\theta - \sin\theta)}$

(C) $\sqrt{4Rg\sin\theta}$

(D) $\sqrt{2Rg(1 + \sin\theta - \cos\theta)}$

59. A 100 kg drop hammer H is operated by a motor. It falls from a height of 9 m on thick nail N which is to be driven into the hard block. The hammer has to be lifted to height of 9 m in 12 s with constant velocity. If the efficiency of the motor is assumed to be 80%, the power required by the motor is approximately

(A) 0.49 kW (B) 4.9 kW
(C) 0.94 kW (D) 6 kW

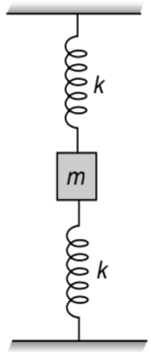
60. A block of mass 1 kg is attached to one end of a spring of force constant $k = 20\ \text{Nm}^{-1}$. The other end of the spring is attached to a fixed rigid support. This spring block system is made to oscillate on a rough horizontal surface having $\mu = 0.04$. The initial displacement of the block from the equilibrium position is $a = 30$ cm. The number of times the block passes from the mean position before coming to rest is $(g = 10\ \text{ms}^{-2})$

(A) 15 (B) 11
(C) 7 (D) 6

61. A motor has an electrical input of 30 kJ and is used to raise a 100 kg load to a height of 25 m when fitted to a crane winch. What is the efficiency of winch? $(g = 10\ \text{ms}^{-2})$

(A) 7.5% (B) 75%
(C) 83.3% (D) 0.75%

62. A block of mass m is attached to the two springs in vertical plane as shown in the figure. If initially both the springs are at their natural lengths. Then velocity of the block is maximum at displacement x given as

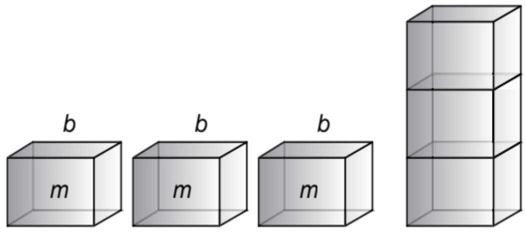


(A) $x = \frac{mg}{2k}$ (B) $x = \frac{mg}{k}$

(C) $x = \frac{mg}{4k}$ (D) $x = \frac{3mg}{2k}$

x is the displacement of the block from its initial position.

63. Three similar cubical slabs each of mass m and edge b are lying on ground. Work done to arrange them one over the other is



(A) $1.5mgb$ (B) $2mgb$

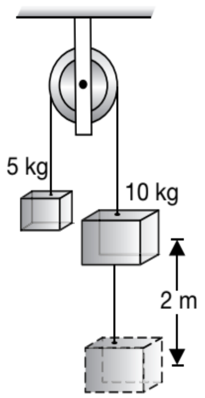
(C) $3mgb$ (D) $4mgb$

64. The potential energy function for the force between two atoms in a diatomic molecule can be expressed approximately as $U = \frac{a}{x^{12}} - \frac{b}{x^6}$, where a and b are positive constants and x is the distance between atoms. The dissociation energy (the energy needed to break up the molecule into separated atoms to infinity) is

(A) $\frac{b^2}{2a}$ (B) $\frac{b^2}{a}$

(C) $\frac{b^2}{4a}$ (D) $\frac{4b^2}{a}$

65. Two blocks of masses 10 kg and 5 kg are connected by a flexible but inextensible string over a shaft as shown in the figure. The system starts from rest with 10 kg mass moving downward. If a constant frictional force of 25 N acts at the shaft, the velocity when the 10 kg block has moved 2 m down is



(A) 2.6 ms^{-1} (B) 6.2 ms^{-1}
(C) 3.2 ms^{-1} (D) 4 ms^{-1}

66. Force acting on a particle moving in a straight line varies with the velocity of the particle as $F = \frac{K}{v}$, where K is a positive constant. The work done by this force in time t is

(A) $\frac{K}{v^2}t$ (B) $2Kt$
(C) Kt (D) $\frac{2Kt}{v^2}$

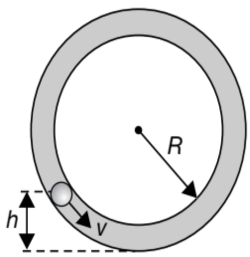
67. A 2 HP pump is used to lift water to the overhead tank on the roof of a building. It has to be operated 8 hours per day and the cost of 1 unit of electricity is ₹6. The electricity bill for month of June will be

(A) ₹2148 (B) ₹2450
(C) ₹1580 (D) ₹840

68. A pendulum of mass 1 kg and length 1 m is released from rest when it makes an angle of $60°$ with the vertical. The power delivered by all the forces acting on the bob when it makes an angle of $30°$ with the vertical is (Take $g = 10\ ms^{-2}$)

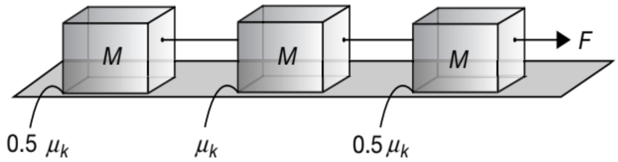
(A) Zero (B) 13.4 watt
(C) 20.4 watt (D) 24.6 watt

69. The minimum speed v with which a small ball should be pushed inside a smooth vertical tube of radius R from a height h such that it may reach the top of the tube is



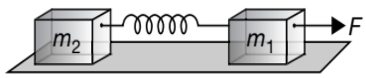
(A) $\sqrt{2g(h+2R)}$ (B) $\frac{5}{2}R$
(C) $\sqrt{g(5R-2h)}$ (D) $\sqrt{2g(2R-h)}$

70. Let a system of three blocks each of mass M, attached by light cords, placed on a horizontal surface move through a distance x with constant velocity. Then work done by the external force is



(A) $3\mu_k Mgx$ (B) $2\mu_k Mgx$
(C) Zero (D) $\frac{2}{3}\mu_k Mgx$

71. Two blocks of masses $m_1 = 1$ kg and $m_2 = 2$ kg are connected by a non-deformed light spring. They are lying on a rough horizontal surface. The coefficient of friction between the blocks and the surface is 0.4. The minimum constant force F that has to be applied in horizontal direction to the block of mass m_1 in order to just shift the other block is (Take $g = 10\ ms^{-2}$)

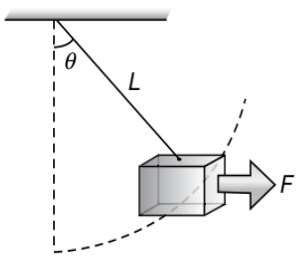


(A) 8 N (B) 15 N
(C) 10 N (D) 25 N

72. A man throws a brick to a height of 5 m where it reaches with a speed of 10 ms^{-1}. If he throws it such that it just reaches that required height, then the percentage of energy saved is ($g = 10\ ms^{-2}$)

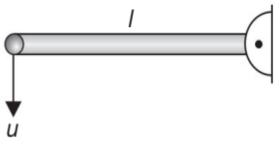
(A) 29% (B) 46%
(C) 38% (D) 50%

73. An object of mass m is tied to string of length L and a variable horizontal force is applied on it which starts at zero and gradually increases (it is pulled extremely slowly so that equilibrium exists at all times) until the string makes an angle θ with the vertical. Work done by the force F is



(A) $mgL(1-\cos\theta)$
(B) $mgL(1-\sin\theta)$
(C) mgL
(D) $mgL(1+\tan\theta)$

74. A ball of mass m is attached to one end of a light rod of length l, the other end of which is hinged. The minimum velocity v that should be imparted to the ball downwards, so that it can complete the circle is



(A) $\sqrt{gl}$ (B) $\sqrt{2gl}$
(C) $\sqrt{3gl}$ (D) $\sqrt{5gl}$

75. A simple pendulum swings with angular amplitude θ. When string is vertical, tension in it is twice the tension in extreme position. Then, $\cos\theta$ is equal to

(A) $\frac{1}{3}$ (B) $\frac{1}{2}$
(C) $\frac{2}{3}$ (D) $\frac{3}{4}$

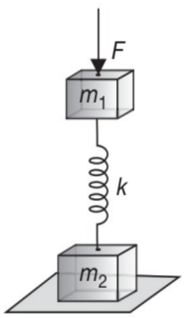
76. A particle is released from a height H has at a certain instant kinetic energy twice its potential energy. The height and speed of particle at that instant are

(A) $\frac{H}{3}, \sqrt{\frac{2gH}{3}}$ (B) $\frac{2H}{3}, \sqrt{\frac{2gH}{3}}$
(C) $\frac{H}{3}, 2\sqrt{\frac{gH}{3}}$ (D) $\frac{H}{3}, \sqrt{2gH}$

77. A uniform flexible chain of mass m and length $2l$ hangs in equilibrium over a smooth horizontal pin of negligible diameter. One end of the chain is given a small vertical displacement so that the chain slips over the pin. The speed of chain when it leaves pin is

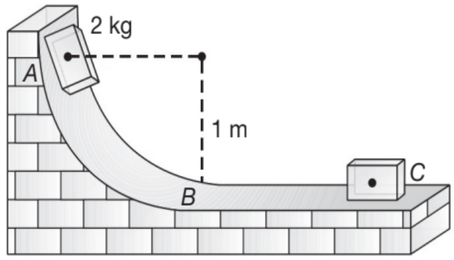
(A) $\sqrt{2gl}$ (B) $\sqrt{gl}$
(C) $\sqrt{4gl}$ (D) $\sqrt{3gl}$

78. A system consists of two blocks of masses m_1 and m_2 respectively connected by a spring of force constant k. The force (F) that should be applied to the upper block for which the lower one just lifts after the force is removed is



(A) $m_1 g$ (B) $\frac{m_1 m_2}{m_1 + m_2} g$
(C) $(m_1 + m_2) g$ (D) $m_2 g$

79. A block of mass 2 kg is released from A on the track that is one quadrant of a circle of radius 1 m. It slides down the track and reaches B with a speed of 4 ms^{-1} and finally stops at C at a distance of 3 m from B. The work done against the force of friction is

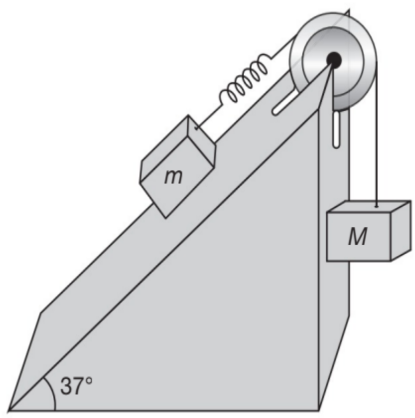


(A) 10 J (B) 20 J
(C) 2 J (D) 6 J

80. A particle moves on a rough horizontal ground with initial velocity v_0 such that $\frac{3}{4}$th of its kinetic energy is lost against friction in time t_0. The coefficient of friction between the particle and the ground is

(A) $\frac{v_0}{gt_0}$ (B) $\frac{v_0}{2gt_0}$
(C) $\frac{3v_0}{4gt_0}$ (D) $\frac{v_0}{4gt_0}$

81. A block of mass m is attached to a light spring of force constant k. The block is placed over a rough inclined surface for which the coefficient of friction is $\mu = \frac{3}{4}$. The minimum value of M required to move the block up the plane is (Neglect mass of string and pulley and friction in pulley)



(A) $\frac{3}{5}$ m (B) $\frac{4}{5}$ m
(C) 2 m (D) $\frac{3}{2}$ m

82. A particle moves in a straight line with retardation proportional to its displacement. Its loss of kinetic energy for any displacement x is proportional to

(A) x (B) x^2
(C) $\ln x$ (D) e^x

83. The potential energy of a particle of mass m is given by $U = \begin{bmatrix} \frac{1}{2}kx^2 & \text{for} & x < 0 \\ 0 & \text{for} & x \geq 0 \end{bmatrix}$. If total mechanical energy of the particle is E. Then its speed at $x = \sqrt{\frac{2E}{k}}$ is

(A) Zero (B) $\sqrt{\frac{2E}{m}}$
(C) $\sqrt{\frac{E}{m}}$ (D) $\sqrt{\frac{E}{2m}}$

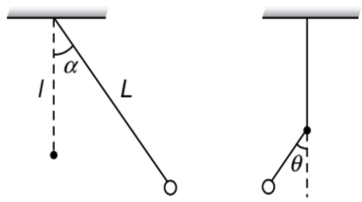
84. A car of mass 1000 kg moves on a rough road where road friction is 10 percent of its weight and air friction 2 percent of its weight. To keep the car at a uniform speed of $36\ \text{kmhr}^{-1}$, the power required will be
(A) 112 kW (B) 56 kW
(C) 12 kW (D) 6 kW

85. A particle of mass 0.5 kg is displaced from position $\vec{r}_1(2, 3, 1)$ m to $\vec{r}_2(4, 3, 2)$ m by applying a force of magnitude 30 N which is acting along $(\hat{i} + \hat{j} + \hat{k})$. The work done by the force is
(A) $10\sqrt{3}$ J (B) $30\sqrt{3}$ J
(C) 30 J (D) $\sqrt{15}$ J

86. A 2 kg block is dropped from a height of 0.4 m on a spring of force constant $k = 1960\ \text{Nm}^{-1}$. The maximum compression of the spring is
(A) 0.1 m (B) 0.2 m
(C) 0.3 m (D) 0.4 m

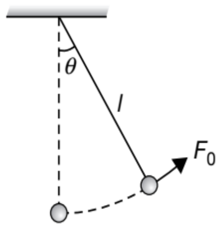
87. A stone of mass 1 kg tied to a light inextensible string of length $L = \frac{10}{3}$ m is whirling in a circular path of radius L in a vertical plane. If the ratio of the maximum tension in the string to the minimum tension in the string is 4 and if g is taken to be $10\ \text{ms}^{-2}$, the speed of the stone at the highest point of the circle is
(A) $20\ \text{ms}^{-1}$ (B) $10\sqrt{3}\ \text{ms}^{-1}$
(C) $5\sqrt{2}\ \text{ms}^{-1}$ (D) $10\ \text{ms}^{-1}$

88. A simple pendulum consisting of a mass M attached in a string of length L is released from rest at an angle α. A pin is located at a distance l below the pivot point. When the pendulum swings down, the string hits the pin as shown in the figure. Assuming that after hitting the pin, the pendulum just oscillates, then the maximum angle θ which string makes with the vertical after hitting the pin is



(A) $\cos^{-1}\left(\frac{L\cos\alpha + l}{L + l}\right)$ (B) $\cos^{-1}\left(\frac{L\cos\alpha + l}{L - l}\right)$
(C) $\cos^{-1}\left(\frac{L\cos\alpha - l}{L - l}\right)$ (D) $\cos^{-1}\left(\frac{L\cos\alpha - l}{L + l}\right)$

89. An agent applies force of constant magnitude F_0 always in the tangential direction as shown in the figure. Find the speed of the bob when string becomes horizontal, assuming that it is at rest at its lowest point



(A) $\sqrt{\frac{l}{m}(\pi F_0 - 2mg)}$ (B) $\sqrt{lg}$
(C) $\sqrt{\frac{\pi F_0 l}{m} - 4mg}$ (D) $\sqrt{\frac{F_0 l}{m}}$

90. The tangential acceleration of a particle in a circular motion of radius 2 m is $a_T = \alpha t\ \text{ms}^{-2}$ (where α is a constant) Initially the particle is at rest. At 2 second from the start, total acceleration of the particle is equally inclined to both the accelerations. The value of constant α is

(A) $\frac{1}{2}\ \text{ms}^{-3}$ (B) $1\ \text{ms}^{-3}$
(C) $2\ \text{ms}^{-3}$ (D) $4\ \text{ms}^{-3}$

91. A car weighing 1000 kg is travelling on a level road with a uniform velocity of $60\ \text{kmh}^{-1}$. The resistance offered to the motion due to air and friction is 50 N. The work done by the car in travelling a distance of 1 km is

(A) 5×10^4 J (B) 60×10^3 J
(C) 60×10^6 J (D) 3000 J

92. A body is attached to the lower end of a vertical spiral spring and it is gradually lowered to its equilibrium position. This stretches the spring by a length d. If the same body attached to the same spring is allowed to fall suddenly, what would be the maximum stretching in this case?

