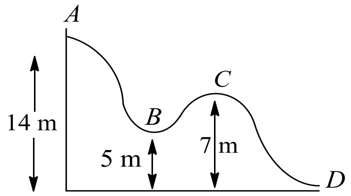
Single Correct Answer Type

1. A body is acted upon by a force which is inversely proportional to the distance converted. The work done will be proportional to
a) s b) s^2 c) $\sqrt{s}$ d) None of these

2. A 1 kg stone at the end of 1 m long string is whirled in a vertical circle at a constant speed of4 ms^{-1}. The tension in the string is 6 N when the stone is
a) At the top of the circle b) At the bottom of the circle
c) Half way down d) None of above

3. A point mass of 1 kg collides elastically with a stationary point mass of 5 kg. After their collision, the 1 kg mass reverses its direction and moves with a speed of 2 ms^{-1}. Which of the following statements(s) is/are correct for the system of these two masses?
a) Total momentum of the system is 3 $kg - ms^{-1}$
b) Momentum of 5 kg mass after collision is 4 $kg - ms^{-1}$
c) Kinetic energy of the centre of mass is 0.75 j
d) Total kinetic energy of the system is 4 j

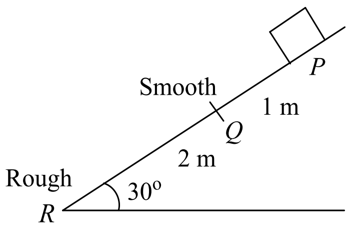
4. Figure shows the vertical section of a frictionless surface. A block of mass 2 kg is released from rest from position A; its KE as it reached position C is (g=10 ms^{-2})



a) 140 J b) 180 J c) 120 J d) 280 J

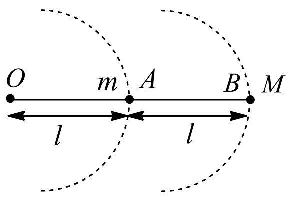
5. A particle is released one by one from the top of two inclined rough surfaces of height h each. The angles of inclination of the two planes are 30° and60°, respectively. All other factors (e.g., coefficient of friction, mass of block, etc.) are same in both the cases. Let K_1 and K_2be the kinetic energies of the particle at the bottom of the plane in the two cases. Then
a) $K_1 = K_2$ b) $K_1 > K_2$ c) $K_1 < K_2$ d) Data insufficient

6. A block of mass 5.0 kg slides down from the top of an inclined plane of length 3 m. The first 1 m of the plane is smooth and the next 2 m is rough. The block is released from rest and again comes to rest at the bottom of the plane. If the plane is inclined at 30° with the horizontal, find the coefficient of friction on the rough portion



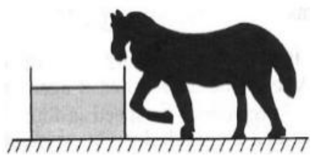
a) $\frac{2}{\sqrt{3}}$ b) $\frac{\sqrt{3}}{2}$ c) $\frac{\sqrt{3}}{4}$ d) $\frac{\sqrt{3}}{5}$

7. Two identical particles, A and$B$, are attached to a string of length $2l$, A to middle and B to one of the ends. The string is whirled in a horizontal circle, with the end O fixed. If the kinetic energy of B relative to A is E, then the absolute kinetic energies of A and B are



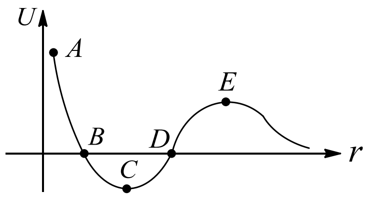
a) E and E b) E and $4E$ c) $4E$ and E d) E and $3E$

8. If a number of forces act on a body and the body is in static or dynamic equilibrium, then
   a) Work done by any individual force must be zero
   b) Net work done by all the forces is positive
   c) Net work done by all the forces is negative
   d) Net work done by all the forces is zero
9. The kinetic energy K of a particle moving along a circle of radius R depends upon the distance s as$K = as^2$. The force acting on the particle is
   a) $2a\frac{s^2}{R}$ b) $2as\left[1+\frac{s^2}{R^2}\right]^{1/2}$ c) $2as$ d) $2a$
10. A person lifts a bucket full of water by means of light rope from a well. Select the incorrect statement
    a) Work done by gravity is negative
    b) Work done by the tension in the rope is positive
    c) Work done on the person is positive
    d) Work done on the person is negative
11. A mass of 2 kg slides down 1/4 circular track of radius 1 m. If the speed of mass at the bottom is 4 ms^{-1}, work done by the frictional force is
    a) 4 J b) -4 J c) 2 J d) -6 J
12. A horse drinks water from a cubical container of side 1 m. The level of the stomach of horse is at 2 m from the ground. Assume that all the water drunk by the horse is at 2 m force the at a level of 2 m from the ground. Then the minimum container is (Take $\rho_{\text{water}} = 1000 \text{ kg m}^{-3}$ and $\text{g} = 10 \text{ ms}^{-2}$)



a) 10 kJ b) 15 kJ c) 20 kJ d) Zero

13. A body of mass m is moving in a circle of radius r with a constant speed$v$. The force on the body is mv^2/r and is force in moving the body over half the circumference of the circle?
    a) $\frac{\pi r^2}{mv^2}$ b) $\frac{mv^2}{r^2}$ c) Zero d) $\frac{mv^2}{r} \times \pi r$
14. A heavy weight is suspended from a spring. A person raises the weight till the spring becomes slack. The work done by him is$W$. The energy stored in the stretched spring was E. What will be the gain in gravitational potential energy?
    a) W b) E c) $W + E$ d) $W - E$
15. Two particles are interacting only because of conservation forces. They complete round trips, ending at the point from where they started. Over this trip
    a) The total KE might have a different value at the beginning and the end
    b) The PE might have a different value at the beginning and the end
    c) The total mechanical energy might have a different value at the beginning and the end
    d) None of the above
16. The given plot shows the variation of U, the potential energy of intersection between two particles, with the distance separating team, r

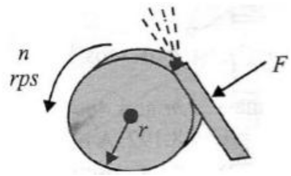


1. B and D are equilibrium points
2. C is a point of stable equilibrium
3. The force of interaction between the two particles is attractive between points C and B, and repulsive between points D and E on the curve
4. The force of intersection between the particles is repulsive between points C and A

Which of the above statement are correct?

a) 1 and 3 b) 1 and 4 c) 2 and 4 d) 2 and3

17. The coefficient of friction between a tool and a grinding wheel isμ. The power developed in watt by the wheel of radius r running at n revolutions per second when the tool is pressed to the wheel with a force F kgf is



a) $\mu Fr(2\pi n)$ b) $\mu F\, gr(2\pi n)$ c) $\mu F\, r$ d) μF g

18. A block of mass m is moving with a constant acceleration a on a rough plane. If the coefficient of friction between the block and the ground is μ, the power delivered by the external agent after a time t from the beginning is equal to

a) ma^2t b) $\mu mgat$ c) $\mu m(a+\mu g)gt$ d) $m(a+\mu g)at$

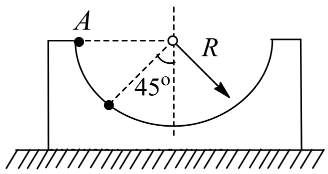
19. Work done by a conservative force on a system is equal to

a) The change in kinetic energy of the system
b) The change in potential energy of the system
c) The change in total mechanical energy of the system
d) None of the above

20. Given that a force $\vec{F}$ acts on a body for time t_1 and displaces the body by$\vec{d}$. In which of the following cases the velocity of the body must increase?