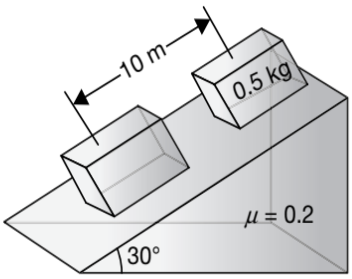
(A) d (B) $2d$

(C) $3d$ (D) $\frac{1}{2}d$

93. A block of mass 4 kg slides on a horizontal smooth surface of a table with a speed $1.6\ \text{ms}^{-1}$. It comes to rest in compressing a spring lying in its path. If the spring has a force constant of $2\ \text{Nm}^{-1}$, the spring should be compressed by

(A) 0.22 m (B) 1.4 m
(C) 2.2 m (D) 0.4 m

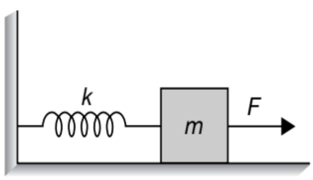
94. A block of mass 0.5 kg has an initial velocity of $10\ \text{ms}^{-1}$ down an inclined rough plane of angle 30°, the coefficient of friction between the block and inclined surface being 0.2. The velocity of the block after it travels a distance of 10 m is



(A) $24\ \text{ms}^{-1}$ (B) $13\ \text{ms}^{-1}$

(C) $8\ \text{ms}^{-1}$ (D) $17\ \text{ms}^{-1}$

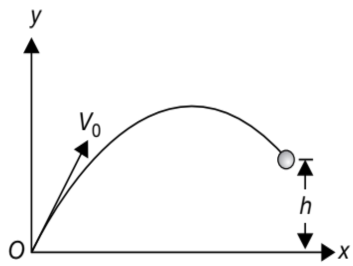
95. If the block in the shown arrangement is acted upon by a constant force F for $t \geq 0$, its maximum speed will be



(A) $\frac{F}{\sqrt{mk}}$ (B) $\frac{2F}{\sqrt{mk}}$

(C) $\frac{F}{\sqrt{2mk}}$ (D) $\frac{\sqrt{2}F}{\sqrt{mk}}$

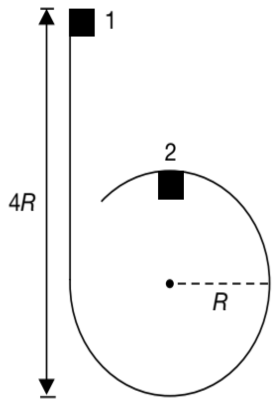
96. A projectile is fired from point O with an initial speed V_0. The speed at an altitude h from the ground is



(A) $\sqrt{V_0^2 + 2gh}$ (B) $\sqrt{2gh}$

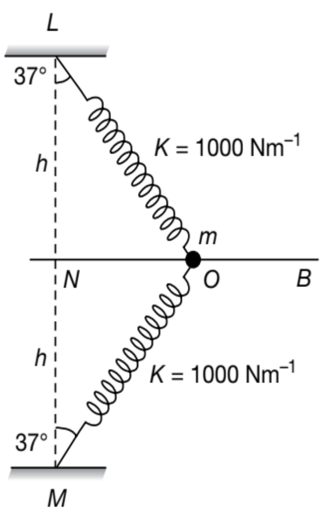
(C) $\sqrt{V_0^2 - 2gh}$ (D) $\sqrt{2gh - V_0^2}$

97. A cube of mass M starts at rest from point 1 at a height $4R$, where R is the radius of the circular track. The cube slides down the frictionless track and around the loop. The force which the track exerts on the cube at point 2 is



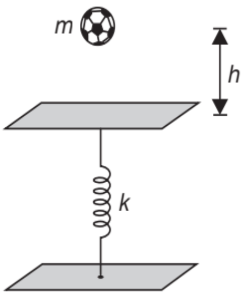
(A) $3Mg$ (B) Mg
(C) $2Mg$ (D) Cube will not reach the point 2

98. A bead of mass 5 kg is free to slide on the horizontal rod AB. They are connected to two identical springs of natural length h ms as shown. If initially bead was at O and M is vertically below L then, velocity of bead (in ms^{-1}) at point N will be



(A) $5h$ (B) $13.3h$
(C) $8h$ (D) $4h$

99. A ball of mass m is dropped from height h on a light platform fixed at the top of a vertical spring as shown in Figure.



Speed of the ball will be maximum at the instant when compression x in the spring is

(A) $\dfrac{mg}{k}$

(B) $\dfrac{mg}{2k}$

(C) $\dfrac{2mg}{k}$

(D) Zero

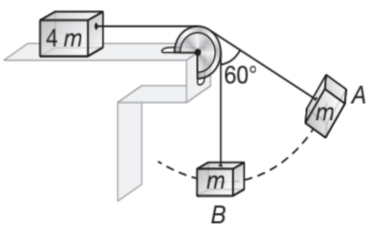
MULTIPLE CORRECT CHOICE TYPE QUESTIONS

This section contains Multiple Correct Choice Type Questions. Each question has four choices (A), (B), (C) and (D), out of which ONE OR MORE is/are correct.

1. A particle is taken from point A to point B under the influence of a force field. Now it is taken back from B to A and it is observed that the work done in taking the particle from A to B is not equal to the work done in taking it from B to A. If W_{nc} and W_c is the work done by non-conservative forces and conservative forces present in the system respectively, ΔU is the change in potential energy, Δk is the change in kinetic energy, then

(A) $W_{nc} - \Delta U = \Delta k$ (B) $W_c = -\Delta U$
(C) $W_{nc} + W_c = \Delta k$ (D) $W_{nc} - \Delta U = -\Delta k$

2. In the system shown in the figure the mass m moves in a circular arc of angular amplitude $60°$. Mass $4m$ is stationary. Then

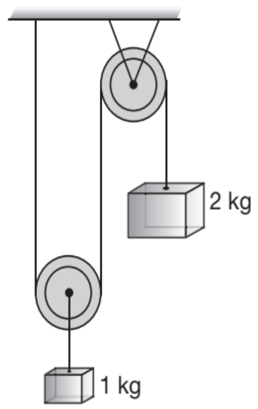


(A) the minimum value of coefficient of friction between the mass $4m$ and the surface of the table is 0.5
(B) the work done by gravitational force on the block m is positive when it moves from A to B
(C) the power delivered by the tension when m moves from A to B is zero
(D) the kinetic energy of m in position B equals the work done by gravitational force on the block when it moves from position A to B

3. An engine is pulling a train of mass m on a level track at a uniform speed v. The resistive force offered per unit mass is f.

(A) Power produced by the engine is mfv.
(B) The extra power developed by the engine to maintain a speed v up a gradient of h in s is $\dfrac{mghv}{s}$.
(C) The frictional force exerting on the train is mf on the level track.
(D) None of above is correct.

4. In the pulley-block system shown in figure strings are light, the pulleys are light and smooth. The system is released from rest. At $t = 0.3$ s

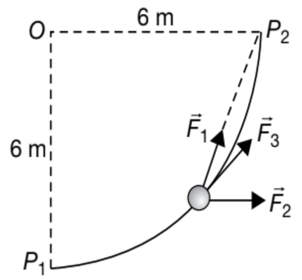


(A) work done on 2 kg block by gravity is 6 J
(B) work done on 2 kg block by string is –2 J
(C) work done on 1 kg block by gravity is –1.5 J
(D) work done on 1 kg block by string is 2 J

5. A block of mass 2 kg is hanging over a smooth and light pulley through a light string. The other end of the string is pulled by a constant force $F = 40\text{ N}$. The kinetic energy of the particle increases 40 J in a given interval of time. Then (Take $g = 10\text{ ms}^{-2}$)

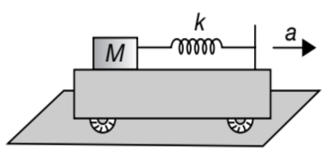
(A) Tension in the string is 40 N
(B) Displacement of the block in the given interval of time is 2 m.
(C) Power developed by this force varies linearly with time
(D) Power developed by this force varies parabolically with displacement.

6. A smooth track in the form of a quarter circle of radius 6 m lies in the vertical plane. A particle moves from P_1 to P_2 under the action of forces $\vec{F}_1$, $\vec{F}_2$ and $\vec{F}_3$. Force $\vec{F}_1$ is always toward P_2 and is always 20 N in magnitude. Force $\vec{F}_2$ always acts horizontally and is always 30 N in magnitude. Force $\vec{F}_3$ always acts tangentially to the track and is of magnitude 15 N. Select the correct alternative(s)



(A) $\vec{F}_1$ is conservative in nature
(B) work done by $\vec{F}_1$ is 120 J
(C) work done by $\vec{F}_2$ is 180 J
(D) work done by $\vec{F}_3$ is 45π J

7. A block of mass M is attached with a spring of spring constant k. The whole arrangement is placed on the frictionless surface of a vehicle as shown in figure. If the vehicle starts moving towards right with an acceleration a (there is no friction anywhere), then

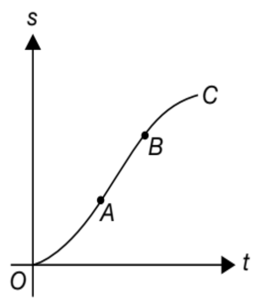


(A) maximum elongation in the spring is $\frac{Ma}{k}$
(B) maximum elongation in the spring is $\frac{2Ma}{k}$
(C) maximum compression in the spring is $\frac{2ma}{k}$
(D) maximum compression in the spring is zero

8. A particle is acted upon by a conservative force $\vec{F} = (7\hat{i} - 6\hat{j})\text{ N}$ (no other force is acting on the particle). Under the influence of this force particle moves from $(0, 0)$ to $(-3\text{ m}, 4\text{ m})$ then

(A) work done by the force is 3 J
(B) work done by the force is –45 J
(C) at $(0, 0)$ speed of the particle must be zero
(D) at $(0, 0)$ speed of the particle must not be zero

9. Displacement time graph of a particle moving in a straight line is as shown in figure. Select the correct alternative(s)

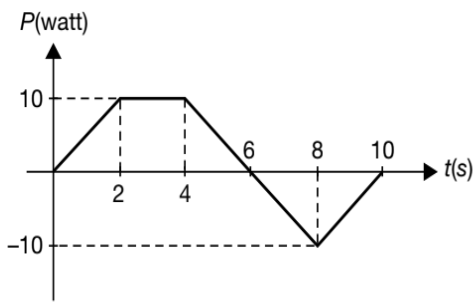


(A) Work done by all the forces in region OA and BC is positive.
(B) Work done by all the forces in region AB is zero.
(C) Work done by all the forces in region BC is negative
(D) Work done by all the forces in region OA is negative.

10. A block initially suspended by an ideal spring of force constant k is pulled down by applying a constant force F and if maximum displacement of block from its initial mean position of rest is x_0 then

(A) increase in energy stored in spring is kx_0^2
(B) $x_0 = \frac{3F}{2k}$
(C) work done by applied force F is Fx_0
(D) $x_0 = \frac{2F}{k}$

11. Power due to a force acting on a block varies with time t as shown in figure. Then angle between force acting on the block and its velocity is



(A) acute at $t = 1$ s
(B) $90°$ at $t = 3$ s
(C) obtuse at $t = 7$ s
(D) change in kinetic energy from $t = 0$ to $t = 10$ s is 20 J

12. A particle is moving in a conservative force field from point A to point B. U_A and U_B are the potential energies of the particle at points A and B and W_c is the work done in the process of taking the particle from A to B.

(A) $W_c = U_B - U_A$ (B) $W_c = U_A - U_B$
(C) $U_A > U_B$ (D) $U_B > U_A$

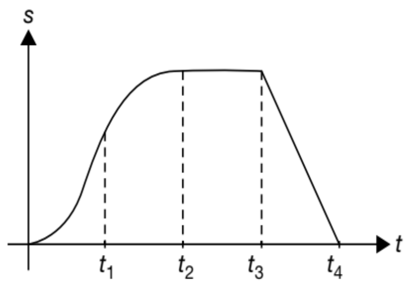
13. Out of the following statements, select the correct alternative(s)
(A) Work done by static friction is always zero.
(B) Work done by kinetic friction can also be positive.
(C) Kinetic energy of a system cannot be increased without applying any external force on the system.
(D) Work energy theorem is valid for non-inertial frames also.

14. Kinetic energy of a particle is continuously increasing with time. It means
(A) resultant force is always along the direction of motion
(B) resultant force is always normal to the direction of motion
(C) resultant force is at an angle less than $90°$ to the direction of motion
(D) its height above the ground level may be decreasing
(E) power associated with resultant force is not equal to zero

15. The potential energy of a particle of mass 1 kg in a conservative field is given as $U = (3x^2y^2 + 6x)$ J, where x and y are measured in meter. Initially particle is at (1, 1) and at rest, then
(A) initial acceleration of particle is $6\sqrt{5}$ ms^{2}
(B) work done to slowly bring the particle to origin is 9 J
(C) work done to slowly bring the particle to origin is –9 J
(D) if particle is left free it moves in straight line

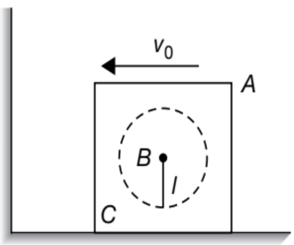
16. A block of mass 2 kg is hanging over a smooth and light pulley through a light string. The other end of the string is pulled by a constant force $F = 40$ N. The kinetic energy of the particle is increased by 40 J in a given interval of time. Then $(g = 10 \text{ ms}^{-2})$
(A) tension in the string is 40 N
(B) displacement of the block in the given interval of time is 2 m
(C) work done by gravity is –20 J
(D) work done by tension is 80 J

17. Displacement time graph of a particle moving in a straight line is as shown in figure. From the graph we observe that the work done on the block is



(A) positive from 0 to t_1
(B) negative from t_1 to t_2
(C) zero from t_2 to t_3
(D) negative from t_3 to t_4

18. A Block A is placed on a smooth horizontal surface and a particle C is suspended with the help of light rod from point B of the block as shown. Now both the block A and the particle C are given velocity v_0 towards left. The block A strikes a fixed wall and suddenly stops. Then, (The rod BC is free to rotate about B)



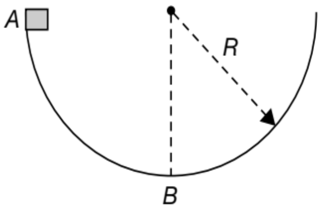
(A) The smallest velocity v_0 for which the particle C will swing in a full circle about the point B is $\sqrt{4gl}$.
(B) The smallest velocity v_0 for which the particle C will swing in a full circle about the point B is $\sqrt{gl}$.
(C) Velocity of point C at the highest point of the circle (for the smallest value of v_0) is zero.
(D) Velocity of point C at the highest point of the circle (for the smallest value of v_0) is $\sqrt{gl}$.

19. A force acting on an object does zero work, if
(A) the force is always perpendicular to its acceleration
(B) the object is stationary but the point of application of the force moves on the object

(C) the force is always perpendicular to its velocity
(D) the object moves in such a way that the point of application of the force remains fixed

20. If the kinetic energy of a body is directly proportional to time t, the magnitude of the force acting on the body is
(A) directly proportional to $\sqrt{t}$
(B) inversely proportional to $\sqrt{t}$
(C) directly proportional to the speed of the body
(D) inversely proportional to the speed of the body

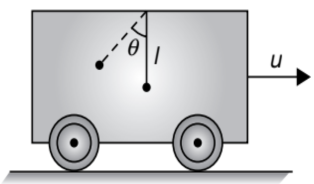
21. A small block of mass m is released from rest from position A inside a smooth hemispherical bowl of radius R as shown in figure. The incorrect statement(s) is/are



(A) Acceleration of block is constant throughout
(B) Acceleration of block at A is g
(C) Acceleration of block at B is $3g$
(D) Acceleration of block at B is $2g$

22. A particle of mass 5 kg moving in the x-y plane has its potential energy given by $U = (-7x + 24y)\text{ J}$, where x and y are in metre. The particle is initially at origin and has a velocity $\vec{u} = (14.4\hat{i} + 4.2\hat{j})\text{ ms}^{-1}$.
(A) The particle has a speed of 25 ms^{-1} at $t = 4\text{ s}$.
(B) The particle has an acceleration of 5 ms^{-2}.
(C) The acceleration of the particle is perpendicular to its initial velocity.
(D) None of the above is correct.

23. A pendulum of length l is suspended on a flat car that is moving with a velocity u on the horizontal road. If the car is suddenly stopped, then, (assume bob of pendulum does not collide anywhere)



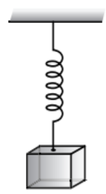
(A) the maximum angle θ with the initial vertical line through which the pendulum swing is $\sin^{-1}\left[\frac{u}{2\sqrt{gl}}\right]$
(B) the maximum angle θ with the initial vertical line through which the pendulum swing is $2\sin^{-1}\left[\frac{u}{2\sqrt{gl}}\right]$
(C) if maximum angle is $60°$, $l = 5\text{ m}$ and $g = 9.8\text{ ms}^{-2}$ then the initial speed of car u is 7 ms^{-1}
(D) if maximum angle θ is $30°$, $l = 5\text{ m}$ and $g = 9.8\text{ ms}^{-2}$, then the initial speed of car u is 6 ms^{-1}

24. A small spherical ball is suspended through a string of length l. The whole arrangement is placed in a vehicle which is moving with velocity v. Now suddenly the vehicle stops and ball starts moving along a circular path. If tension in the string at the highest point is twice the weight of the ball and v' be the velocity of ball at the highest point, then
(A) $v = \sqrt{5gl}$
(B) $v = \sqrt{7gl}$
(C) $v' = \sqrt{gl}$
(D) $v' = \sqrt{3gl}$

25. One end of a light spring of force 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 case(s) may be
(A) The spring was initially stretched by a distance x and finally was in its natural length.
(B) The spring was initially in its natural length and finally it was compressed by a distance x.
(C) The spring was initially compressed by a distance x and finally was in its natural length.
(D) The spring was initially in its natural length and finally stretched by a distance x.

26. If a particle under the action of a force F has potential energy U then in equilibrium
(A) $F = 0$ and $U = 0$
(B) $F \neq 0$ and $U = 0$
(C) $F = 0$ and $U \neq 0$
(D) $F \neq 0$ and $U \neq 0$

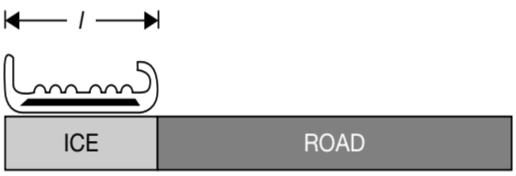
27. A block suspended from a spring is released when the spring is unstretched. Then, which of the following OPTIONS is/are correct?



(A) Block starts oscillating simple harmonically.
(B) Throughout the motion block is accelerated.
(C) Maximum acceleration of block is g.
(D) In the upward motion of block, spring is detached from the block at its mean position, then block will rise to a height greater than from where it was released.

28. The potential energy U, in joule, of a particle of mass 1 kg moving in x-y plane varies as $U = 3x + 4y$, where (x, y) are the co-ordinates of the particle in metre. If the particle starts from rest from $(6, 4)$ at time $t = 0$ then
(A) the particle has constant acceleration
(B) the particle has zero acceleration
(C) the speed of particle when it crosses the y-axis is $10\ \text{ms}^{-1}$
(D) co-ordinates of particle at $t = 1$ s are $(4.5, 2)$

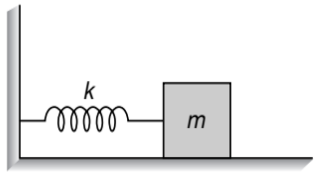
29. A sledge moving over a smooth horizontal surface of ice at a velocity v_0 drives out on a horizontal road and comes to a halt as shown. The sledge has a length l, mass m and friction between runners and road is μ.



(A) No work is done by the friction to switch the sledge from ice to the road.
(B) A work of $\frac{1}{2}\mu mgl$ is done against friction while sledge switches completely on to road.
(C) The distance covered by the sledge on the road is $\left(\frac{v_0^2}{2\mu g} - \frac{l}{2}\right)$.
(D) Total distance moved by the sledge before stopping is $\left(\frac{v_0^2}{2\mu g} + \frac{l}{2}\right)$.

30. A particle moves in a straight line with constant acceleration under a constant force F. Select the incorrect alternative(s)
(A) power developed by this force varies linearly with time
(B) power developed by this force varies parabolically with time
(C) power developed by this force varies linearly with displacement
(D) power developed by this force varies parabolically with displacement

31. The spring is given a compression a and released. The block of mass m again comes to rest when the spring extends by b. During this process, the work done by the spring on the block is W. If μ be the coefficient of friction between the block and the surface, then



(A) $W = \frac{1}{2}k(a+b)^2$ (B) $W = \frac{1}{2}k(a^2 - b^2)$
(C) $\mu = \frac{k(a-b)}{2mg}$ (D) $\mu = \frac{k(a+b)}{2mg}$

32. One end of a light spring of force constant k is fixed to a wall and the other end is tied to a block placed on a smooth horizontal surface. For a possible displacement, the work done by the spring is $\frac{1}{2}kx^2$. The possible case(s) may be
(A) the spring was initially stretched by a distance x and finally was in its natural length
(B) the spring was initially in its natural length and finally it was compressed by a distance x
(C) the spring was initially compressed by a distance x and finally was in its natural length
(D) the spring was initially in its natural length and finally stretched by a distance x

33. A ball of mass m is attached to the lower end of a 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 length and comes to rest again after descending through a distance x. Then select the correct statement(s).
(A) $x = \frac{mg}{k}$
(B) $x = \frac{2mg}{k}$
(C) The ball will have no acceleration at the position where it has descended through $\frac{x}{2}$.
(D) The ball will have an upward acceleration equal to g at its lowermost position.

34. The potential energy U for a force field $\vec{F}$ is such that $U = -kxy$, where k is a constant.
(A) $\vec{F} = ky\hat{i} + kx\hat{j}$
(B) $\vec{F} = kx\hat{i} + ky\hat{j}$
(C) The force $\vec{F}$ is a conservative force
(D) The force $\vec{F}$ is a non-conservative force.

35. During projectile motion, the power due to gravitational force
(A) is constant throughout
(B) varies linearly with time
(C) is positive for complete path
(D) is negative for first half, zero at topmost point and positive for rest half

36. Two blocks A and B having different kinetic energies K_A and $K_B(>K_A)$ are released on rough horizontal ground having same coefficient of friction for both the blocks. Then
(A) momentum of B is greater than momentum of A
(B) more work has to be done by friction to stop B
(C) B will travel more distance before stopping
(D) from the given data we cannot compare the distances travelled by them before stopping

37. Which of the following can be negative
(A) kinetic energy (B) potential energy
(C) mechanical energy (D) energy

38. A force $F=-kx^3$ is acting on a block moving along x-axis. Here, k is a positive constant. Work done by this force is
(A) positive in displacing the block from $x=3$ to $x=1$
(B) positive in displacing the block from $x=-1$ to $x=-3$
(C) negative in displacing the block from $x=3$ to $x=1$
(D) negative in displacing the block from $x=-1$ to $x=-3$

39. Suppose a car is modeled as a cylinder moving with a speed v. If A is the area of cross-section of the car and ρ is the density of air then
(A) power loss due to air resistance is $\frac{1}{2}A\rho v^3$
(B) power loss due to air resistance is $A\rho v^3$
(C) drag force is $\frac{1}{2}A\rho v^2$
(D) drag force is $A\rho v^2$

40. A block is suspended by an ideal spring of force constant k. If the block is pulled down by applying constant force F and if maximum displacement of block from its initial position of rest is x_0 then
(A) Increase in energy stored in spring is kx_0^2
(B) $x_0=\frac{3F}{2k}$
(C) $x_0=\frac{2F}{k}$
(D) Work done by applied force F is Fx_0

REASONING BASED QUESTIONS

This section contains Reasoning type questions, each having four choices (A), (B), (C) and (D) out of which ONLY ONE is correct. Each question contains STATEMENT 1 and STATEMENT 2. You have to mark your answer as

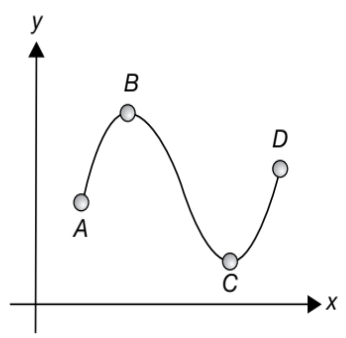
Bubble (A) If both statements are TRUE and STATEMENT 2 is the correct explanation of STATEMENT 1.
Bubble (B) If both statements are TRUE but STATEMENT 2 is not the correct explanation of STATEMENT 1.
Bubble (C) If STATEMENT 1 is TRUE and STATEMENT 2 is FALSE.
Bubble (D) If STATEMENT 1 is FALSE but STATEMENT 2 is TRUE.

1. **Statement-1:** Under the action of a force of constant magnitude, work done is path independent.
Statement-2: Work done by force of gravity is path independent.

2. **Statement-1:** Two cars of unequal mass are moving with equal velocity in straight line. On applying equal resistive force on both the cars, work done to stop them are equal.
Statement-2: Work done is equal to change in its kinetic energy.

3. **Statement-1:** A car and heavy truck have the same speed moving on a road. Same force is applied on both and both stop in same distance.
Statement-2: Same force will cause the different retardation in the two vehicles.

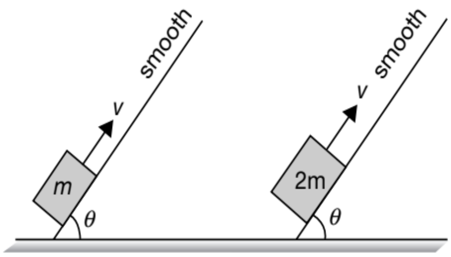
4. **Statement-1:** The potential energy of a particle varies with distance x as shown in the graph.



The force acting on the particle is zero at point B and C.
Statement-2: The slope of y-x curve is zero at point B and C.

5. **Statement-1:** A body is connected to a string and if it just completes a circle, it must have zero velocity at the top.
Statement-2: A body is projected in vertically upward direction, at the highest point the acceleration of particle is non-zero.

6. **Statement-1:** Consider the two situation shown in the figure. In first case height attained by particle above ground is same as the height attained by particle in case II.
Statement-2: As planes are smooth so initial kinetic energy is converted into potential energy. Initial kinetic energy in two cases is different.



7. **Statement-1:** Power developed in a uniform circular motion is always zero.
Statement-2: Work done in case of a uniform circular motion is zero.

8. **Statement-1:** A heavy weight is suspended from the spring. A person raises the weight slowly till the spring become slack. The work done by person is W. The energy stored on the stretched spring was E. The gain in gravitational potential energy is $(W+E)$.
Statement-2: Work done by the spring force is always negative.

9. **Statement-1:** A bomb at rest explodes into two fragments of different masses. The kinetic energies of the two fragments will be in inverse ratio of their masses.
Statement-2: Kinetic energy of a body is inversely proportional to its momentum.

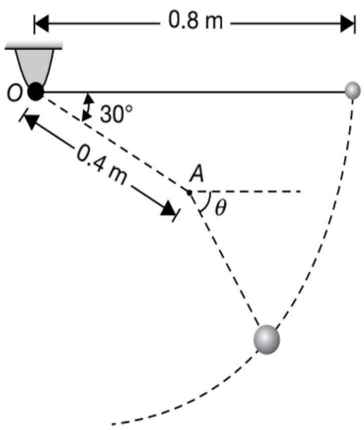
10. **Statement-1:** When a man raises himself up by pulling down on a horizontal bar as in a gymnasium, it is work done by the normal reaction from the bar that goes on to increase his potential energy.
Statement-2: Normal force applied by the bar on the man is responsible for lifting the centre of mass of the man.

LINKED COMPREHENSION TYPE QUESTIONS

This section contains Linked Comprehension Type Questions or Paragraph based Questions. Each set consists of a Paragraph followed by questions. Each question has four choices (A), (B), (C) and (D), out of which only one is correct. (For the sake of competitiveness there may be a few questions that may have more than one correct options).

Comprehension 1

A small sphere B of mass m is released from rest in the position shown and swings freely in a vertical plane, first about O and then about the peg A after the cord comes in contact with the peg.



Based on above information, answer the following questions.

1. The tension in the cord just before it comes in contact with the peg is

(A) $\frac{mg}{2}$ (B) mg

(C) $\frac{3mg}{2}$ (D) $2mg$

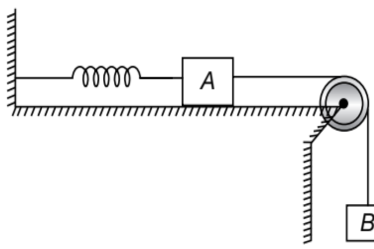
2. The tension in the cord just after it comes in contact with the peg is

(A) $\frac{5mg}{2}$ (B) $\frac{3mg}{2}$

(C) $\frac{mg}{2}$ (D) $\frac{mg}{4}$

Comprehension 2

Consider the set up shown below in figure. Block A has a mass m and the block B has a mass $2m$. The block A is attached to a rigid wall through a spring of spring constant k. The system is released from rest with the spring unstretched. Assume friction to be absent everywhere.



Based on the above facts, answer the following questions.

3. The maximum extension x_{max} produced in spring is

(A) $\frac{mg}{k}$ (B) $\frac{2mg}{k}$

(C) $\frac{3mg}{k}$ (D) $\frac{4mg}{k}$

4. The speed of the block A, when the extension in the spring is half the maximum extension is

(A) $g\sqrt{\frac{m}{k}}$ (B) $2g\sqrt{\frac{2m}{3k}}$

(C) $g\sqrt{\frac{2m}{3k}}$ (D) $2g\sqrt{\frac{m}{3k}}$

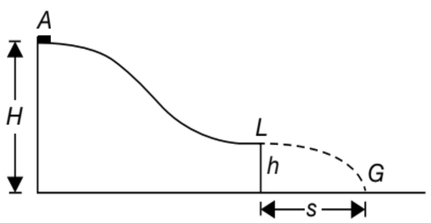
5. Net acceleration of the block B, when extension in the spring is one fourth the maximum extension is

(A) g (B) $\frac{g}{2}$

(C) $\frac{g}{3}$ (D) $\frac{g}{4}$

Comprehension 3

A small disc A slides down with zero initial velocity from the top of a smooth hill of height H which also has a horizontal portion as shown in figure.



Based on the above facts and figures, answer the following questions.

6. The speed of launch of the particle as a projectile at lowest point of the hill L is

(A) $\sqrt{2gH}$ (B) $\sqrt{2gh}$

(C) $\sqrt{2g(H+h)}$ (D) $\sqrt{2g(H-h)}$

7. Time taken by the particle to go from L to G is

(A) $\sqrt{\frac{2H}{g}}$ (B) $\sqrt{\frac{2h}{g}}$

(C) $\sqrt{\frac{2(H+h)}{g}}$ (D) $\sqrt{\frac{2(H-h)}{g}}$

8. The height of the horizontal portion h to ensure the maximum distance s covered by the disc is

(A) H (B) $\frac{H}{2}$

(C) $\frac{H}{3}$ (D) $\frac{H}{4}$

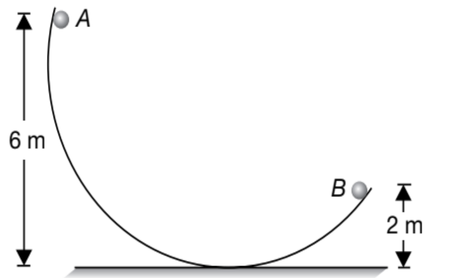
9. The maximum distance then covered by the disc is s_{max}. Then s_{max} equals

(A) $\frac{H}{4}$ (B) $\frac{H}{3}$

(C) $\frac{H}{2}$ (D) H

Comprehension 4

A ball is released from point A as shown in figure. The ball leaves the track at B. All surfaces are smooth.



Based on above information, answer the following questions.

10. Let h be the maximum height from ground reached by ball after leaving track at B. Then

(A) $h = 6$ m

(B) $h < 6$ m

(C) $h > 6$ m

(D) speed of ball at B will change if shape of track is changed keeping h_A and h_B constant

11. If track makes an angle $30°$ with horizontal at B then maximum height attained by ball will be

(A) 3 m (B) 4 m

(C) 4.5 m (D) 5 m

Comprehension 5

The work done by a variable force $\vec{F}$ is measured by taking an infinitesimal length element $d\vec{l} = \hat{i}\,dx + \hat{j}\,dy + \hat{k}\,dz$ such that $W = \int \vec{F} \cdot d\vec{l}$. A particle of mass 2 kg is being acted upon by a variable force $\vec{F} = k\left(x^2y^3\hat{i} + x^3y^2\hat{j}\right)$. The particle is taken from $(0, 0)$ to (a, a) along different paths. Based on the above facts, answer the following questions.

12. The work done to take the particle from $(0, 0)$ to $(a, 0)$ (for $k = 24$) is

(A) Zero (B) $4a^6$

(C) $6a^6$ (D) $8a^6$

13. The work done to take the particle from $(a, 0)$ to (a, a) (for $k = 9$) is

(A) Zero (B) a^6

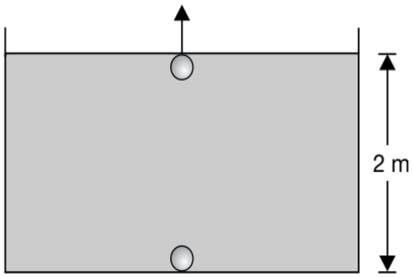
(C) $3a^6$ (D) $5a^6$

14. The work done to take the particle from $(0, 0)$ to $(a, 0)$ to (a, a) is
(A) ka^6 (B) $\frac{ka^6}{2}$
(C) $\frac{ka^6}{3}$ (D) $\frac{ka^6}{4}$

15. The force $\vec{F} = k\left(x^3y^2\hat{i} + x^2y^3\hat{j}\right)$ is a
(A) conservative force
(B) non-conservative force
(C) force which is neither conservative nor non-conservative
(D) None of above facts seems to be true

Comprehension 6

A ball of mass 2 kg is released from the bottom of a tank filled with water upto 2 m. On reaching the top its kinetic energy is found to be 16 J. Ignoring the viscosity and taking $g = 10\text{ ms}^{-2}$, answer the following questions.



16. The work done by upthrust is W_1 and that done by gravity is W_2, then
(A) $W_1 = 32\text{ J}, W_2 = -16\text{ J}$ (B) $W_1 = -16\text{ J}, W_2 = 32\text{ J}$
(C) $W_1 = 40\text{ J}, W_2 = -24\text{ J}$ (D) $W_1 = 56\text{ J}, W_2 = -40\text{ J}$

17. Density of the ball in $\frac{\text{kg}}{\text{m}^3}$ is
(A) $\frac{5}{7}\times 10^3$ (B) $\frac{3}{4}\times 10^3$
(C) $\frac{2}{3}\times 10^3$ (D) $\frac{1}{3}\times 10^3$

Comprehension 7

The radial component of a conservative force (like electrostatic or gravitational force) can be calculated from the potential energy function U, by using the formula $F = -\frac{dU}{dr}$. Consider a particle bound to a certain point at a distance r from the centre of the force such that the potential energy of this particle varies with r as $U(r) = \frac{A}{r^2} - \frac{B}{r}$ where A and B are positive constants. Based on the above facts, answer the following questions.