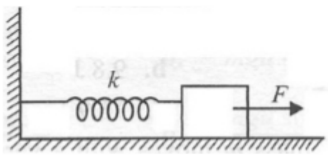
a) $F > d$ b) $F < d$ c) $\vec{F}||\vec{d}$ d) $\vec{F} \perp \vec{d}$

21. A ball of mass m is released from A inside a smooth wedge of mass m as shown in figure. What is the speed of the wedge when the ball reaches point B?



a) $\left(\frac{gR}{3\sqrt{2}}\right)^{1/2}$ b) $\sqrt{2gR}$ c) $\left(\frac{5gR}{2\sqrt{3}}\right)^{1/2}$ d) $\sqrt{\frac{3}{2}gR}$

22. A block attached to a spring, pulled by a constant horizontal force, is kept on smooth surface as shown in figure. Initially, the spring is in the natural length state. Then the maximum positive work that the applied force F can do is (given that string does not break)



a) $\frac{F^2}{k}$ b) $\frac{2F^2}{k}$ c) ∞ d) $\frac{F^2}{2k}$

23. Two identical 5 kg blocks are moving with same speed of 2 ms^{-1} towards each other along a frictionless horizontal surface. The two blocks collide, stick together, and come to rest. Consider the two blocks as a system. The works done by external and internal forces are, respectively

a) 0, 0 b) 0, 20 J c) 0, −20 J d) 20 J, −20 J

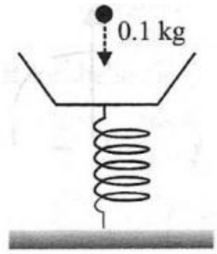
24. A shell is fired from a cannon with velocity $v\ m/sec$ at an angle θ with the horizontal direction. At the highest point in its path it explodes into two pieces of equal mass. One of the pieces retraces its path to the cannon and the speed in m/sec of the other piece immediately after the explosion is

a) $3v\cos\theta$ b) $2v\cos\theta$ c) $\frac{3}{2}v\cos\theta$ d) $\frac{\sqrt{3}}{2}v\cos\theta$

25. In the above question, the net work done by the external forces on the box is

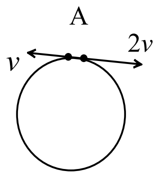
a) 300 J b) Zero c) 3200 J d) 6400 J

26. A mass less platform is kept on alight elastic spring as shown in figure. When a particle of mass 0.1 kg is dropped on the pan from a height of 0.24 m, the particle strikes the pan, and the spring is compressed by 0.01 m. From what height should the particle be dropped to cause a compression of 0.04 m?



a) 0.96 m b) 2.96 m c) 3.96 m d) 0.48 m

27. Two small particles of equal masses start moving in opposite directions from a point A in a horizontal circular orbit. Their tangential velocities are v and $2v$, respectively, as shown in the figure. Between collisions, the particles move with constant speeds. After making how many elastic collisions, other than that at A, these two particles will again reach the point A

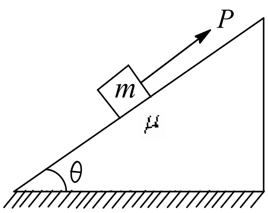


a) 4 b) 3 c) 2 d) 1

28. A nucleus with mass number 220 initially at rest emits an α −particle.If the Q value of the reaction is 5.5 MeV, calculate the kinetic energy of the α −particle

a) 4.4MeV b) 5.4MeV c) 5.6MeV d) 6.5MeV

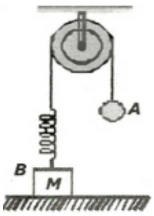
29. A block of mass m is being pulled up a rough incline by an agent delivering constant power$P$. The coefficient of friction between the block and the incline isμ. The maximum speed of the block during the course of ascent is



a) $v = \frac{P}{mg\sin\theta + \mu\, mg\cos\theta}$ b) $v = \frac{P}{mg\sin\theta - \mu\, mg\cos\theta}$

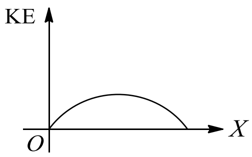
c) $v = \frac{2P}{mg\sin\theta - \mu\, mg\cos\theta}$ d) $v = \frac{3P}{mg\sin\theta - \mu\, mg\cos\theta}$

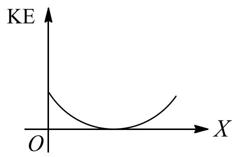
30. In the figure, the ball A is released from rest, when the spring is at its natural (unstretched) length. For the block B of mass M to leave contact with ground at some stage, the minimum mass of A must be

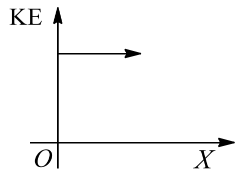


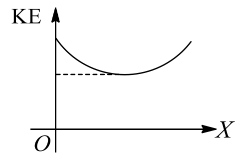
a) $2M$ b) M c) $M/2$ d) $M/4$

31. A projectile is fired with some velocity making certain angle with the horizontal. Which of the following graphs is the best representation for the kinetic energy of a projectile (K.E.) versus its horizontal displacement(x)?

a) 

b) 

c) 

d) 