18. For the particle, the equilibrium distance is r_0. Then
(A) $r_0 = \frac{A}{B}$ (B) $r_0 = \frac{2A}{B}$
(C) $r_0 = \frac{3A}{B}$ (D) $r_0 = \frac{B}{4A}$

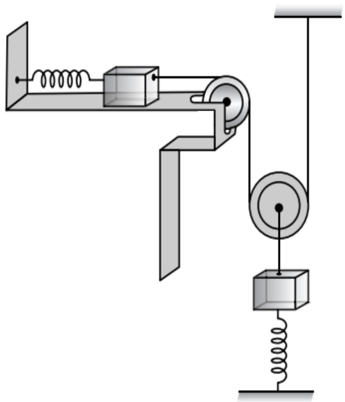
19. The nature of the equilibrium
(A) is stable
(B) is unstable
(C) is neutral
(D) non-predictable, as data provided is insufficient

20. The particle is moved from the equilibrium position to infinity. A work W is done in the process. Then
(A) $W = \frac{B^2}{2A}$ (B) $W = \frac{B^2}{4A}$
(C) $W = \frac{2B^2}{A}$ (D) $W = \frac{4B^2}{A}$

21. It is found that at a particular radial position, the total energy possessed by the particle is $E = -\frac{3B^2}{16A}$. Assuming the motion to be purely radial, the velocity will be zero at position given by (in terms of equilibrium distance r_0)
(A) r_0 (B) $\frac{r_0}{3}$
(C) $\frac{2r_0}{3}$ (D) $\frac{r_0}{5}$

Comprehension 8

The system is released from rest with both the springs in unstretched positions. The mass of each block is 1 kg and force constant of each spring is 10 Nm^{-1}.



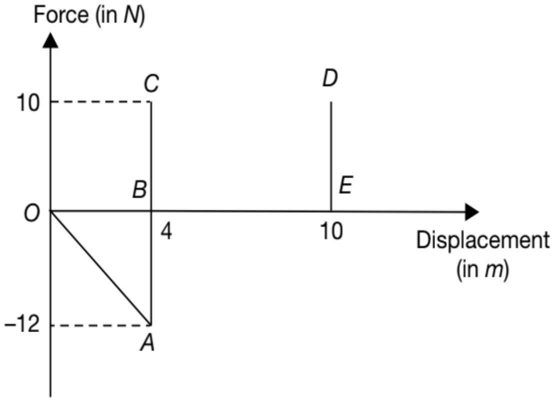
Based on above information, answer the following questions.

22. Extension of horizontal spring, in equilibrium, is
(A) 0.2 m (B) 0.4 m
(C) 0.6 m (D) 0.8 m

23. Maximum speed of the block placed horizontally is
(A) $1.26\ ms^{-1}$ (B) $1.93\ ms^{-1}$
(C) $2.21\ ms^{-1}$ (D) $3.21\ ms^{-1}$

Comprehension 9

The kinetic energy is the capacity of the body to do work by virtue of its motion. For a body of mass m moving with a velocity v, it is mathematically defined as $KE = \frac{1}{2}mv^2$.



For conservative forces doing work, the kinetic energy always increases (or remains constant) and for non-conservative forces doing work, the kinetic energy decreases. A plot of force vs displacement is shown here. The conservative force is shown as positive and that due to non-conservative force is shown as negative. Consider a body of mass 4 kg having a velocity of $20\ ms^{-1}$ at the origin of the coordinates. Based on the above facts and figures, answer the following questions.

24. The kinetic energy of the particle at the origin of the coordinates is
(A) 400 J (B) 600 J
(C) 800 J (D) 1000 J

25. The kinetic energy of the body at B, $x = 4$ m is
(A) 376 J (B) 576 J
(C) 776 J (D) 824 J

26. The kinetic energy of the body at E, $x = 10$ m is
(A) 1036 J (B) 836 J
(C) 636 J (D) 436 J

27. Let us assume the body to return to O under the action of these forces, then the kinetic energy of the body at the origin of the coordinates will
(A) again be 800 J
(B) be more than 800 J
(C) be less than 800 J
(D) be greater or less than 800 J

Comprehension 10

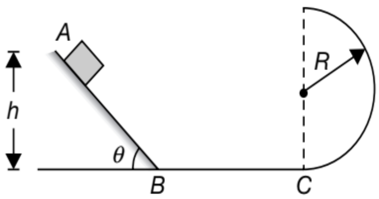
A bob of mass 1 kg is suspended from an inextensible string of length 1 m. When the string makes an angle of $60°$ with the vertical, speed of the bob is $4\ ms^{-1}$. Based on above information, answer the following questions.

28. Net acceleration of the bob at this instant is
(A) $10.4\ ms^{-2}$ (B) $16\ ms^{-2}$
(C) $18.2\ ms^{-2}$ (D) $20.4\ ms^{-2}$

29. The maximum height upto which the bob will rise with respect to the bottom most point is
(A) 1.3 m (B) > 1.3 m
(C) < 1.3 m (D) > 2 m

Comprehension 11

A block is released from height $h(\neq 0)$ on a rough track AB as shown in figure. The coefficient of friction between the block and the surface is $\mu = 0.5$ and the track BC is smooth. From C onwards there is a circular smooth track of radius $R = 50$ cm. Given $\tan\theta = \frac{3}{4}$ and $g = 10\ ms^{-2}$. Based on above information, answer the following questions.



30. For what value of h block does not leave contact with any surface.
(A) $h = 2.5$ m (B) $h \leq 2$ m
(C) $h = 2$ m (D) $h \leq 1.5$ m

31. If the block is placed on the above calculated height, how many times will the block cross point C?
(A) Infinite number of times
(B) 2 times
(C) 4 times
(D) 3 times

Comprehension 12

A projectile of mass $m = 1$ kg is projected with velocity v_0 at angle θ. If $\vec{a}$ be the acceleration of the projectile $\vec{v}$ be its velocity, h be its height, K be its kinetic energy and U be its potential energy at any instant, then based on above information, answer the following questions.

32. The magnitude of rate of change of potential energy of the projectile is numerically equal to the magnitude of

(A) $\vec{a} \times \vec{v}$ (B) $\vec{a} \cdot \vec{v}$

(C) $|\vec{a}| \times |\vec{v}|$ (D) $\frac{|\vec{a}|}{|\vec{v}|}$

33. A graph is plotted between $\frac{K}{U}$ (on y-axis), and $\frac{1}{h}$ (on x-axis) then the graph will be

(A) a straight line passing through origin
(B) a straight line not passing through origin
(C) a parabola passing through origin
(D) a parabola not passing through origin

Comprehension 13

A particle of mass 2 kg moving along x axis is being acted upon by a single conservative force denoted by $F(x)$. The potential energy of the particle is $U(x) = 20 + (x-2)^2$, where U is in joule and x is in metre. The velocity that the particle possesses at $x = 5$ m is 4 ms^{-1}. Based on the above facts, answer the following questions.

34. The system possesses a mechanical energy equal to

(A) 25 J (B) 35 J
(C) 45 J (D) 55 J

35. The maximum kinetic energy possessed by the particle is

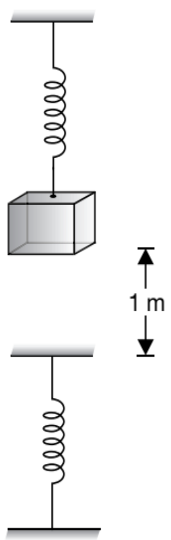
(A) 15 J (B) 25 J
(C) 30 J (D) 35 J

36. For what value of x (say x_0) will the particle be in equilibrium?

(A) $x_0 = 1$ m (B) $x_0 = 2$ m
(C) $x_0 = 3$ m (D) $x_0 = 4$ m

Comprehension 14

A block of mass $m = 2$ kg is suspended by a spring of force constant $k = 10$ Nm^{-1}. An another spring of same value of force constant is 1 m below it. Initially both the springs were unstretched. The block is released from rest.



Based on above information, answer the following questions.

37. The maximum extension in the upper spring is

(A) 3.26 m (B) 1.67 m
(C) 2.82 m (D) None of these

38. The equilibrium position of the block from where it was released is

(A) 1 m (B) 2 m
(C) 1.2 m (D) 1.5 m

Comprehension 15

The velocity versus displacement of a particle of mass 2 kg moving in a straight line is given by

$$v = \sqrt{9 + 4s}$$

where v is in ms^{-1} and s in metre. Based on above information, answer the following questions.

39. Work done by all the forces acting on the particle in a time interval from $t = 0$ to $t = 2$ s is

(A) 10 J (B) 20 J
(C) 30 J (D) 40 J

40. The average power is $\frac{3}{4}^{\text{th}}$ the instantaneous power at time t_0, then

(A) $t_0 = 1.5$ s (B) $t_0 = 2$ s
(C) $t_0 = 2.5$ s (D) $t_0 = 3$ s

Comprehension 16

A pendulum of mass m, length l has angular amplitude θ. Tension in the string at extreme position is T_1 and at bottom is T_2. Based on above information, answer the following questions.

41. If $T_2 = T_1$, then θ is equal to

(A) $\cos^{-1}\left(\frac{1}{2}\right)$ (B) $\cos^{-1}\left(\frac{1}{3}\right)$

(C) $\cos^{-1}\left(\frac{2}{3}\right)$ (D) $\cos^{-1}\left(\frac{3}{4}\right)$

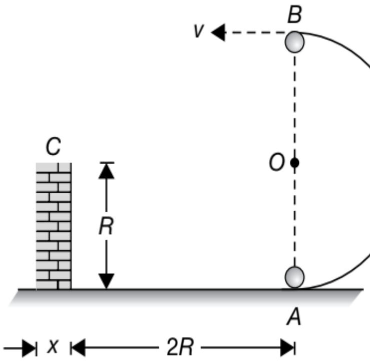
42. If maximum tension which the string can bear is twice the weight of bob, then the maximum value of θ is

(A) $\cos^{-1}\left(\frac{1}{3}\right)$ (B) $\cos^{-1}\left(\frac{2}{3}\right)$

(C) $\cos^{-1}\left(\frac{3}{4}\right)$ (D) $\frac{\pi}{3}$

Comprehension 17

A small ball is given some velocity at point A towards right so that it moves on the semicircular track and does not leave contact upto the highest point B. After leaving the highest point B, it falls at the top of a building of height R and width $x(x \ll 2R)$. (All the surfaces are frictionless).



Based on above information, answer the following questions.

43. The velocity given to the ball at point A so that it may hit the top of the building is

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

(C) $\sqrt{4gR}$ (D) $\sqrt{6gR}$

44. If the collision of ball with the building is elastic, then the angle with the horizontal at which the ball will rebound from the top of the building is

(A) 30° (B) 45°

(C) 60° (D) 90°

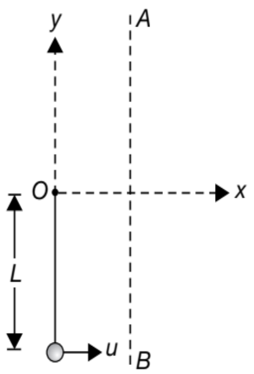
45. The horizontal distance of the ball from the foot of building where the ball strikes the horizontal ground is

(A) $\sqrt{2}R$ (B) $(1+\sqrt{2})R$

(C) $2(1+\sqrt{2})R$ (D) $12R$

Comprehension 18

A particle of mass m is suspended vertically from a point O by an inextensible massless string of length L. A vertical line AB is at a distance $\frac{3\sqrt{3}}{8}L$ from O as shown in figure. The object is given a horizontal velocity $u=\sqrt{\frac{7gL}{2}}$. 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. Based on above information, answer the following questions.



46. The magnitude of the change in its velocity as it reaches a position, where the string is horizontal

(A) $\sqrt{\frac{3gL}{2}}$ (B) $\sqrt{\frac{5gL}{2}}$

(C) $\sqrt{3gL}$ (D) $\sqrt{5gL}$

47. When the particle's motion ceases to be circular, the angle made by the string with the horizontal is

(A) 30° (B) 60°

(C) 37° (D) $\cos^{-1}\left(\frac{2}{3}\right)$

48. When the particle leaves the circular path its velocity vector is

(A) $\sqrt{\frac{gL}{8}}\left(-\hat{i}+\sqrt{3}\hat{j}\right)$ (B) $\sqrt{\frac{gL}{2}}\left(-\hat{i}+\sqrt{3}\hat{j}\right)$

(C) $\sqrt{\frac{gL}{2}}\left(-\sqrt{3}\hat{i}+\hat{j}\right)$ (D) $\sqrt{\frac{gL}{8}}\left(-\sqrt{3}\hat{i}+\hat{j}\right)$

Comprehension 19

The Work Energy Theorem for a particle says, that the total work done on a particle equals the change in its kinetic energy. It means, to change the K.E. of a particle, we have to apply some force on it and the force must do work on it. On a system of particles, the work done by external and internal forces on the system is equal to the change in K.E. of the system. Based on above information, answer the following questions.

49. When you lift a stone from the floor and put it on top of the table slowly, there is no change in its K.E. This implies.

(A) You have not done any work on the stone because had you done any work, then according to W-E theorem the K.E. of the stone would have changed.

(B) Work done by the force of gravity on the stone is also zero as that has also not lead to any change in K.E. of stone.

(C) Gravity has done a positive work and you have done a negative work. Therefore, the total work done on the stone equals zero and hence change in K.E. equals zero

(D) The net work done on the stone is zero and hence its change in K.E. is zero

50. Suppose a heavy box is kept on a smooth inclined plane and is pushed up by a force F parallel to the plane.

(A) The work done by the force F as well as work done by the force of gravity both depend on how fast was the box moving at A and B as the box goes from A to B

(B) The work done by the force of gravity alone depends on how fast was the box moving at A and B as the box goes from A to B

(C) The work done by the force F alone will depend on how fast was the box moving at A and B as the box goes from A to B

(D) None of them depends on how fast the box was moving at A and B as the box goes from A to B

51. A balls is given a speed V_0 on a rough horizontal surface. The ball travels through a distance l on the surface and stops.

(A) The work done by K-friction can be found by W.E. theorem as $-\mu mgl = 0 - \frac{1}{2}mv_0^2$ and hence work done by kinetic friction is positive

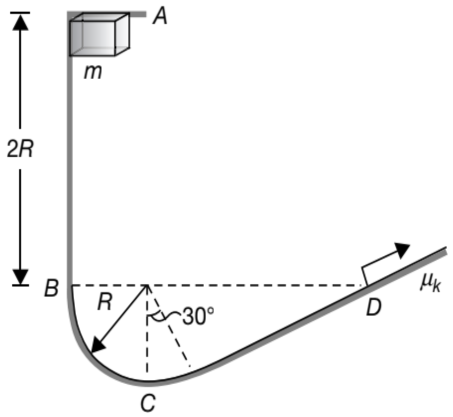
(B) The work done by the kinetic friction can never be positive. Therefore, work done is either $-\mu mgl$ or $-\frac{1}{2}mv_0^2$, only expressed in two different ways

(C) In this case the work done by kinetic friction is negative and it can be expressed by either, $-\mu mgl$ or $-\frac{1}{2}mv_0^2$

(D) The work done by kinetic friction is negative and is μmgl and not $-\frac{1}{2}mv_0^2$ because $\frac{1}{2}mv_0^2$ is the change in K.E. and that is a result of work done by all the forces like gravity and normal reaction as well

Comprehension 20

A block of mass m is released on a track shown in figure. The track is smooth from A to D and rough from point D onwards. Based on above information, answer the following questions.



52. The normal force N_B exerted by the track just after crossing point B is

(A) $2mg$ (B) $3mg$

(C) $4mg$ (D) $5mg$

53. The normal force N_C at C is

(A) $2mg$ (B) $3mg$

(C) $4mg$ (D) $7mg$

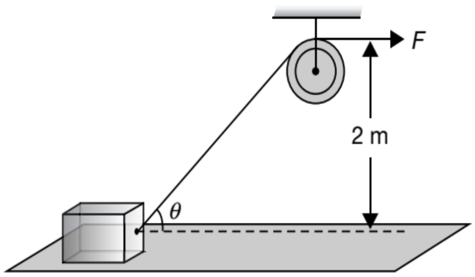
54. The distance travelled along the incline beyond point D where the block stops is

(A) $\frac{2R}{\sqrt{3}\mu_k + 1}$ (B) $\frac{4R}{\mu_k + 1}$

(C) $\frac{4R}{\sqrt{3}\mu_k + 1}$ (D) $\frac{4R}{\sqrt{3}\mu_k + 3}$

Comprehension 21

A force $F = 50$ N is applied at one end of a string, the other end of which is tied to a block of mass 10 kg. The block is free to move on a frictionless horizontal surface. Take initial instant as $\theta = 30°$ and final instant as $\theta = 37°$. For the time between these two instants, answer the following questions? Take $\sin(37°) = \frac{3}{5}$.



55. Net work done by the force F on the block is

(A) $\frac{20}{3}$ J (B) $\frac{50}{3}$ J

(C) $\frac{100}{3}$ J (D) 75 J

56. What is the final velocity of the block if initially it was at rest?

(A) $\sqrt{5}$ ms^{-1} (B) $\sqrt{\frac{25}{3}}$ ms^{-1}

(C) $\sqrt{\frac{20}{3}}$ ms^{-1} (D) 5 ms^{-1}

57. Find the ratio of initial acceleration to final acceleration of the block.

(A) $\frac{3\sqrt{5}}{8}$ (B) $\frac{5\sqrt{3}}{8}$

(C) $\frac{8\sqrt{3}}{5}$ (D) $\frac{8\sqrt{5}}{3}$

Comprehension 22

A particle moves in x-y plane under the action of a path dependent force $F = y\hat{i} + x\hat{j}$. The work done by the force as it moves in x-y plane can be evaluated by solving the line integral of force i.e. $\int \vec{F} \cdot d\vec{l}$, where $d\vec{l} = dx\hat{i} + dy\hat{j}$. The position coordinates x and y may vary according to some constraint determined by the path followed by the particle. Based on the information shared, answer the following questions.

58. When the particle moves along a straight-line path from origin to the point (a, a), the work done by the force on the particle is

(A) a^2 (B) $2a$

(C) $\frac{a^2}{2}$ (D) Zero

59. When the particle moves from $(0, 0)$ to $(a, 0)$ and then from $(a, 0)$ to (a, a) in straight line paths, then work done by the force on the particle is

(A) a^2 (B) $2a$

(C) $\frac{a^2}{2}$ (D) Zero

60. The infinitesimal work done (dW) by the given force when displaced through $d\vec{l}$ is given by

$$dW = \vec{F} \cdot d\vec{l} = ydx + xdy$$

From this, it can be inferred that the work done by the force

(A) depends only on initial and final values of x and y

(B) depends on initial and final values and on the path followed

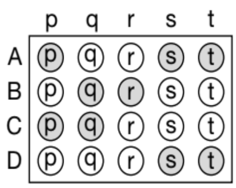
(C) is zero for any values of x and y.

(D) is zero when object returns to original position after following any path.

MATRIX MATCH/COLUMN MATCH TYPE QUESTIONS

Each question in this section contains statements given in two columns, which have to be matched. The statements in **COLUMN-I** are labelled A, B, C and D, while the statements in **COLUMN-II** are labelled p, q, r, s (and t). Any given statement in **COLUMN-I** can have correct matching with **ONE OR MORE** statement(s) in **COLUMN-II**. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following examples:

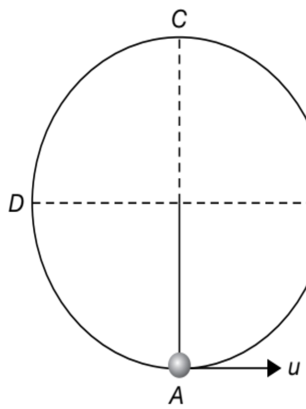
If the correct matches are A → p, s and t; B → q and r; C → p and q; and D → s and t; then the correct darkening of bubbles will look like the following:



1. Match the following

COLUMN-I	COLUMN-II
(A) Work done by all the forces	(p) Change in potential energy
(B) Work done by conservative forces	(q) Change in kinetic energy
(C) Work done by external forces	(r) Change in mechanical energy
(D) Work done by non-conservative forces	(s) Decrease in potential energy

2. A particle is suspended from a string of length l and is given a velocity $u = 3\sqrt{gl}$ at the bottom. If v_B, T_B and v_C, T_C be the velocity, tension at points B and C, then match the following.

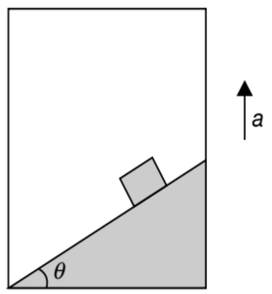


COLUMN-I	COLUMN-II
(A) $\frac{v_B^2}{gl}$	(p) $\frac{7}{2}$
(B) $\frac{v_C^2}{gl}$	(q) 4

(Continued)

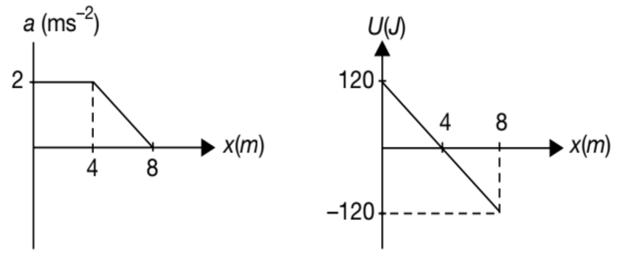
COLUMN-I	COLUMN-II
(C) $\dfrac{T_B}{2mg}$	(r) 5
(D) $\dfrac{T_C}{mg}$	(s) 7

3. A block of mass $1\ \text{kg}$ is stationary with respect to a rough wedge making an angle of $30°$ with horizontal as shown in figure. Starting from rest with an acceleration of $2\ \text{ms}^{-2}$ the work done on the block at $t = 4\ \text{s}$.



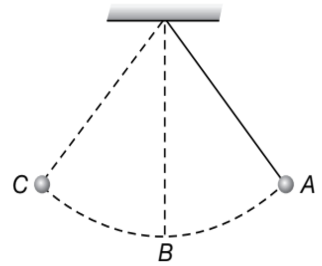
COLUMN-I	COLUMN-II
(A) by the gravity	(p) 144 J
(B) by the normal reaction	(q) 32 J
(C) by the friction	(r) 56 J
(D) by all the forces	(s) 48 J

4. Acceleration versus x and potential energy versus x graph of a particle of mass $1\ \text{kg}$ moving along x-axis are shown in figure. Assume that at $x = 0$, the velocity of the particle is $4\ \text{ms}^{-1}$, match the following at $x = 8\ \text{m}$.



COLUMN-I	COLUMN-II
(A) Kinetic energy	(p) 120 J
(B) Work done by conservative forces	(q) 240 J
(C) Total work done	(r) 128 J
(D) Work done by external forces	(s) 112 J
	(t) –112 J

5. A pendulum is released from point A as shown in figure. At any instant, the net force on the bob is making an angle θ with the string. Then match the following.



COLUMN-I	COLUMN-II
(A) For $\theta = 30°$	(p) Particle may be moving along BA
(B) For $\theta = 120°$	(q) Particle may be moving along CB
(C) For $\theta = 90°$	(r) Particle is at A
(D) For $\theta = 0°$	(s) Particle is at B
	(t) None of these

6. Match the following.

COLUMN-I	COLUMN-II
(A) Magnetic potential energy	(p) Positive
(B) Electrostatic potential energy	(q) Negative
(C) Gravitational potential energy	(r) Zero
(D) Elastic potential energy	(s) Not defined

7. Match the following.

COLUMN-I	COLUMN-II
(A) If the work done by force in cyclic path is zero, the force is	(p) Non conservative
(B) If the work done by a force in cyclic path is not zero, the force is	(q) Negative
(C) Work done by friction force can be	(r) Conservative
(D) Work done by spring force can be	(s) Positive

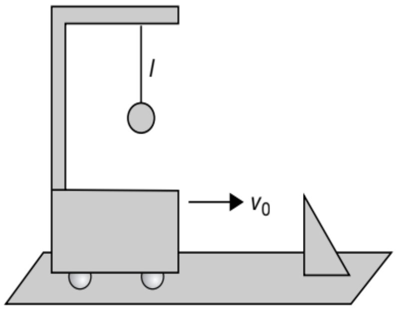
8. Match the following.

COLUMN-I	COLUMN-II
(A) Conservative force	(p) Potential can be defined
(B) Non conservative force	(q) Potential can't be defined
(C) Gravitational force	(r) Path dependent work
(D) Frictional force	(s) Position dependent work

9. A particle of mass 500 g moves along a horizontal circle of radius 16 m such that normal acceleration of particle varies with time as $a_n = 9t^2$.

COLUMN-I	COLUMN-II
(A) Tangential force on particle at $t = 1$ s (in Newton)	(p) 72
(B) Total force on particle at $t = 1$ s (in Newton)	(q) 36
(C) Power delivered by total force at $t = 1$ s (in watt)	(r) 7.5
(D) Average power developed by total force over first one second (in watt)	(s) 6

10. A bob of mass 2 kg is suspended from a vehicle by a rope of length $l = 5$ m. The vehicle and the bob are moving at a constant speed v_0. The vehicle is suddenly stopped by a bumper and the bob on the rope swings out a maximum angle of $60°$. Taking $g = 10\ \text{ms}^{-2}$, match the following.



COLUMN-I	COLUMN-II
(A) Net force, in N, acting on the bob at lowest point just after the vehicle is stopped	(p) $5\sqrt{3}$
(B) Acceleration, in ms^{-2}, of the bob at lowest point	(q) $10\sqrt{3}$
(C) Net force, in N, acting on the bob at its highest point	(r) 10
(D) Acceleration, in ms^{-2}, of the bob at its highest point	(s) 20

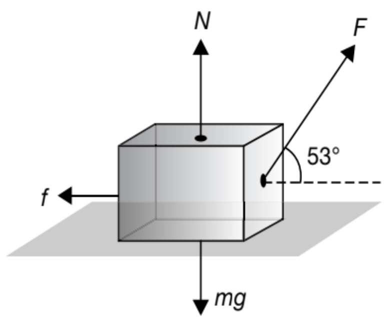
INTEGER/NUMERICAL ANSWER TYPE QUESTIONS

In this section, the answer to each question is a numerical value obtained after doing series of calculations based on the data given in the question(s).

1. A small block of mass 1 kg is kept on a rough inclined wedge of inclination $45°$ fixed in an elevator. The elevator goes up with a uniform velocity $v = 2\ \text{ms}^{-1}$ and the block does not slide on the wedge. Calculate the work done, in joule by the force of friction on the block in 1 s. Take $g = 10\ \text{ms}^{-2}$.

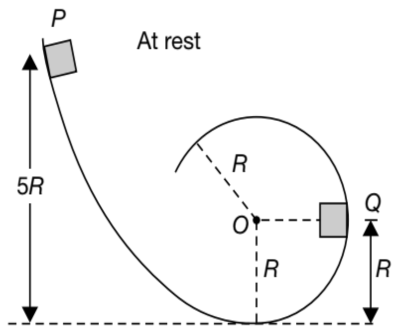
2. A train of mass 2×10^5 kg has a constant speed of $20\ \text{ms}^{-1}$ up a hill inclined at $\theta = \sin^{-1}\left(\frac{1}{50}\right)$ to the horizontal when the engine is working at 8×10^5 watt. Calculate the resistance to the motion of the train, in newton. Take $g = 9.8\ \text{ms}^{-2}$.

3. A block of mass $m = 4$ kg is dragged 2 m along a horizontal surface by a force $F = 30$ N acting at $53°$ to the horizontal. The initial speed is $3\ \text{ms}^{-1}$ and $\mu_k = \frac{1}{8}$. Given that $\cos(37°) = \frac{3}{5}$.



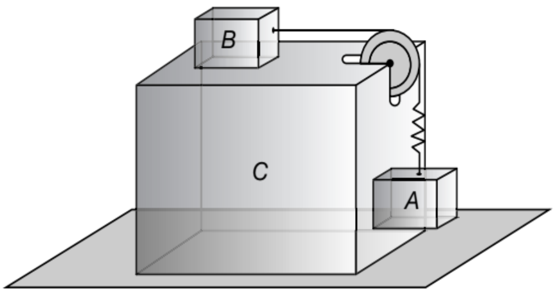
(a) Find the change in kinetic energy of the block, in joule.
(b) Find its final speed, in cms^{-1}.

4. A small block of mass m slides along a smooth frictionless track as shown in the figure.



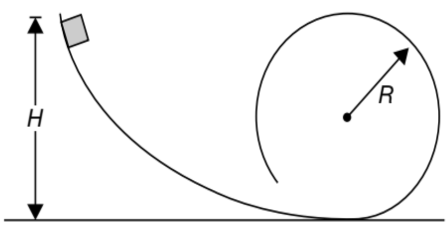
(a) If it starts from rest at P, the resultant force acting on it at Q is $\sqrt{x}$ mg. Calculate x
(b) At height $h = *R$ above the bottom of the loop should the block be released so that the force it exerts against the track at the top of the loop equals its weight. Find $*$.

5. Two blocks A and B are connected to each other by a string and a spring. The string passes over a frictionless pulley as shown in figure.



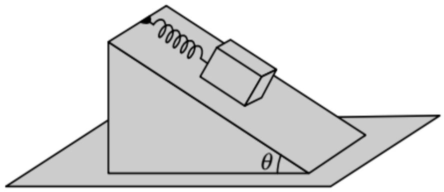
Block B slides over the horizontal top surface of a stationary block C and the block A slides along the vertical side of C, both with the same uniform speed. The coefficient of friction between the surfaces of the blocks is 0.2. The force constant of the spring is 1960 Nm^{-1}. If the mass of block A is 2 kg, calculate the mass of block B, in kg, and the energy stored in the spring in mJ. Take $g = 9.8 \text{ ms}^{-2}$.

6. A body slides down an inclined surface which ends into a vertical loop of radius $R = 40 \text{ cm}$ as shown in figure.



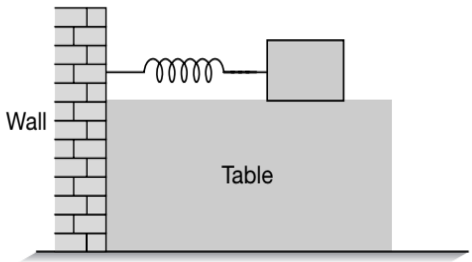
What must be the height H, in cm, of the inclined surface for the body not to fall at the uppermost point of the loop? Assume friction to be absent.

7. A block of mass $m = 2 \text{ kg}$ is attached to a spring whose spring constant is $k = 8 \text{ Nm}^{-1}$. The block slides on an incline for which $\mu_k = \frac{1}{8}$ and $\theta = 37°$ as shown in figure.



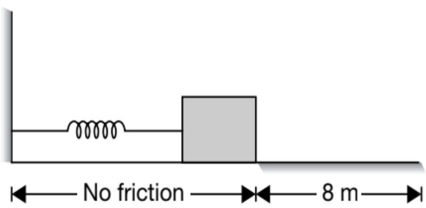
If the block starts at rest with the spring unextended, what is its speed, in ms^{-1}, when it has moved a distance $d = 0.5 \text{ m}$ down the incline?

8. A small block of ice with mass 120 g is placed against a horizontal compressed spring mounted on a horizontal table top that is 2.5 m above the floor as shown in figure.



The spring has a force constant $k = 2400 \text{ Nm}^{-1}$ and is initially compressed 5 cm. The mass of the spring is negligible. The spring is released and the block slides along the table, goes off the edge and travels to the floor. If there is negligible, friction between the ice and the table and ice does not melt in the process, what is the speed of the block of ice, in ms^{-1}, when it reaches the floor. Take $g = 10 \text{ ms}^{-2}$

9. Figure shows, a 4 kg block accelerated by a compressed spring whose spring constant is 640 Nm^{-1}. After leaving the spring at the spring's relaxed length, the block travels over a horizontal surface, with a coefficient of kinetic friction of 0.25, for a distance of 8 m before stopping.

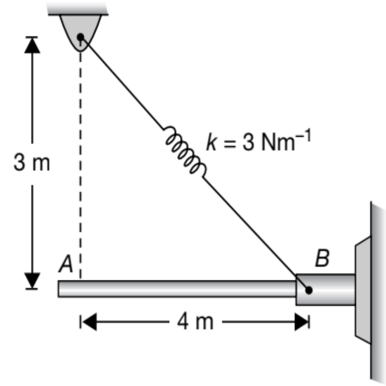


(a) Calculate the increase in the thermal energy, in joule, of the block-floor system.

(b) Calculate the maximum kinetic energy of the block, in joule.

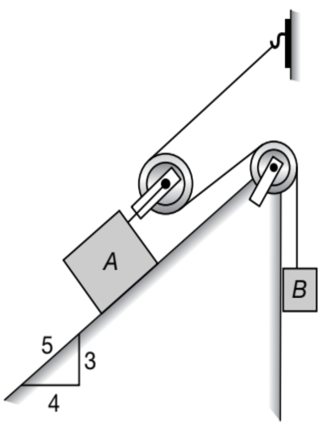
(c) Through what distance is the spring compressed, in cm, before the block begins to move?

10. It is observed that when the 2 kg smooth collar is slided back to point B and released from rest, the collar attains a speed of $2\ \text{ms}^{-1}$ when it arrives at point A as shown in figure.



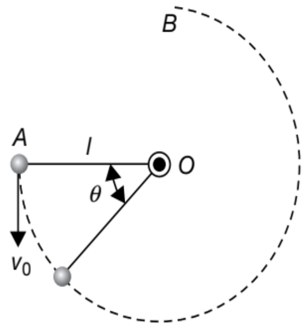
Calculate the necessary unstretched length of the spring, in metre, if it has a stiffness $k = 2\ \text{Nm}^{-1}$.

11. Block A has a weight of 300 N and block B has a weight of 50 N. If the coefficient of kinetic friction between the incline and block A is $\mu_k = \frac{1}{5}$ as shown in figure.



The speed, in ms^{-1}, of block A after it moves 1 m down the plane, starting from rest is $\frac{4}{5}\sqrt{*}$, where $*$ is not readable. Find $*$. Neglect the mass of the cord and pulleys. Take $g = 10\ \text{ms}^{-2}$.

12. The sphere at A is given a downward velocity v_0 of magnitude $5\ \text{ms}^{-1}$ and swings in a vertical plane at the end of a rope of length $l = 2\ \text{m}$ attached to a support at O as shown in figure.