32. Two masses of $1g$ and $4g$ are moving with equal kinetic energies. The ratio of the magnitudes of their linear momenta is

a) $4 : 1$ b) $\sqrt{2} : 1$ c) $1 : 2$ d) $1 : 16$

33. A body is moved along a straight line by a machine delivering a constant power. The distance moved by the body in time t is proportional to

a) $\sqrt{t}$ b) $t^{3/4}$ c) $t^{3/2}$ d) t^2

34. A particle free to move along the x-axis has potential energy given by $U(x) = k[1 - \exp(-x^2)]$ for $-\infty \leq x \leq +\infty$, where k is a positive constant of appropriate dimensions. Then

a) At point away from the origin, the particle is in unstable equilibrium

b) For any finite non-zero value of x, there is a force directed away from the origin

c) If its total mechanical energy is $k/2$, it has its minimum kinetic energy at the origin

d) For small displacements from $x = 0$, the motion is simple harmonic

35. The displacement x in metre of a particle of mass m kg moving in one dimension under the action of a force is related to the time t in second by the equation$x = (t - 3)^2$. The work done by the force (in joules) in first six seconds is

a) $18m$ b) Zero c) $9m/2$ d) $36m$

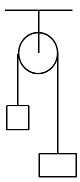
36. The distance converted by a body to come to rest when it is moving with a speed of 4 ms^{-1} is s when a retarding force F is applied. If the KE is doubled, the distance covered by it to come to rest for the same retarding force F is

a) 4 s b) 6 s c) 2 s d) 8 s

37. An engine pumps water continuously through a hole. Speed with which water passes through the hole nozzle is$v$, and k is the mass per unit length of the water jet as it leaves the nozzle. Find the rate at which kinetic energy is being imparted to the water

a) $\frac{1}{2}kv^2$ b) $\frac{1}{2}kv^3$ c) $\frac{V^2}{2k}$ d) $\frac{V^3}{2k}$

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

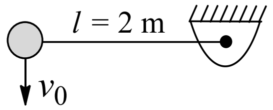


a) 6 $Joule$ b) 5 $Joule$ c) 8 $Joule$ d) 2 $Joule$

39. Two men A and$B$, each weighing 80 kg, run up the same stair case. While A does it in 20 s. B does it in 15 s. The ratio of the powers developed by A and B is

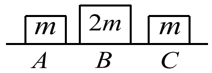
a) $\frac{4}{3}$ b) $\frac{3}{4}$ c) $\frac{1}{2}$ d) $\frac{1}{4}$

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



a) $\cos^{-1}\frac{2}{3}$ b) $\cos^{-1}\left(\frac{1}{4}\right)$ c) $60°$ d) $30°$

41. Three objects A, B and C are kept in a straight line on a frictionless horizontal surface. These have masses $m, 2m$ and m respectively. The object A moves towards B with a speed 9 m/s and makes an elastic collision with it. Thereafter, B makes completely inelastic collision with C. All motions occur on the same straight line. Find the final speed (in m/s) of the object C



a) 3 m/s b) 4 m/s c) 5 m/s d) 1 m/s

42. A pump motor is used to deliver water at a certain rate from a given pipe. To obtain n times water from the same pipe in the same time, by what amount should the power of the motor be increased?

a) n^2 times b) n^3 times c) n times d) $n^{3/2}$ times

43. 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 forces acting on it is

a) Zero b) $mk^2r^2t^2$ c) mk^2r^2t d) mk^2rt

44. Work done in time t on a body of mass m, which is accelerated from rest to a speed v in time t_1 as a function of time t, is given by

a) $\frac{1}{2}m\frac{v^2t}{t_1}$ b) $mv^2\left(\frac{t}{t_1}\right)^2$ c) $\frac{1}{2}\left(\frac{mv}{t_1}\right)^2 t^2$ d) $\frac{1}{2}mv^2\left(\frac{t}{t_1}\right)^2$

45. In the above questions, if equal forces are applied on two springs, then

a) More work is done on Q b) More work is done on P

c) Heir force constants will becomes equal d) Equal work is done on both the springs

46. In the above question, the maximum power delivered by the agent in pulling up the rope is

a) $\lambda\ lgv$ b) $\lambda\ lgv + \frac{v^3\lambda}{2}$ c) $\lambda\ lgv + v^3\lambda$ d) $\frac{llgv}{2} + \frac{\lambda v^3}{2}$

47. Two constant forces $\vec{F}_1$ and $\vec{F}_2$ act on a body of mass 8 kg. These forces displace the body from point $P(1, -2, 3)$ to $Q\ (2, 3, 7)$ in 2 s starting from rest. Force $\vec{F}_1$ is of magnitude 9 N and is acting along vector$(2\hat{\imath} - 2\hat{\jmath} + \hat{k})$. Work done by the force $\vec{F}_2$ is

a) 80 J b) −80 J c) −180 J d) 180 J

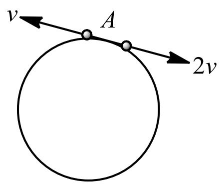
48. A car drives along a straight level frictionless road by an engine delivering constant power. Then velocity is directly proportional to

a) t b) $\frac{1}{\sqrt{t}}$ c) $\sqrt{t}$ d) None of these

49. An automobile weighing 1200 kg climbs up a hill that rises 1 in 20. Neglecting frictional effects, the minimum power developed by the engine is 9000 W. If $g = 10\ \text{ms}^{-2}$, then the velocity of the automobile is

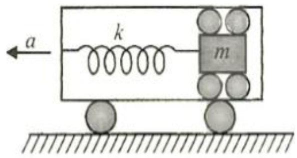
a) 36 kmh^{-1} b) 54 kmh^{-1} c) 72 kmh^{-1} d) 90 kmh^{-1}

50. Two small particles of equal masses start moving in opposite directions from a point A in a horizontal circular orbit. Their tangential velocities are $v\ and\ 2v$ respectively, as shown in the figure. Between collisions, the particles move with constant speeds. After making how many elastic collisions, other than that at A ,these two particles will again reach The point A?



a) 4 b) 3 c) 2 d) 1

51. A block of mass m is connected to spring of spring constant k as shown in figure. The frame in which the block is placed is given acceleration a towards left. Neglect friction between the block and the frame walls. The maximum velocity of the block relative to the frame is



a) $\sqrt{\frac{m}{k}}$ b) $a\sqrt{\frac{m}{k}}$ c) $a\sqrt{\frac{m}{2k}}$ d) $2a\sqrt{\frac{m}{k}}$

52. A toy gun uses a spring of force constant$K$. Before being triggered in the upward direction, the spring is compressed by a distance$x$. If the mass of the shot is m, on being triggered it will go up to a maximum height of

a) $\frac{Kx^2}{mg}$ b) $\frac{x^2}{Kmg}$ c) $\frac{Kx^2}{2mg}$ d) $\frac{K^2x^2}{mg}$

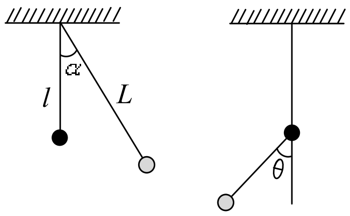
53. A particle moved from position $\vec{r}_1 = 3\hat{\imath} + 2\hat{\jmath} - 6\hat{k}$ to position $\vec{r}_2 = 14\hat{\imath} + 13\hat{\jmath} + 9\hat{k}$ Under the action of force $(4\hat{\imath} + \hat{\jmath} + 3\hat{k})$ N. The work done is

a) 10 J b) 100 J c) 0.01 J d) 1 J

54. A particle of mass m moves with a variable velocity$v$, which changes with distance covered x along a straight line as$v = k\sqrt{x}$, where k is a positive constant. The work done by all the forces acting on the particle, during the first t seconds is

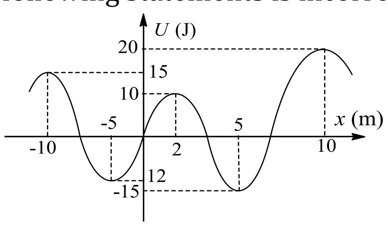
a) $\frac{mk^4}{t^2}$ b) $\frac{mk^4t^2}{4}$ c) $\frac{mk^4t^2}{8}$ d) $\frac{mk^4t^2}{16}$

55. A simple pendulum consisting of a mass M attached to a string of length L is released from rest at an angleα. 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 figure. The maximum angle θ which the 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) $\cos^{-1}\left[\frac{L\cos\alpha - l}{L + l}\right]$

56. In figure, the variation of potential energy of a particle of mass $m = 2$ kg is represented w.r.t. its x-coordinate. The particle moves under the effect of the conservation force along the x-axis. Which of the following statements is incorrect about the particle?