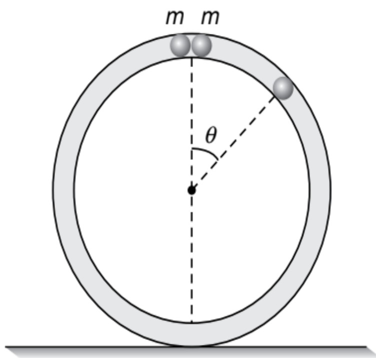
The angle at which the rope will break is $\theta = \sin^{-1}\left(\frac{1}{*}\right)$, where $*$ is not readable knowing that the maximum tension that the rope can withstand is twice the weight of the sphere and taking $g = 10\ \text{ms}^{-2}$, find $*$.

13. A particle is suspended from a fixed point by a string of length 5 m. It is projected from the equilibrium position with such a velocity that the string slackens after the particle has reached a height 8 m above the lowest point.

(a) The velocity of the particle (just before the string slackens), in ms^{-1}, is found to be $\sqrt{*}$, where $*$ is not readable, find $*$.

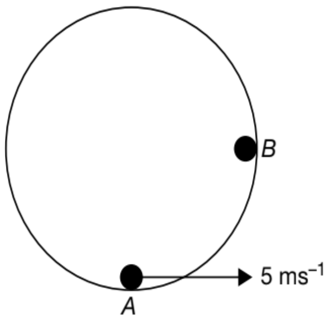
(b) The height to which the particle can rise further, in cm, is $24x$. Find x.

14. A circular tube of mass M is placed vertically on a horizontal surface as shown in the figure.



Two small spheres, each of mass m, just fit in the tube are released from the top. If θ gives the angle between radius vector of either ball with the vertical, obtain the value of the ratio $\frac{m}{M}$, if the tube just breaks its contact with ground when $\theta = 60°$. Neglect any friction.

15. A ball of mass $1\ \text{kg}$ moves inside a smooth fixed spherical shell of radius $1\ \text{m}$ with an initial velocity $v = 5\ \text{ms}^{-1}$ from the bottom as shown in figure.



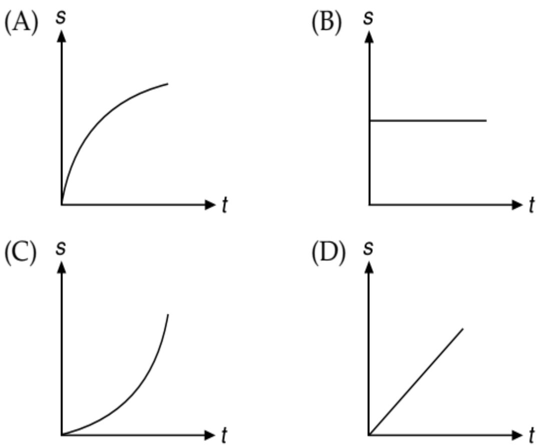
The total force acting on the particle at point B is $x\sqrt{x}$ N. Calculate x

ARCHIVE: JEE MAIN

1. **[Online September 2020]**
A person pushes a box on a rough horizontal platform surface. He applies a force of 200 N over a distance of 15 m. Thereafter, he gets progressively tired and his applied force reduces linearly with distance to 100 N. The total distance through which the box has been moved is 30 m. What is the work done by the person during the total movement of the box?
(A) 5690 J (B) 5250 J
(C) 3280 J (D) 2780 J

2. **[Online September 2020]**
If the potential energy between two molecules is given by $U = -\frac{A}{r^6} + \frac{B}{r^{12}}$, then at equilibrium, separation between molecules, and the potential energy are
(A) $\left(\frac{B}{A}\right)^{\frac{1}{6}}, 0$ (B) $\left(\frac{B}{2A}\right)^{\frac{1}{6}}, -\frac{A^2}{2B}$
(C) $\left(\frac{2B}{A}\right)^{\frac{1}{6}}, -\frac{A^2}{4B}$ (D) $\left(\frac{2B}{A}\right)^{\frac{1}{6}}, -\frac{A^2}{2B}$

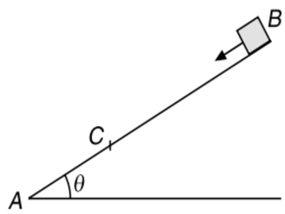
3. **[Online September 2020]**
A particle is moving unidirectionally on a horizontal plane under the action of a constant power supplying energy source. The displacement (s) time (t) graph that describes the motion of the particle is
(Graphs are drawn schematically and are not to scale)



4. **[Online September 2020]**
A body of mass 2 kg is driven by an engine delivering a constant power 1 Js^{-1}. The body starts from rest and moves in a straight line. After 9 second, the body has moved a distance ...... (in metre).

5. **[Online September 2020]**
A cricket ball of mass 0.15 kg is thrown vertically up by a bowling machine so that it rises to a maximum height of 20 m after leaving the machine. If the part pushing the ball applies a constant force F on the ball and moves horizontally a distance of 0.2 m while launching the ball, the value of F (in N) is ...... $\left(g = 10 \text{ ms}^{-2}\right)$

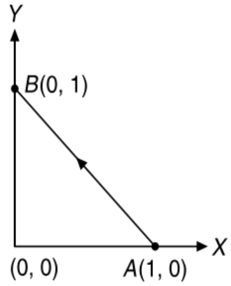
6. **[Online September 2020]**
A small block starts slipping down from a point B on an inclined plane AB, which is making an angle θ with the horizontal section BC is smooth and the remaining section CA is rough with a coefficient of friction μ. It is found that the block comes to rest as it reaches the bottom (point A) of the inclined plane. If $BC = 2AC$, the coefficient of friction is given by $\mu = k\tan\theta$. The value of k is ......



7. **[Online January 2020]**
An elevator in a building can carry a maximum of 10 persons, with the average mass of each person being 68 kg. The mass of the elevator itself is 920 kg and it moves with a constant speed 3 ms^{-1}. The frictional force opposing the motion is 6000 N. If the elevator is moving up with its full capacity, the power delivered by the motor to the elevator $\left(g = 10 \text{ ms}^{-2}\right)$ must be at least
(A) 56300 W (B) 48000 W
(C) 66000 W (D) 62360 W

8. [Online January 2020]

Consider a force $\vec{F} = -x\hat{i} + y\hat{j}$. The work done by this force in moving a particle from point $A(1,0)$ to $B(0,1)$ along the line segment shown is ……
(All quantities are in SI units)



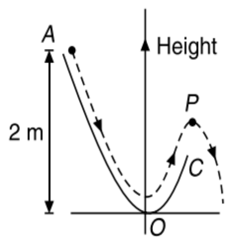
(A) $\frac{3}{2}$ (B) 1
(C) 2 (D) $\frac{1}{2}$

9. [Online January 2020]

A 60 HP electric motor lifts an elevator having a maximum total load capacity of 2000 kg. If the frictional force on the elevator is 4000 N, the speed of the elevator at full load is close to …… ms^{-1}. Take $1\text{ HP} = 746\text{ W}$ and $g = 10\text{ ms}^{-2}$.

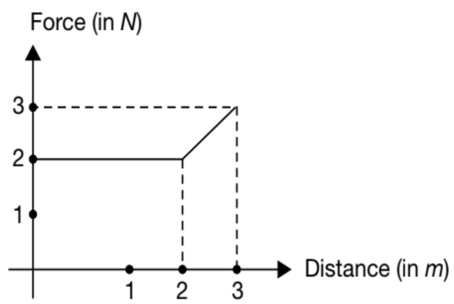
10. [Online January 2020]

A particle $(m = 1\text{ kg})$ slides down a frictionless track (AOC) starting from rest at a point A (height 2 m). After reaching C, the particle continues to move freely in air as a projectile. When it reaches its highest point P (height 1 m), the kinetic energy of the particle (in J) is …… (Figure drawn is schematic and not to scale, take $g = 10\text{ ms}^{-2}$)



11. [Online April 2019]

A particle moves in one dimension from rest under the influence of a force that varies with the distance travelled by the particle as shown in the Figure. The kinetic energy of the particle after it has travelled 3 m is



(A) 4 J (B) 2.5 J
(C) 5 J (D) 6.5 J

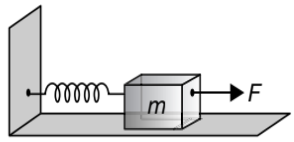
12. [Online April 2019]

A uniform cable of mass M and length L is placed on a horizontal surface such that its $\left(\frac{1}{n}\right)^{th}$ part is hanging below the edge of the surface. To lift the hanging part of the cable upto the surface, the work done should be

(A) $\frac{MgL}{n^2}$ (B) $nMgL$
(C) $\frac{MgL}{2n^2}$ (D) $\frac{2MgL}{n^2}$

13. [Online January 2019]

A block of mass m, lying on a smooth horizontal surface, is attached to a spring (of negligible mass) of spring constant k. The other end of the spring is fixed, as shown in the figure. The block is initially at rest in its equilibrium position. If now the block is pulled with a constant force F, the maximum speed of the block is



(A) $\frac{F}{\pi\sqrt{mk}}$ (B) $\frac{\pi F}{\sqrt{mk}}$
(C) $\frac{2F}{\sqrt{mk}}$ (D) $\frac{F}{\sqrt{mk}}$

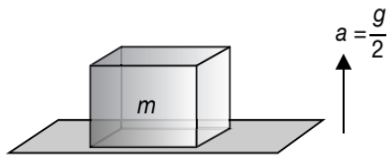
14. [Online January 2019]

A force acts on a 2 kg object so that its position is given as a function of time as $x = 3t^2 + 5$. What is the work done by this force in first 5 seconds?

(A) 950 J (B) 900 J
(C) 850 J (D) 875 J

15. [Online January 2019]

A block of mass m is kept on a platform which starts from rest with constant acceleration $\frac{g}{2}$ upward, as shown in figure. Work done by normal reaction on block in time t is



(A) $\frac{3mg^2t^2}{8}$ (B) $-\frac{mg^2t^2}{8}$
(C) 0 (D) $\frac{mg^2t^2}{8}$

16. [Online January 2019]
A particle which is experiencing a force, given by $\vec{F} = 3\hat{i} - 12\hat{j}$, undergoes a displacement of $\vec{d} = 4\hat{i}$. If the particle had a kinetic energy of 3 J at the beginning of the displacement, what is its kinetic energy of the end of the displacement?
(A) 15 J (B) 9 J
(C) 12 J (D) 10 J

17. [Online January 2019]
A pendulum is executing simple harmonic motion and its maximum kinetic energy is K_1. If the length of the pendulum is doubled and it performs simple harmonic motion with the same amplitude as in the first case, its maximum kinetic energy is K_2. Then
(A) $K_2 = 2K_1$ (B) $K_2 = \frac{K_1}{4}$
(C) $K_2 = K_1$ (D) $K_2 = \frac{K_1}{2}$

18. [2018]
A particle is moving in a circular path of radius a under the action of an attractive potential $U = -\frac{k}{2r^2}$. Its total energy is
(A) $-\frac{k}{4a^2}$ (B) $\frac{k}{2a^2}$
(C) Zero (D) $-\frac{3}{2}\frac{k}{a^2}$

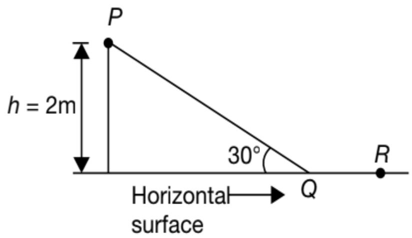
19. [Online 2018]
Two particles of the same mass m are moving in circular orbits because of force, given by $F(r) = -\frac{16}{r} - r^3$. The first particle is at a distance $r = 1$ and the second, at $r = 4$. The best estimate for the ratio of kinetic energies of the first and the second particle is closest to
(A) 10^{-1} (B) 6×10^{-2}
(C) 6×10^{2} (D) 3×10^{-3}

20. [Online 2018]
A body of mass m starts moving from rest along x-axis so that its velocity varies as $v = a\sqrt{s}$ where a is a constant and s is the distance covered by the body. The total work done by all the forces acting on the body in the first t seconds after the start of the motion is
(A) $\frac{1}{4}ma^4t^2$ (B) $4ma^4t^2$
(C) $\frac{1}{8}ma^4t^2$ (D) $8ma^4t^2$

21. [2017]
A body of mass $m = 10^{-2}$ kg is moving in a medium and experiences a frictional force $F = -kv^2$. Its initial speed is $v_0 = 10\ \text{ms}^{-1}$. If, after 10 s, its energy is $\frac{1}{8}mv_0^2$, the value of k will be
(A) $10^{-3}\ \text{kgm}^{-1}$ (B) $10^{-3}\ \text{kgs}^{-1}$
(C) $10^{-4}\ \text{kgm}^{-1}$ (D) $10^{-1}\ \text{kgm}^{-1}\text{s}^{-1}$

22. [2017]
A time dependent force $F = 6t$ acts on a particle of mass 1 kg. If the particle starts from rest, the work done by the force during the first 1 second will be
(A) 4.5 J (B) 22 J
(C) 9 J (D) 18 J

23. [2016]
A point particle having some mass, moves along the uniformly rough track PQR as shown in the figure. The coefficient of friction, between the particle and the rough track equals μ. The particle is released, from rest, from the point P and it comes to rest at a point R. The energies, lost by the ball, over the parts, PQ and QR, of the track, are equal to each other, and no energy is lost when particle changes direction from PQ to QR. The values of the coefficient of friction μ and the distance $x(=QR)$, are respectively close to



(A) 0.29 and 6.5 m
(B) 0.2 and 6.5 m
(C) 0.2 and 3.5 m
(D) 0.29 and 3.5 m

24. [2016]
A person trying to lose weight by burning fat lifts a mass of 10 kg upto a height of 1 m 1000 times. Assume that the potential energy lost each time he lowers the mass is dissipated. How much fat will he use up considering the work done only when the weight is lifted up? Fat supplies 3.8×10^7 J of energy per kg which is converted to mechanical energy with a 20% efficiency rate. Take $g = 9.8\ \text{ms}^{-2}$
(A) 12.89×10^{-3} kg (B) 2.45×10^{-3} kg
(C) 6.45×10^{-3} kg (D) 9.89×10^{-3} kg

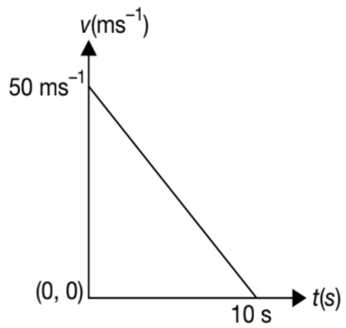
25. [Online 2016]
Concrete mixture is made by mixing cement, stone and sand in a rotating cylinder drum. If the drum rotates too fast, the ingredients remain stuck to the wall of the drum and proper mixing of ingredients does not take place. The maximum rotational speed of the drum in revolutions per minute (rpm) to ensure proper mixing is close to [Take the radius of the drum to be 1.25 m and its axle to be horizontal]

(A) 27.0 (B) 0.4
(C) 1.3 (D) 8.0

26. [Online 2016]
A car of weight W is on an inclined road that rises by 100 m over a distance of 1 km and applies a constant frictional force $\frac{W}{20}$ on the car. While moving uphill on the road at a speed of $10\ \text{ms}^{-1}$, the car needs power P. If it needs power $\frac{P}{2}$ while moving downhill at speed v then value of v is

(A) $20\ \text{ms}^{-1}$ (B) $5\ \text{ms}^{-1}$
(C) $15\ \text{ms}^{-1}$ (D) $10\ \text{ms}^{-1}$

27. [Online 2016]
Velocity-time graph for a body of mass 10 kg is shown in figure. Work-done on the body in first two seconds of the motion is



(A) –9300 J (B) 12000 J
(C) –4500 J (D) –12000 J

28. [Online 2016]
A particle of mass M is moving in a circle of fixed radius R in such a way that its centripetal acceleration at time t is given by n^2Rt^2 where n is a constant. The power delivered to the particle by the force acting on it, is

(A) $\frac{1}{2}Mn^2R^2t^2$ (B) Mn^2R^2t
(C) MnR^2t^2 (D) MnR^2t

29. [Online 2015]
A block of mass $m = 0.1$ kg is connected to a spring of unknown spring constant k. It is compressed to a distance x from its equilibrium position and released from rest. After approaching half the distance $\left(\frac{x}{2}\right)$ from equilibrium position, it hits another block and comes to rest momentarily, while the other block moves with a velocity $3\ \text{ms}^{-1}$. The total initial energy of the spring is

(A) 1.5 J (B) 0.6 J
(C) 0.3 J (D) 0.8 J

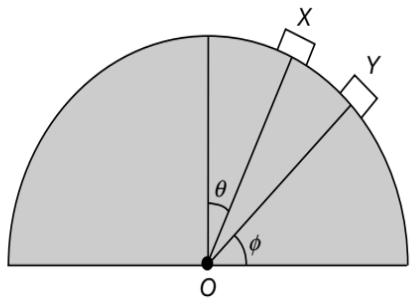
30. [Online 2015]
A particle is moving in a circle of radius r under the action of a force $F = \alpha r^2$ which is directed towards centre of the circle. Total mechanical energy (kinetic energy + potential energy) of the particle is (take potential energy $= 0$ for $r = 0$)

(A) αr^3 (B) $\frac{1}{2}\alpha r^3$
(C) $\frac{4}{3}\alpha r^3$ (D) $\frac{5}{6}\alpha r^3$

31. [2014]
When a rubber-band is stretched by a distance x, it exerts a restoring force of magnitude $F = ax + bx^2$ where a and b are constants. The work done in stretching the unstretched rubber-band by L is

(A) $aL^2 + bL^3$ (B) $\frac{1}{2}(aL^2 + bL^3)$
(C) $\frac{aL^2}{2} + \frac{bL^3}{3}$ (D) $\frac{1}{2}\left(\frac{aL^2}{2} + \frac{bL^3}{3}\right)$

32. [Online 2014]
A particle is released on a vertical smooth semi-circular track from point X so that OX makes angle θ from the vertical (see figure). The normal reaction of the track on the particle vanishes at point Y where OY makes angle ϕ with the horizontal. Then



(A) $\sin\phi = \cos\phi$ (B) $\sin\phi = \frac{1}{2}\cos\theta$
(C) $\sin\phi = \frac{2}{3}\cos\theta$ (D) $\sin\phi = \frac{3}{4}\cos\theta$

33. [Online 2014]

A spring of unstretched length 1 has a mass m with one end fixed to a rigid support. Assuming spring to be made of a uniform wire, the kinetic energy possessed by it if its free end is pulled with uniform velocity v is

(A) $\frac{1}{2}mv^2$ (B) mv^2

(C) $\frac{1}{3}mv^2$ (D) $\frac{1}{6}mv^2$

34. [Online 2014]

A wind-powered generator converts wind energy into electrical energy. Assume that the generator converts a fixed fraction of the wind energy intercepted by its blades into electrical energy. For wind speed v, the electrical power output will be most likely proportional to

(A) v^4 (B) v^2

(C) v (D) v^3

35. [Online 2014]

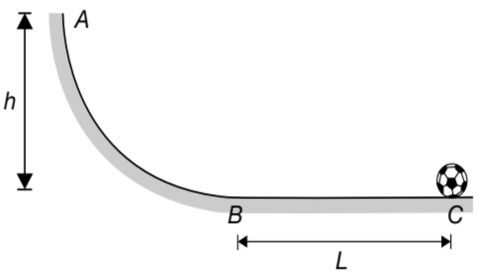
A bullet looses $\left(\frac{1}{n}\right)^{th}$ of its velocity passing through one plank. The number of such planks that are required to stop the bullet can be

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

(C) Infinite (D) n

36. [Online 2014]

A small ball of mass m starts at a point A with speed v_0 and moves along a frictionless track AB as shown. The track BC has coefficient of friction μ. The ball comes to stop at C after travelling a distance L which is



(A) $\frac{2h}{\mu}+\frac{v_0^2}{2\mu g}$ (B) $\frac{h}{\mu}+\frac{v_0^2}{2\mu g}$

(C) $\frac{h}{2\mu}+\frac{v_0^2}{\mu g}$ (D) $\frac{h}{2\mu}+\frac{v_0^2}{2\mu g}$

37. [2013]

This question has Statement 1 and Statement 2. Of the four choices given after the Statements, choose the one that best describes the two Statements.

Statement 1: A point particle of mass m moving with speed v collides with stationary point particle of mass M. If the maximum energy loss possible is given as $f\left(\frac{1}{2}mv^2\right)$ then $f=\left(\frac{m}{M+m}\right)$

Statement 2: Maximum energy loss occurs when the particles get stuck together as a result of the collision.

(A) Statement 1 is true, Statement 2 is true, Statement-II is **correct** explanation of Statement-I.

(B) Statement-I is true, Statement-II is true, Statement-II is **not** a correct explanation of Statement-I.

(C) Statement-I is true, Statement-II is false.

(D) Statement-I is false, Statement-II is true.

38. [Online 2013]

A 70 kg man leaps vertically into the air from a crouching position. To take the leap the man pushes the ground with a constant force F to raise himself. The centre of gravity rises by 0.5 m before he leaps. After the leap the c.g. rises by another 1 m. The maximum power delivered by the muscles is [Take $g=10\text{ ms}^{-2}$]

(A) 6.26×10^3 Watts at the start

(B) 6.26×10^3 Watts at take off

(C) 6.26×10^4 Watts at the start

(D) 6.26×10^4 Watts at take off

39. [2012]

This question has Statement 1 and Statement 2. Of the four choices given after the statements, choose the one that best describes the two statements. If two springs S_1 and S_2 of force constants k_1 and k_2, respectively, are stretched by the same force, it is found that more work is done on spring S_1 than on spring S_2.

Statement 1: If stretched by the same amount, work done on S_1, will be more than that on S_2.

Statement 2: $k_1 < k_2$.

(A) Statement 1 is true, Statement 2 is false.

(B) Statement 1 is true, Statement 2 is true, Statement 2 is the correct explanation of Statement 1.

(C) Statement 1 is true, Statement 2 is true, Statement 2 is not the correct explanation of Statement 1.

(D) Statement 1 is false, Statement 2 is true.

40. [Online 2012]

A particle gets displaced by $\Delta\vec{r}=\left(2\hat{i}+3\hat{j}+4\hat{k}\right)\text{ m}$ under the action of a force $\vec{F}\left(7\hat{i}+4\hat{j}+3\hat{k}\right)$. The change in its kinetic energy is

(A) 38 J (B) 70 J
(C) 52.5 J (D) 126 J

41. [2010]
The potential energy function for the force between two atoms in a diatomic molecule is approximately given by $U(x)=\frac{a}{x^{12}}-\frac{b}{x^6}$, where a and b are constant and x is the distance between the atoms. If the dissociation energy of the molecule is $D=\left[U(x=\infty)-U_{\text{at equilibrium}}\right]$, D is

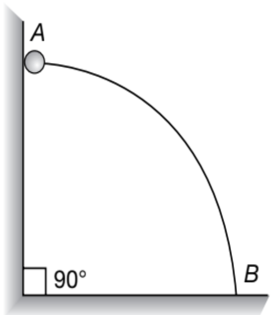
(A) $\frac{b^2}{6a}$ (B) $\frac{b^2}{2a}$
(C) $\frac{b^2}{12a}$ (D) $\frac{b^2}{4a}$

ARCHIVE: JEE ADVANCED

Single Correct Choice Type Problems

(In this section each question has four choices (A), (B), (C) and (D), out of which ONLY ONE is correct)

1. [JEE (Advanced) 2014]
A wire, which passes through the hole in a small bead, is bent in the form of quarter of a circle. The wire is fixed vertically on ground as shown in the figure. The bead is released from near the top of the wire and it slides along the wire without friction. As the bead moves from A to B, the force it applies on the wire is

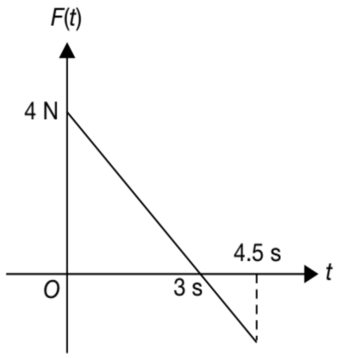


(A) always radially outwards
(B) always radially inwards
(C) radially outwards initially and radially inwards later
(D) radially inwards initially and radially outwards later

2. [JEE (Advanced) 2013]
The work done on a particle of mass m by a force, $K\left[\frac{x}{(x^2+y^2)^{\frac{3}{2}}}\hat{i}+\frac{y}{(x^2+y^2)^{\frac{3}{2}}}\hat{j}\right]$ (K being a constant of appropriate dimensions), when the particle is taken from the point $(a, 0)$ to the point $(0, a)$ along a circular path of radius a about the origin in the x-y plane is

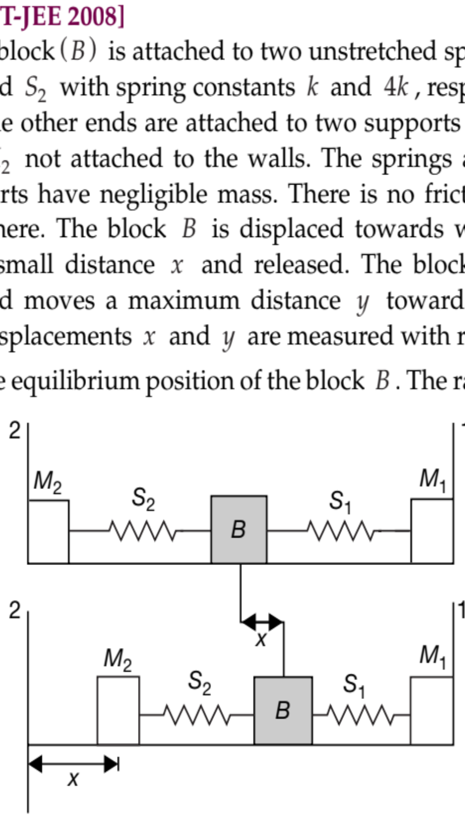
(A) $\frac{2K\pi}{a}$ (B) $\frac{K\pi}{a}$
(C) $\frac{K\pi}{2a}$ (D) 0

3. [IIT-JEE 2010]
A block of mass 2 kg is free to move along the x axis. It is at rest and from $t=0$ onwards it is subjected to a time-dependent force $F(t)$ in the x direction. The force $F(t)$ varies with t as shown in the figure. The kinetic energy of the block after 4.5 s is



(A) 4.50 J (B) 7.50 J
(C) 5.06 J (D) 14.06 J

4. [IIT-JEE 2008]
A block (B) is attached to two unstretched springs S_1 and S_2 with spring constants k and $4k$, respectively. The other ends are attached to two supports M_1 and M_2 not attached to the walls. The springs and supports have negligible mass. There is no friction anywhere. The block B is displaced towards wall 1 by a small distance x and released. The block returns and moves a maximum distance y towards wall 2. Displacements x and y are measured with respect to the equilibrium position of the block B. The ratio $\frac{y}{x}$ is

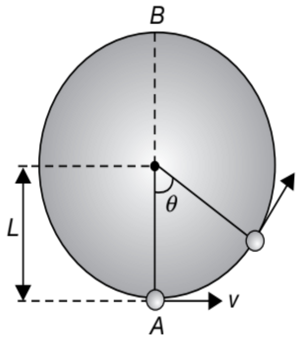


(A) 4 (B) 2

(C) $\frac{1}{2}$ (D) $\frac{1}{4}$

5. [IIT-JEE 2008]

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

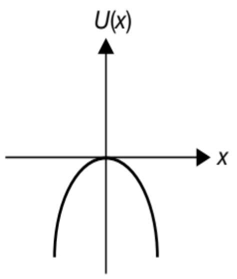


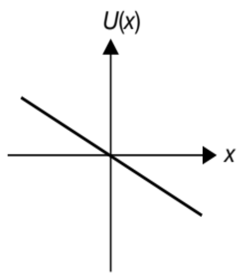
(A) $\theta = \frac{\pi}{4}$ (B) $\frac{\pi}{4} < \theta < \frac{\pi}{2}$

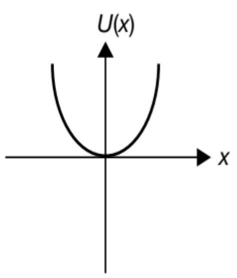
(C) $\frac{\pi}{2} < \theta < \frac{3\pi}{4}$ (D) $\frac{3\pi}{4} < \theta < \pi$

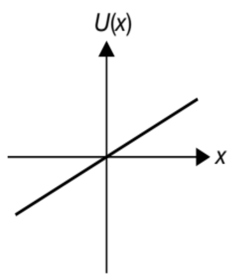
6. [IIT-JEE 2004]

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)

(A)


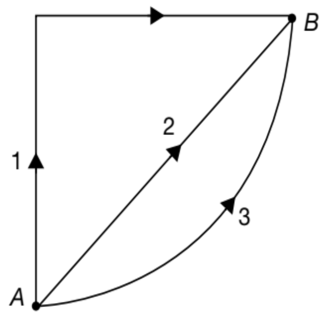
(B)


(C)


(D)


7. [IIT-JEE 2003]

If W_1, W_2 and W_3 represent the work done in moving a particle from A to B along three different paths 1, 2 and 3 respectively (as shown) in the gravitational field of a point mass m. Find the correct relation between W_1, W_2 and W_3



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

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

8. [IIT-JEE 2002]

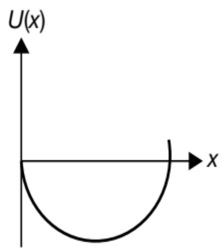
An ideal spring with spring constant k is hung from the ceiling and a block of mass M is attached to its lower end. The block is released with the spring initially unstretched. Then the maximum extension in the spring is

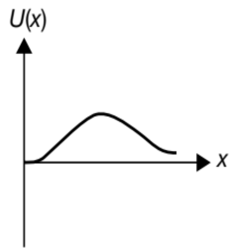
(A) $\frac{4Mg}{k}$ (B) $\frac{2Mg}{k}$

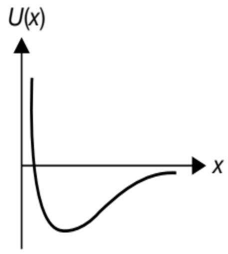
(C) $\frac{Mg}{k}$ (D) $\frac{Mg}{2k}$

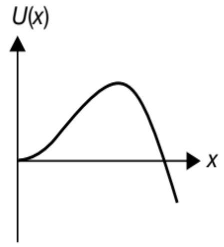
9. [IIT-JEE 2002]

A particle, which is constrained to move along x-axis, is subjected to a force in the same direction which varies with the distance x of the particle from the origin as $F(x) = -kx + ax^3$. Here, k and a are positive constant. For $x \geq 0$, the functional form of the potential energy $U(x)$ of the particle is

(A)


(B)


(C)


(D)


10. [IIT-JEE 2000]

A wind-powered generator converts wind energy into electrical energy. Assume that the generator converts a fixed fraction of wind energy interception by its blades into electrical energy. For wind speed v, the electrical power output will be proportional to

(A) v (B) v^2
(C) v^3 (D) v^4

11. [IIT-JEE 1999]
A spring of force constant k is cut into two pieces such that one piece is double the length of the other. Then the long piece will have a force constant of

(A) $\left(\frac{2}{3}\right)k$ (B) $\left(\frac{3}{2}\right)k$
(C) $3k$ (D) $6k$

12. [IIT-JEE 1998]
A stone 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 the lowest position and has a speed u. The magnitude of the change in velocity as it reaches a position where the string is horizontal is

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

13. [IIT-JEE 1998]
A force $\vec{F} = -k(y\hat{i} + x\hat{j})$, where k is a positive constant, acts on a particle moving in the xy 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 on the particle is

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

14. [IIT-JEE 1994]
A particle of mass m is moving in a circular path of constant radius r such that its centripetal acceleration a_c is varying with time t as $a_c = k^2rt^2$, where k is a constant. The power delivered to the particle by the force acting on it is

(A) $2\pi mk^2r^2$ (B) mk^2r^2t
(C) $\frac{(mk^4r^2t^5)}{3}$ (D) Zero

15. [IIT-JEE 1985]
A uniform chain of length L and mass M is lying on a smooth table and one-third of its length is hanging vertically down over the edge of the table. The work required to pull the hanging part on the table is

(A) MgL (B) $\frac{MgL}{3}$
(C) $\frac{MgL}{9}$ (D) $\frac{MgL}{18}$

16. [IIT-JEE 1984]
A body is moved along a straight line by a machine delivering constant power. The distance moved by the body in time t is proportional to

(A) $t^{\frac{1}{2}}$ (B) $t^{\frac{3}{4}}$
(C) $t^{\frac{3}{2}}$ (D) t^2

17. [IIT-JEE 1980]
Two masses of 1 g and 4 g are moving with equal kinetic energies. The ratio of the magnitudes of their momenta is

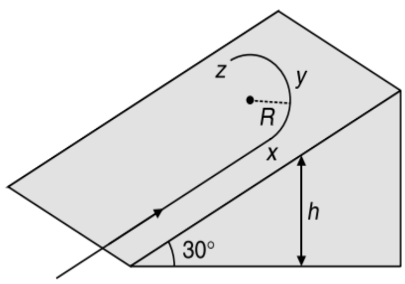
(A) $4:1$ (B) $\sqrt{2}:1$
(C) $1:2$ (D) $1:16$

18. [IIT-JEE 1980]
If a machine is lubricated with oil,
(A) the mechanical advantage of the machine increases
(B) the mechanical efficiency of the machine increases
(C) both its mechanical advantage and efficiency increases
(D) its efficiency increases, but its mechanical advantage decreases

Multiple Correct Choice Type Problems

(In this section each question has four choices (A), (B), (C) and (D), out of which ONE OR MORE is/are correct)

1. JEE (Advanced) 2020
A student skates up a ramp makes an angle 30° with the horizontal. He/she starts (as shown in Figure) at the bottom of the ramp with speed v_0 and wants to turn around over a semicircular path xyz of radius R during which he/she reaches a maximum height h (at point y) from the ground as shown in Figure. Assume that the energy loss is negligible and the force required for this turn at the highest point is provided by his/her weight only. Then (g is the acceleration due to gravity)



(A) $v_0^2 - 2gh = \frac{1}{2}gR$

(B) $v_0^2 - 2gh = \frac{\sqrt{3}}{2}gR$

(C) the centripetal force required at points x and z is zero

(D) the centripetal force required is maximum at points x and z

2. [IIT-JEE 1987]

A particle is acted upon by a force of constant magnitude which is always directed perpendicular to the velocity of the particle. The motion of the particle takes place in a plane. From the information given, we conclude that the particle

(A) has constant velocity.

(B) has constant acceleration.

(C) has constant kinetic energy.