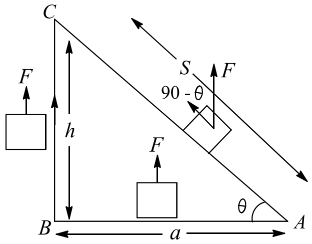
a) If it is released at the origin, it will move in negative x-axis

b) If it is released at $x = 2 + \Delta$ where $\Delta \to 0$, then its maximum speed will be 5 ms^{-1} and it will perform oscillatory motion

c) If initially $x = -10$ and $\vec{u} = \sqrt{6}\hat{\imath}$, then it will cross $x = 10$

d) $x = -5$ and $x = +5$ are unstable equilibrium positions of the particle

57. If we shift a body in equilateral from A to C in a gravitational field via path AC or ABC,



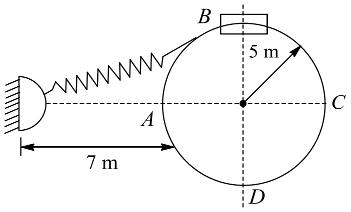
a) The work done by force $\vec{F}$ for both paths will be same

b) $W_{AV} > W_{ABC}$

c) $W_{AC} < W_{ABC}$

d) None of the above

58. A collar B of mass 2 kg is constrained to move along a horizontal smooth and fixed circular track of radius 5 m. The spring lying in the plane of the circular track and having spring constant 200 Nm^{-1} is underformed when the collar is at$A$. If the collar starts from rest at B, the normal reaction exerted by the track on the collar when it passes through A is

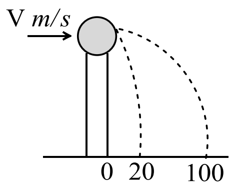


a) 360 N
b) 720 N
c) 1440 N
d) 2880 N

59. An engine pumps up 100 kg of water through a height of 10 m in 5 s. given that the efficiency of the engine is 60 %. What is the power of the engine? Take g=10 ms^{-2}

a) 33 kW
b) 3.3 kW
c) 0.33 kW
d) 0.033 kW

60. A ball of mass 0.2 kg rests on a vertical post of height 5 m. A bullet of mass 0.01 kg, travelling with a velocity V m/s in a horizontal direction, hits the centre of the ball. After the collision, the ball and bullet travel independently. The ball hits the ground at a distance of 20 m and the bullet at a distance of 100 m from the foot of the post. The initial velocity V of the bullet is

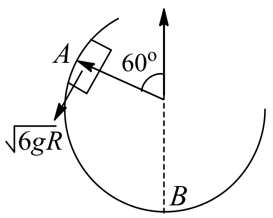


a) 250 m/s
b) $250\sqrt{2}$ m/s
c) 400 m/s
d) 500 m/s

61. One end of an unstretched vertical spring is attached to the ceiling and an object attached to the other end is slowly lowered to its equilibrium position. If S is the gain in spring energy and G is the loss in gravitational potential energy in the process, then

a) $S = G$
b) $S = 2G$
c) $G = 2S$
d) None of these

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



a) 0.25
b) 0.35
c) 0.45
d) 0.55

63. **Statement I** In an elastic collision between two bodies, the relative speed of the bodies after collision is equal to the relative speed before the collision.

Statement II Inan elastic collision, the linear momentum of the system is conserved.

a) Statement I is true ,statement II is true; statement II is a correct explanation for statement I
b) Statement I is true, Statement II is true; statement II is not correct explanation for statement I
c) Statement I is true, Statement II is false
d) Statement I is false, Statement II is True

64. A stone of mass 1 kg tied to a light inextensible string of length $L = 10/3$ 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 is 4 and if g is taken to be 10 ms^{-2}, the speed of the stone at the highest point of the circle is

a) 10 ms^{-1}
b) $5\sqrt{3}$ ms^{-1}
c) $10\sqrt{3}$ ms^{-1}
d) 20 ms^{-1}

65. If a person is pushing a box inside a moving train, the work done in the frame of Earth will be (Let $\vec{s}_0$ be the displacement of train and $\vec{s}$ be the displacement of box in the train)

a) $\vec{F}.\vec{s}_0$
b) $\vec{F}.\vec{s}$
c) $\vec{F}.(\vec{s}+\vec{s}_0)$
d) Zero

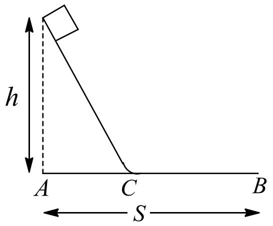
66. A bus can be stopped by applying a retarding force F when it is moving with speed v on a level road. The distance converted by it before coming to rest is s. If the load of the bus increases by 50% because of passengers, for the same speed and same retarding force, the distance converted by the bus to come to rest shall be

a) $1.5s$
b) $2s$
c) $1s$
d) $2.5s$

67. A particle of mass m is projected at an angle α to the horizontal with an initial velocity$u$. The work done by gravity during the time it reaches its highest point is

a) $u^2 \sin^2 \alpha$
b) $\frac{mu^2 \cos^2 \alpha}{2}$
c) $\frac{mu^2 \sin^2 \alpha}{2}$
d) $-\frac{mu^2 \sin^2 \alpha}{2}$

68. A block slides down on an icy hill of height h (as shown in figure) and stops after covering a distanceCB. The distance AB is equal to$S$. The coefficient of friction μ between the block and ice surface (inclined and horizontal) is



a) $\mu = \frac{h}{S}$
b) $\mu = \frac{h}{\sqrt{S^2 - h^2}}$
c) $\mu = \frac{S}{h}$
d) Data sufficient

69. The potential energy of a particle is determined by the expression$U = \alpha(x^2 + y^2)$, where α is a positive constant. The particle begins to move from a point with coordinates (3, 3), only under the action of potential field force. Then its kinetic energy T at the instant when the particle is at a point with the coordinates (1, 1) is

a) 8α
b) 24α
c) 16α
d) Zero

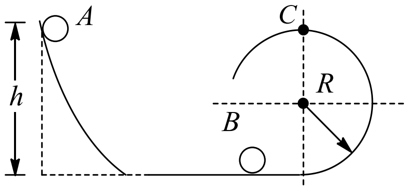
70. In which of the following cases can the work done increase the potential energy?

a) Both conservation and non-conservation forces
b) Conservation force only
c) Non-conservation force only
d) Neither conservation nor non-conservation forces

71. A particle is projected along a horizontal field whose coefficient of friction varies as$\mu = \frac{A}{r^2}$, where r is the distance from the origin in metres and A is a positive constant. The initial distance of the particle is 1 m from the origin and its velocity is radially outwards. The minimum initial velocity at this point so the particle never stops is

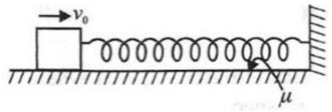
a) ∞ b) $2\sqrt{gA}$ c) $\sqrt{2gA}$ d) $4\sqrt{gA}$

72. Ball A of mass$m$, after sliding from an inclined plane, strikes elastically another ball B of same mass at rest. Find the minimum height h so that ball B just completes the circular motion of the surface at$C$. (All surface are smooth)



a) $h=\frac{5}{2}R$ b) $h=2R$ c) $h=\frac{2}{5}R$ d) $h=3R$

73. In the position shown, the spring is at its natural length. The block of mass m is given a velocity v_0 towards the vertical support at$t=0$. The coefficient of friction between the block and the surface is given by$\mu=\alpha x$, where α is a positive constant and x is the position of the blo0ck from its starting position. The block comes to rest for the first time at x, which is



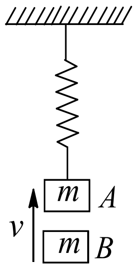
a) $v_0\sqrt{\frac{m}{k+\alpha mg}}$ b) $v_0\sqrt{\frac{m}{k}}$ c) $v_0\sqrt{\frac{m}{\alpha g}}$ d) None of these

74. Two springs P and Q having stiffness constant k_1 and$k_2(<k_1)$, respectively are stretched equally. Then

a) More work is done on Q b) More work is done on P

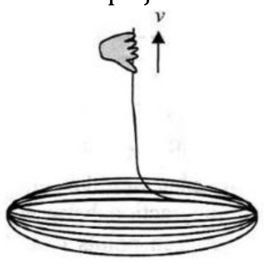
c) Their force constants will become equal d) Equal work is done on both the springs

75. Block A is hanging from a vertical spring and is at rest. Block B strikes block A with velocity v and sticks to it. Then the value of v for which the spring just attains natural length is



a) $\sqrt{\frac{60\ mg^2}{k}}$ b) $\sqrt{\frac{6\ mg^2}{k}}$ c) $\sqrt{\frac{10\ mg^2}{k}}$ d) None of these

76. A uniform rope of linear mass density λ and length l is coiled on a smooth horizontal surface. One end is pulled up with constant velocity$v$. Then the average power applied by the external agent in pulling the entire rope just off the ground is



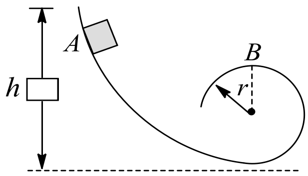
a) $\frac{1}{2}\lambda lv^2+\frac{\lambda l^2 g}{2}$ b) λlgv c) $\frac{1}{2}\lambda v^3+\frac{\lambda lvg}{2}$ d) $\lambda lgv+\frac{1}{2}\lambda v^3$

77. An engine can pull four coaches at a maximum speed of$20\ ms^{-1}$. The mass of the engine is twice the mass of energy coach. Assuming resistive forces to be proportional to the weight, approximate maximum speeds of the engine, when it pulls 12 and 6 coaches, are

a) $8.5\ \mathrm{ms^{-1}}$ and $15\ \mathrm{ms^{-1}}$, respectively b) $6.5\ \mathrm{ms^{-1}}$ and $8\ \mathrm{ms^{-1}}$, respectively

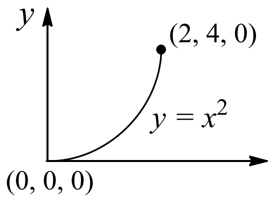
c) 8.5 ms^{-1} and 13 ms^{-1}, respectively   d) 10.5 ms^{-1} and 15 ms^{-1}, respectively

78. A mass m starting from A reaches B of a frictionless track. On reaching it B, it pushes the track with a force equal to x times its weight, then applicable relation is



a) $h = \frac{(x+5)}{2}r$ b) $h = \frac{x}{2}r$ c) $h = r$ d) $h = \left(\frac{x+1}{2}\right)r$

79. A force $\vec{F} = (3xy - 5z)\hat{j} + 4z\hat{k}$ is applied on a particle. The work done by the force when the particle moves from point (0, 0, 0) to point (2, 4, 0) as shown in figure is

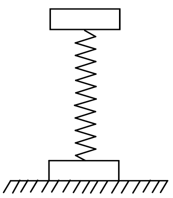


a) $\frac{280}{5}$ units   b) $\frac{140}{5}$ units   c) $\frac{232}{5}$ units   d) $\frac{192}{5}$ units

80. 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. If g is acceleration due to gravity, the work required to pull the hanging part on to the table is

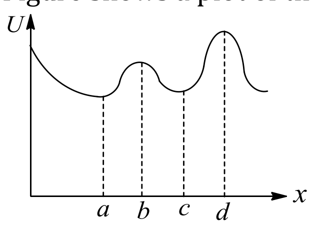
a) MgL b) $MgL/3$ c) $MgL/9$ d) $MgL/18$

81. Two discs, each having mass$m$, are attached rigidly top the ends of a vertical spring. One of the discs rests on a horizontal surface and the other produces a compression x_0 on the spring when it is in equilibrium. How much further causing compression is removed, the extension of the spring will be able to lift the lower disc off the table?



a) x_0 b) $2x_0$ c) $3x_0$ d) $1.5x_0$

82. Figure shows a plot of the potential energy as a function of x for a particle moving along the x-axis



Which of the following statement (s) is/are true?