(D) moves in a circular path.

Reasoning Based Questions

This section contains Reasoning type questions, each having four choices (A), (B), (C) and (D) out of which ONLY ONE is correct. Each question contains STATEMENT 1 and STATEMENT 2. You have to mark your answer as

Bubble (A) If both statements are TRUE and STATEMENT 2 is the correct explanation of STATEMENT 1.

Bubble (B) If both statements are TRUE but STATEMENT 2 is not the correct explanation of STATEMENT 1.

Bubble (C) If STATEMENT 1 is TRUE and STATEMENT 2 is FALSE.

Bubble (D) If STATEMENT 1 is FALSE but STATEMENT 2 is TRUE.

1. [IIT-JEE 2007]

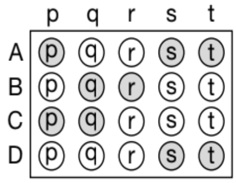
Statement-1: A block of mass m starts moving on a rough horizontal surface with a velocity v. It stops due to friction between the block and the surface after moving through a certain distance. The surface is now tilted to an angle of $30°$ with the horizontal and the same block is made to go up on the 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.

Statement-2: The coefficient of friction between the block and the surface decreases with the increase in the angle of inclination.

Matrix Match/Column Match Type Questions

Each question in this section contains statements given in two columns, which have to be matched. The statements in **COLUMN-I** are labelled A, B, C and D, while the statements in **COLUMN-II** are labelled p, q, r, s (and t). Any given statement in **COLUMN-I** can have correct matching with **ONE OR MORE** statement(s) in **COLUMN-II**. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following examples:

If the correct matches are A $\rightarrow$ p, s and t; B $\rightarrow$ q and r; C $\rightarrow$ p and q; and D $\rightarrow$ s and t; then the correct darkening of bubbles will look like the following:



1. [JEE (Advanced) 2015]

A particle of unit mass is moving along the x axis under the influence of a force and its total energy is conserved. Four possible forms of the potential energy of the particle are given in **COLUMN-I** (a and U_0 are constants). Match the potential energies in **COLUMN-I** to the corresponding statements in **COLUMN-II**.

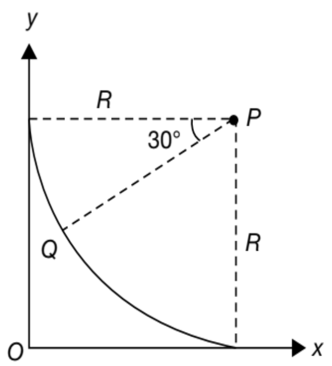
COLUMN-I	COLUMN-II
(A) $U_1(x)=\frac{U_0}{2}\left[1-\left(\frac{x}{a}\right)^2\right]^2$	(p) The force acting on the particle is zero at $x=a$
(B) $U_2(x)=\frac{U_0}{2}\left(\frac{x}{a}\right)^2$	(q) The force acting on the particle is zero at $x=0$
(C) $U_3(x)=\frac{U_0}{2}\left(\frac{x}{a}\right)^2 \exp\left[-\left(\frac{x}{a}\right)^2\right]$	(r) The force acting on the particle is zero at $x=-a$
(D) $U_4(x)=\frac{U_0}{2}\left[\frac{x}{a}-\frac{1}{3}\left(\frac{x}{a}\right)^3\right]$	(s) The particle experiences an attractive force towards $x=0$ in the region $\lvert x\rvert<a$
	(t) The particle with total energy $\frac{U_0}{4}$ can oscillate about the point $x=-a$

Linked Comprehension Type Questions

This section contains Linked Comprehension Type Questions or Paragraph based Questions. Each set consists of a Paragraph followed by questions. Each question has four choices (A), (B), (C) and (D), out of which only one is correct. (For the sake of competitiveness there may be a few questions that may have more than one correct options)

Comprehension 1

A small block of mass 1 kg is released from rest at the top of a rough track. The track is a circular arc of radius 40 m. The block slides along the track without toppling and a frictional force acts on it in the direction opposite to the instantaneous velocity. The work done in overcoming the friction up to the point Q, as shown in the figure, is 150 J. (Take the acceleration due to gravity, $g = 10\text{ ms}^{-2}$)



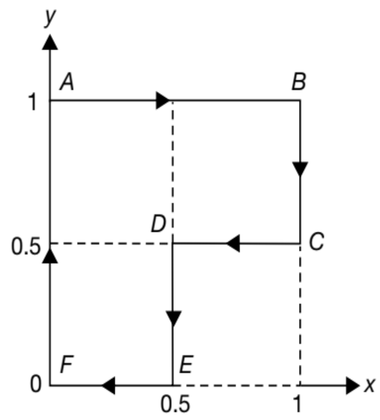
1. **[JEE (Advanced) 2013]**
The speed of the block when it reaches the point Q is
(A) 5 ms^{-1} (B) 10 ms^{-1}
(C) $10\sqrt{3}\text{ ms}^{-1}$ (D) 20 ms^{-1}

2. **[JEE (Advanced) 2013]**
The magnitude of the normal reaction that acts on the block at the point Q is
(A) 7.5 N (B) 8.6 N
(C) 11.5 N (D) 22.5 N

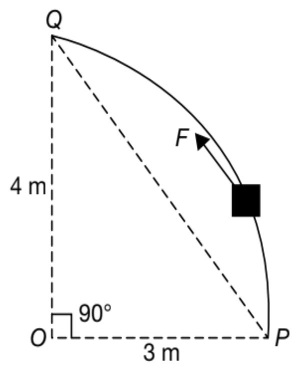
Integer/Numerical Answer Type Questions

In this section, the answer to each question is a numerical value obtained after series of calculations based on the data provided in the question(s).

1. **[JEE (Advanced) 2019]**
A particle is moved along a path *AB-BC-CD-DE-EF-FA*, as shown in figure, in presence of a force $\vec{F} = (\alpha y\hat{i} + 2\alpha x\hat{j})$ N, where x and y are in meter and $\alpha = -1\text{ Nm}^{-1}$. The work done on the particle by this force $\vec{F}$ will be______ joule.



2. **[JEE (Advanced) 2014]**
Consider an elliptically shaped rail PQ in the vertical plane with $OP = 3\text{ m}$ and $OQ = 4\text{ m}$. A block of mass 1 kg is pulled along the rail from P to Q with a force of 18 N, which is always parallel to line PQ (see figure). Assuming no frictional losses, the kinetic energy of the block when it reaches Q is $(n \times 10)$ J. The value of n is (Take acceleration due to gravity to be 10 ms^{-2})

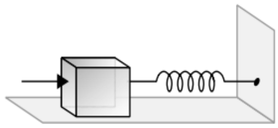


3. **[JEE (Advanced) 2013]**
A bob of mass m, suspended by a string of length l_1, is given a minimum velocity required to complete a full circle in the vertical plane. At the highest point, it collides elastically with another bob of mass m suspended by a string of length l_2, which is initially at rest. Both the strings are massless and inextensible. If the second bob, after collision acquires the minimum speed required to complete a full circle in the vertical plane, the ratio $\frac{l_1}{l_2}$ is

4. **[JEE (Advanced) 2013]**
A particle of mass 0.2 kg is moving in one dimension under a force that delivers a constant power 0.5 W to the particle. If the initial speed (in ms^{-1}) of the particle is zero, the speed (in ms^{-1}) after 5 s is

5. **[IIT-JEE 2011]**

A block of mass $0.18\ \text{kg}$ is attached to a spring of force constant $2\ \text{Nm}^{-1}$. 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 $0.06\ \text{m}$ and comes to rest for the first time. The initial velocity of the block in ms^{-1} is $V = \frac{N}{10}$. Find the value of N.

ANSWER KEYS–TEST YOUR CONCEPTS AND PRACTICE EXERCISES

Test Your Concepts-I (Based on Work Done by a Constant and Variable Force)

1. $-mgh\left(1-\frac{k^2}{2}\right)$
2. $-f\ell_0$
3. $-mg\ell\sin\theta$
4. (a) 4.03 J (b) –3.5 J
5. (a) 0 (b) $-\frac{\alpha}{3}(0.026)$ (c) $\frac{\alpha}{3}(0.026)$
6. –3380 J
7. 83 J
8. (a) –6 J (b) –8 J
   (c) Force is non-conservative in nature.
9. 30 J
10. 25 J
11. (a) 4 J (b) 0 (c) –1 J (d) 3 J
12. 60 J
13. $-ka^2$
14. (a) 50 J (b) 100 J (c) 50 J
15. Work done by the gravitational force is mgh
    Work done by the tension force is $-\frac{mgh}{2}$

Test Your Concepts-II (Based on Kinetic Energy, Potential Energy and Power)

1. $\frac{P}{f}, \frac{Pm}{8r^2}$
2. (a) $\sqrt{\frac{2Pt}{m}}$ (b) $\left(\frac{8P}{9m}\right)^{1/2} t^{3/2}$
4. $P=\begin{cases} 40t & \text{for } t\le 0.2\text{ s} \\ -100t^2+60t & \text{for } t>0.2\text{ s}\end{cases}$, 2533 J
5. 30 W
6. 1.2×10^6 watt
7. $-\frac{1}{4}$
8. $\sqrt{19}$ ms^{-1}
9. 50 J
10. 3
11. 1
12. 240 J
13. 4.9 kmh^{-1}
14. 9 J
15. 3.75 J
16. –0.25 J

Test Your Concepts-III (Based on Conservation of Energy and Work Energy Theorem)

1. $mg\ell(1-\cos\theta)$
2. 5 ms^{-1}
3. 3.54 ms^{-1}, 3.96 ms^{-1}
4. 6.25 ms^{-1}
5. (a) 0.4 J (b) 1.2 J
6. $\frac{M^2g}{2km}+\frac{Mg}{k}$
7. $\sqrt{2gR}\cos\alpha$, $\sqrt{2gR}\sin\alpha$
8. (a) 3.87 ms^{-1} (b) = 0.1 m
9. $\sqrt{rg\left(\frac{4}{\pi}+\frac{\pi}{2}\right)}$
10. (a) 13.2 kJ (b) –12 kJ (c) 1.2 kJ (d) 5.47 ms^{-1}
11. 0.374 ms^{-1}
12. (a) 2.33 J (b) 2.635 J
13. (a) $\frac{\alpha x^2}{2}+\frac{\beta x^3}{3}$ (b) 6 ms^{-1}
14. $\frac{\left[mg(\sin\theta+\mu_s\cos\theta)\right]^2}{2k}$
15. 0.5 m
16. (a) 0.98 m (b) 1.39 ms^{-1}
17. $\sqrt{\frac{k}{m}\left[\frac{L_0^2}{4}-(L_0-x)^2\right]}$
18. $\sqrt{\frac{2}{3}(1+\pi)gr}$

Test Your Concepts-IV (Based on Work Energy Theorem for Non-conservative Systems)

1. (a) $+\frac{1}{2}mv^2$ (b) $\frac{v^2}{2\mu_k g}$ (c) $2d$

2. (a) 0.82 N (b) 2.45 ms^{-1}
3. (a) $-\mu Mg\ell$ (b) $-\frac{1}{2}k\ell^2$
 (c) Gravitational force, normal reaction, zero
 (d) $-\left(\mu Mgl + \frac{1}{2}kl^2\right)$
 (e) $\frac{1}{k}\left[\sqrt{\mu^2M^2g^2 + Mkv_0^2} - \mu Mg\right]$
4. $\left(\frac{M^2v_0^2}{2}\right)\left(\frac{gb}{k+Mgb}\right)$
5. (a) 0.2 (b) –2.4 J
6. (a) 0.8 ms^{-1} (b) 0.82 ms^{-1}
7. –750 J
8. $\left(m_1 + \frac{m_2}{2}\right)\mu g$
9. –0.044 J
10. 0.115
11. 5 J

Test Your Concepts-V (Based on Relation Between Conservative Force and Potential Energy and Types of Equilibrium)

1. $-\left(2y\hat{i} + (2x+z)\hat{j} + y\hat{k}\right)$
2. $aU_0\exp(-az)\left[\sin(ax)\hat{i} + \cos(ax)\hat{k}\right]$
3. $U_0 - ax^2y + \frac{ay^3}{3}$
4. 20 J
5. 7 m
6. D
7. A

Test Your Concepts-VI (Based on Vertical Circle)

1. $\frac{5}{2}R$
2. 16.15 N
3. (a) 29 N (b) 15.5 N
4. 5.66 ms^{-1}, 16.75 ms^{-2}
5. (a) 2 N (b) 64 N (c) 1.2 J
6. $\sqrt{\frac{mgR}{k}}\sqrt{5+2\mu_k}$
7. $\sqrt{\frac{7rg}{2}}$, 30°
8. (a) $\frac{3L}{2}$ (b) $\frac{40}{27}L$
9. $\sqrt{\frac{48g\ell}{5}}$
10. 15.65 ms^{-1}
11. 10 ms^{-1}

Single Correct Choice Type Questions

1. D	2. D	3. A	4. A	5. C	6. C	7. B	8. B	9. D	10. D
11. A	12. D	13. A	14. D	15. B	16. C	17. A	18. C	19. B	20. B
21. C	22. A	23. D	24. B	25. A	26. A	27. B	28. B	29. A	30. D
31. A	32. C	33. C	34. B	35. B	36. B	37. A	38. D	39. B	40. C
41. B	42. B	43. C	44. B	45. C	46. A	47. C	48. D	49. D	50. B
51. D	52. C	53. B	54. A	55. B	56. D	57. C	58. D	59. C	60. C
61. C	62. A	63. C	64. C	65. A	66. C	67. A	68. B	69. D	70. B
71. A	72. D	73. A	74. B	75. D	76. C	77. B	78. C	79. B	80. B
81. A	82. B	83. B	84. A	85. B	86. A	87. D	88. C	89. A	90. B
91. A	92. B	93. C	94. B	95. A	96. C	97. A	98. A	99. A	

Multiple Correct Choice Type Questions

1. A, B, C	**2.** A, B, C, D	**3.** A, B, C	**4.** A, B, C, D	**5.** A, B, C, D
6. A, C, D	**7.** B, D	**8.** B, D	**9.** B, C	**10.** C, D
11. A, C, D	**12.** B, C	**13.** B, D	**14.** A, C, D, E	**15.** A, C
16. A, B, D	**17.** A, B, C	**18.** A, C	**19.** B, C, D	**20.** B, D
21. A, C	**22.** A, B, C	**23.** B, C	**24.** B, D	**25.** A, C
26. A, C	**27.** A, C, D	**28.** A, C, D	**29.** B, C, D	**30.** B, C
31. B, C	**32.** A, C	**33.** B, C, D	**34.** A, C	**35.** B, D
36. B, D	**37.** B, C	**38.** A, D	**39.** A, C	**40.** C, D

Reasoning Based Questions

1. D	**2.** D	**3.** D	**4.** A	**5.** D	**6.** A	**7.** A	**8.** C	**9.** C	**10.** D

Linked Comprehension Type Questions

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

Matrix Match/Column Match Type Questions

1. A → (q)	B → (s)	C → (r)	D → (r)
2. A → (s)	B → (r)	C → (p)	D → (q)
3. A → (t)	B → (p)	C → (s)	D → (q)
4. A → (r)	B → (q)	C → (p)	D → (t)
5. A → (p, q)	B → (t)	C → (r)	D → (s)
6. A → (p, q, r)	B → (p, q, r)	C → (q, r)	D → (p, r)
7. A → (r)	B → (p)	C → (q, s)	D → (q, s)
8. A → (p, s)	B → (q, r)	C → (p, s)	D → (q, r)
9. A → (s)	B → (r)	C → (p)	D → (q)
10. A → (s)	B → (r)	C → (q)	D → (p)

Integer/Numerical Answer Type Questions

1. 10	**2.** 800	**3.** (a) 32, (b) 500	**4.** (a) 65, (b) 3	**5.** 0.098
6. 100	**7.** 2	**8.** 10	**9.** (a) 80, (b) 80, (c) 50	**10.** 3
11. 2	**12.** 4	**13.** 4	**14.** 2	**15.** 5

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1. B	**2.** C	**3.** D	**4.** 18	**5.** 150	**6.** 3	**7.** C	**8.** B	**9.** 1.9	**10.** 10
11. D	**12.** C	**13.** D	**14.** B	**15.** A	**16.** A	**17.** A	**18.** C	**19.** B	**20.** C
21. C	**22.** A	**23.** D	**24.** A	**25.** A	**26.** C	**27.** C	**28.** B	**29.** B	**30.** D
31. C	**32.** C	**33.** D	**34.** D	**35.** A	**36.** B	**37.** D	**38.** B	**39.** D	**40.** A
41. D									

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Single Correct Choice Type Problems

1. C	**2.** D	**3.** C	**4.** C	**5.** D	**6.** A	**7.** B	**8.** B	**9.** D	**10.** C
11. B	**12.** D	**13.** C	**14.** B	**15.** D	**16.** C	**17.** C	**18.** B		

Multiple Correct Choice Type Problems

1. A, D **2.** C, D

Reasoning Based Questions

1. C

Matrix Match/Column Match Type Questions

1. (A) → (p, q, r, t) (B) → (q, s) (C) → (p, q, r, s) (D) → (p, r, t)

Linked Comprehension Type Questions

1. B **2.** A

Integer/Numerical Answer Type Questions

1. 0.75 **2.** 5 **3.** 5 **4.** 5 **5.** 4