a) a, c and d are points of equilibrium

b) a is a point of stable equilibrium

c) b is a stable equilibrium point

d) All of the above

83. A particle moves along a circle with its speed increasing at a constant rate. Choose the incorrect statement

a) Net force acting on the particle is towards the centre of the circle

b) The centripetal force does no work on the particle

c) Net work is being done on the particle

d) None of the above

84. A ball hits the floor and rebounds after inelastic collision. In this case

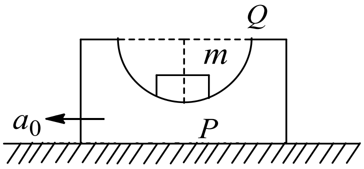
a) The momentum of the ball just after the collision is the same as that just before the collision

b) The mechanical energy of the ball remains the same in the collision

c) The total momentum of the ball and the earth is conserved

d) The total energy of the ball and the earth is conserved

85. A block of mass m is lying at rest at point P of wedge having a smooth semi-circular track of radius$R$. What should be the minimum value of a_0 so that the mass can just reach point Q



a) $\frac{g}{2}$ b) $\sqrt{g}$ c) g d) None possible

86. The kinetic energy acquired by a mass m in travelling a certain distance d, starting from rest, under the action of a force F such that the force F is directly proportional to t is

a) Directly proportional to t^2 b) Independent of t

c) Directly proportional to t^4 d) Directly proportional to t

87. When a mass of 2 kg is suspended slowly by a spring with its upper end fixed to the ceiling, the spring stretches by 1 cm. work done by the spring is ($g = 10\ ms^{-2}$)

a) -0.2 J b) -0.1 J c) -0.4 J d) None of these

88. When a bicycle accelerated on a levelled road,

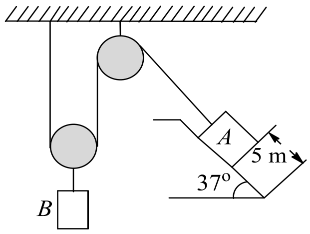
a) The net work done by the friction is positive

b) The net work done by the friction is zero

c) The friction on the front wheel does positive work

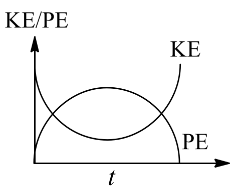
d) The friction on the rear wheel does negative work

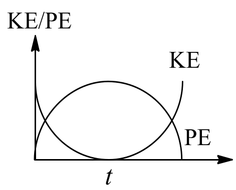
89. The blocks A and B shown in figure have masses $M_A = 5$ kg and $M_B = 4$ kg. The system is released from rest. The speed of B after A has travelled a distance 1 m along the incline is

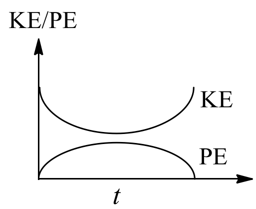


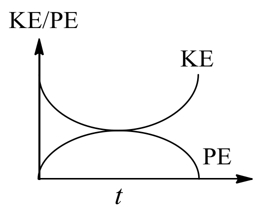
a) $\frac{\sqrt{3}}{2}\sqrt{g}$ b) $\frac{\sqrt{3}}{4}\sqrt{g}$ c) $\frac{\sqrt{g}}{2\sqrt{3}}$ d) $\frac{\sqrt{g}}{2}$

90. A particle is projected at an angle $\theta = 30°$ with the horizontal. Which of the following curves best represents the variation of KE and potential energy as a function of time? (take the point of projection as the reference level for the gravitational potential energy)

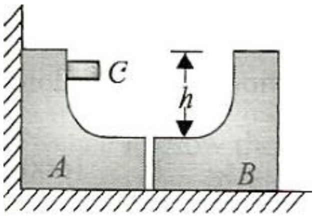
a)


b)


c)


d)


91. Two identical blocks, each having mass$M$, are placed as shown in figure. These two blocks A and B are smoothly conjugated, so that when another block C of mass m passes from A to B there is no jerk. All the surfaces are frictionless, and all three blocks are free to move



Block C is released from rest, then

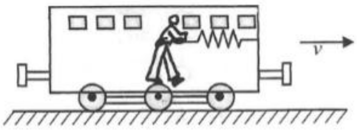
a) Block C will move for a very small duration

b) Block A will move for a very small duration

c) Block B will acquire maximum speed when C is at the lowest point on B and moving towards left

d) Block B will acquire maximum speed when C is at the topmost point of B

92. A moving railway compartment has a spring of constant k fixed to its front wall. A boy stretches this spring by distance x and in the mean time the compartment moves by a distance$s$. The work done by boy w.r.t. earth is

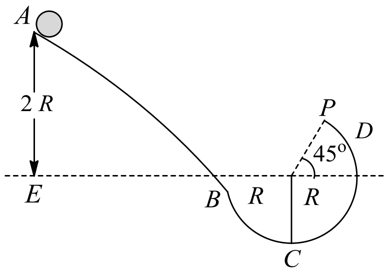


a) $\frac{1}{2}kx^2$ b) $\frac{1}{2}(kx)(s+x)$ c) $\frac{1}{2}kxs$ d) $\frac{1}{2}kx(s+x+s)$

93. A mass M is lowered with the help of a string by a distance h at a constant acceleration g/2. The work done by the string will be

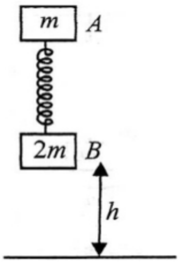
a) $\frac{Mgh}{2}$ b) $-\frac{Mgh}{2}$ c) $\frac{3Mgh}{2}$ d) $-\frac{3Mgh}{2}$

94. A particle of mass m slides on a frictionless surface$ABCD$, starting from rest as shown in figure. The part BCD is a circular arc. If it looses contact at point P, the maximum height attained by the particle C is



a) $R\left[2+\frac{1}{2\sqrt{2}}\right]$ b) $\left[1+\frac{1}{2\sqrt{2}}\right]R$ c) $3R$ d) None of these

95. From what minimum height h must the system be released when a spring is unstretched so that after perfectly inelastic collision ($e=0$) with ground, B may be lifted off the ground (spring constant $=k$)



a) $mg/(4k)$ b) $4mg/k$ c) $mg/(2k)$ d) None

96. A weightlifter lifts a weight off the ground and holds it up, then

a) Work is done in lifting as well as holding the weight

b) No work is done in both lifting and holding the weight

c) Work is done in lifting the weight but no work is required to be done in holding it up

d) No work is done in lifting the weight but work is required to be done in holding it up

97. Water is drawn from a well in a 5 kg drum of capacity 55 L by two ropes connected to the top of the drum. The linear mass density of each rope is 0.5 kgm^{-1}. The work done in lifting water to the ground from the

surfaces of water in the well 20 m below is [g = 10 ms^{-2}]

a) 1.4×10^4 J b) 1.5×10^4J c) $9.8 \times 10 \times 6$ J d) 18 J

98. Which of the following statements is correct?

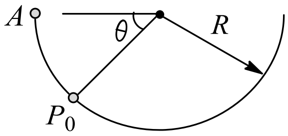
a) Kinetic energy of a system can be changed without changing its momentum

b) Kinetic energy of a system cannot be changed without changing its momentum

c) Momentum of a system cannot be changed without changing its kinetic energy

d) A system cannot have energy without having momentum

99. A bead of mass m is released from rest at A to move along the fixed smooth circular track as shown in figure. The ratio of magnitude of centripetal force and normal reaction by the track on the bead at any point P_0 described by the angle $\theta (\neq 0)$ would



a) Increase with θ b) Decrease with θ

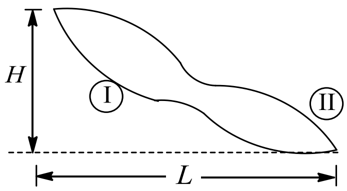
c) Remain constant d) First increase with θ and then decrease

100. In a tug of war, both the teams A and B remain in equilibrium, then

a) Work done by team A is positive b) Work done by team B is positive

c) Work done by both the teams is negative d) Work done by both the teams is zero

101. A body is lifted over route 1 and then route II such that force is always tangent to the path. The coefficient of friction is same for both paths. Work done



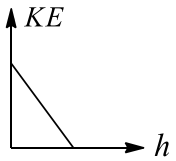
a) On both the routes is same b) On route I is more

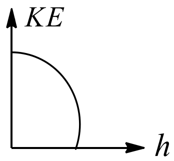
c) On route II is more d) On both the routes is zero

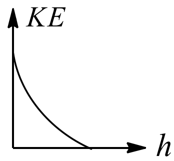
102. A particle is projected vertically upwards with a speed of 16 ms^{-1}. After some time, when it again passes through the point of projection, its speed is found to be 8 ms^{-1}. It is known that the work done by air resistance is same during upward and downward motion. Then the maximum height attained by the particle is (take g = 10 ms^{-2})

a) 8 m b) 4.8 m c) 17.6 m d) 12.8 m

103. Which of the following graphs depicts the variation of kinetic energy of a ball bouncing on a horizontal floor with height? (Neglect air resistance)

a) 

b) 

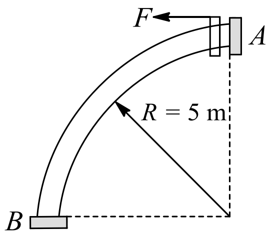
c) 

d) None of these

104. A machine delivers power to a body which is proportional to velocity of the body. If the body starts with a velocity which is almost negligible, then the distance covered by the body is proportional to

a) $\sqrt{V}$ b) $\sqrt[3]{\frac{V}{2}}$ c) $v^{5/3}$ d) v^2

105. A bead of mass 1/2 kg starts from rest from A to move in a vertical plane along a smooth fixed quarter ring of radius 5 m, under the action of a constant horizontal force $F = 5$ N as shown. The speed of bead as it reaches point B is

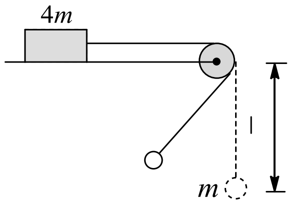


a) $14.14\ \text{ms}^{-1}$ b) $7.07\ \text{ms}^{-1}$ c) $5\ \text{ms}^{-1}$ d) $25\ \text{ms}^{-1}$

106. Figure shows a smooth curved track terminating in a smooth horizontal part. A spring of spring constant $400\ \text{Nm}^{-1}$ is attached at one end to the wedge fixed rigidly with the horizontal part. A 40 g mass is released from rest at a height of 5 m on the cured track. The maximum compression of the spring is

a) 10 cm b) 5 cm c) 12 cm d) 8 cm

107. Two bodies of masses m and $4m$ are attached to a light string as shown in figure. A body of mass m hanging from string is executing oscillations with angular amplitude60°, while other body is at rest on a horizontal surface. The minimum coefficient of friction between mass $4m$ and the horizontal surface is (here pulley is light and smooth)

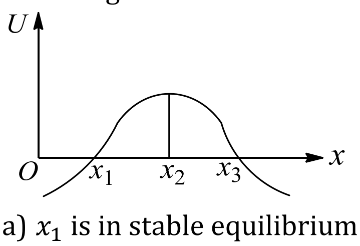


a) $\frac{1}{4}$ b) $\frac{3}{4}$ c) $\frac{1}{2}$ d) $\frac{1}{8}$

108. A particle located in a one-dimensional potential field has its potential energy function as $U(x) = \frac{a}{x^4} - \frac{b}{x^2}$, where a and b are positive constants. The position of equilibrium x corresponds to

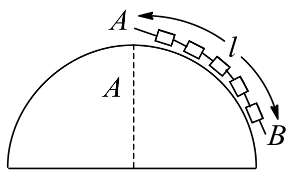
a) $\frac{b}{2a}$ b) $\sqrt{\frac{2a}{b}}$ c) $\sqrt{\frac{2b}{a}}$ d) $\frac{a}{2a}$

109. In figure, the potential energy U of a particle is plotted against its position x from origin. Which of the following statements is correct?



a) x_1 is in stable equilibrium b) x_2 is in stable equilibrium
c) x_3 is in stable equilibrium d) None of these

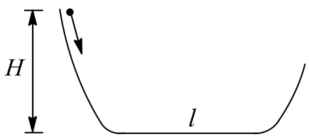
110. A uniform chain AB of mass m and length l is placed with one end A at the highest point of a hemisphere of radius$R$. Referring to the top of the hemisphere as the datum level, the potential energy of the chain is (given that $l < \frac{\pi R}{2}$)



a) $\frac{mR^2g}{l}\left(\frac{l}{R} - \sin\frac{l}{R}\right)$ b) $\frac{mR^2g}{2l}\left(\frac{l}{R} - \sin\frac{l}{R}\right)$ c) $\frac{mR^2g}{2l}\left(\sin\frac{l}{R} - \frac{l}{R}\right)$ d) $\frac{mR^2g}{l}\left(\sin\frac{l}{R} - \frac{l}{R}\right)$

111. A particle of mass m slides along a curved-flat-curved track. The curved portions of the track are smooth. If

the particle is released at the top of one of the curved portions, the particles comes to rest at flat portion of length l and of $\mu = \mu_{\text{kinetic}}$ after covering a distance of

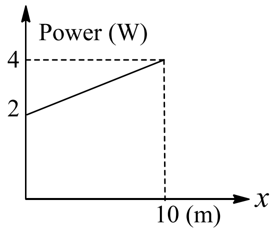


a) $\frac{l}{3\mu}$ b) $\frac{H}{2\mu_{\text{kinetic}}}$ c) $\frac{l}{6}$ d) $\frac{H}{\mu_{\text{kinetic}}}$

112. A man places a chain (of mass m and length$l$) on a table slowly. Initially, the lower end of the chain just touches the table. The man brings down the chain by length$l/2$. Work done by the man in this process is

a) $-mg\frac{l}{2}$ b) $-\frac{mgl}{4}$ c) $\frac{-3mgl}{8}$ d) $-\frac{mgl}{8}$

113. A particle A of mass 10/7 kg is moving in the positive direction of x-axis. At initial position $x = 0$, its velocity is 1 ms^{-1}, then its velocity at $x = 10$ m is (use the graph given)

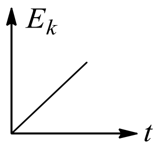


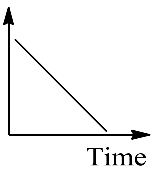
a) 4 ms^{-1} b) 2 ms^{-1} c) $3\sqrt{2}$ ms^{-1} d) $\frac{100}{3}$ ms^{-1}

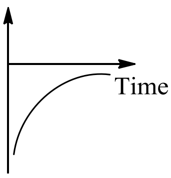
114. A man M_1 of mass 80 kg runs up a staircase in 15 s. Another man M_2 also of mass 80 kg runs up the same staircase in 20 s. The ration of the powers developed by them will be

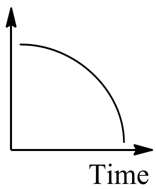
a) 1 b) $\frac{4}{3}$ c) $\frac{16}{9}$ d) None of these

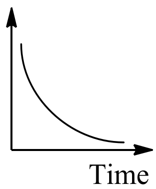
115. The kinetic energy (KE) versus time graph for a particle moving along a straight line is shown in figure. The force versus time graph for the particle may be



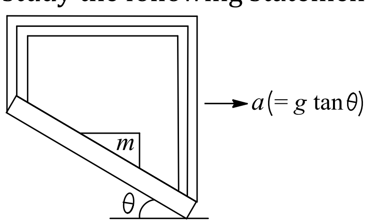
a) 

b) 

c) 

d) 

116. A block m is kept stationary on the surface of an accelerating cage as shown in figure. At the given instant, study the following statements regarding the block



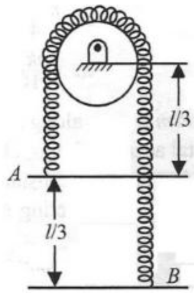
I. Normal reaction performs work on the block
II. Frictional work done on the block is negative
III. No net work is done by normal reaction and friction on the block

Now mark the correct answer

a) Only statement i is correct b) Only statement ii is correct
c) Only statement iii is correct d) All the statements are correct

117. Two ends $A$and B of a smooth chain of mass m and length l are situated as shown in figure. If an external

agent pulls A till it comes to same level of B, work done by external agent is

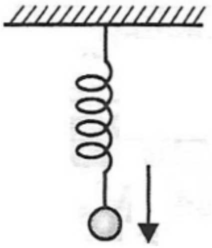


a) $\frac{mgl}{36}$ b) $\frac{mgl}{15}$ c) $\frac{mgl}{9}$ d) None of the above

118. A 40 kg box is pushed along 20 m by two coolies over a railway platform whose coefficient of friction with the box is 0.4. The forces applied by the two coolies are horizontal. If $\mathrm{g} = 10\ \mathrm{ms}^{-2}$, then the work done by the two coolies is

a) +1600 J b) −1600 J c) +3200 J d) −3200 J

119. A Gradually lowered mass stretches a spring by y meter. If same body attached to the same spring is released suddenly, the maximum stretch in this will be



a) Same b) Double c) Triple d) Half

120. A small block of mass 2 kg is kept on a rough inclined surface of inclination $\theta = 30°$ fixed in a lift. The lift goes up with a uniform speed of 1 ms^{-1} and the block does not slide relative to the inclined surface. The work done by the force of friction bon the block in a time interval of 2 s is

a) Zero b) 9.8 J c) 29.4 J d) 16.9 J

121. Two particles A and B are interacting with each other only. Initially, particle A has a speed of 5 ms^{-1} and particle B has a speed of 10 ms^{-1}. In the course of their motion, they return to their initial position. Finally A has a speed of 4 ms^{-1} and B ha speed of 7 ms^{-1}. We can conclude that

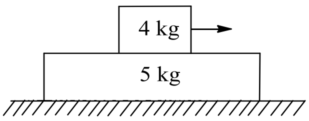
a) The potential energy changed from beginning to the end of trip

b) The mechanical energy was increased by non-conservative forces

c) The mechanical energy was decreased by non-conservative forces

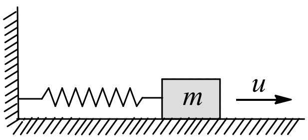
d) None of these

122. A large slab of mass 5 kg lies on a smooth horizontal surface, with a block of mass 4 kg lying on the top of it. The coefficient of friction between the block and the slab is 0.25. If the block is pulled horizontally by a force of $F = 6$ N, the work done by the force of friction on the slab, between the instants $t = 2\mathrm{s}$ and $t = 3a$, is ($\mathrm{g} = 10\ \mathrm{ms}^{-2}$)



a) 2.4 J b) 5.55 J c) 4.44 J d) 10 J

123. A block of mass m has initial velocity u having direction towards $+x$axis. The block stops after covering a distance S causing similar extension in the spring of constant K holding it. If μ is the kinetic friction between the block and the surface on which it was moving, the distance S is given by



a) $\frac{1}{K}\mu^2m^2g^2$

b) $\frac{1}{K}(mKu^2-\mu^2m^2g^2)^{1/2}$

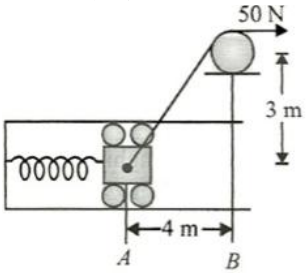
c) $\frac{1}{K}(\mu^2m^2g^2+mKu^2+\mu mg)^{1/2}$

d) $\frac{-\mu mg+\sqrt{\mu^2m^2g^2+mu^2k}}{k}$

124. An electric motor creates a tension of 4500 N in hoisting a cable and reels it at rate of 2 ms^{-1}. The power of the electric motor is

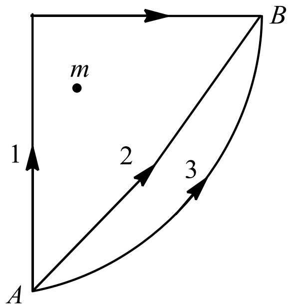
a) 15 kW
b) 9 kW
c) 225 W
d) 9000 H.P.

125. A 20 kg block attached to a spring of spring constant 5 Nm^{-1} is released from rest at A. The spring at this instant is having an elongation of 1 m. The block is allowed to move in smooth horizontal slot with the help of a constant force 50 N in the rope as shown. the velocity of the block as it reaches B is (assume the rope to be light)



a) 4 ms^{-1}
b) 2 ms^{-1}
c) 1 ms^{-1}
d) 3 ms^{-1}

126. 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) $w_2 > w_1 > w_3$

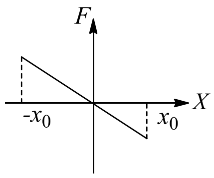
127. The potential energy of particle of mass m free move along the x-axis is given by $U = (1/2)kx^2$ for $x < 0$ and $U = 0$ for $x \geq 0$ (x denotes the x-coordinate of the particle and k is a positive constant). If the total mechanical energy of the particle is E, then its speed at $x = -\sqrt{2E/k}$ is

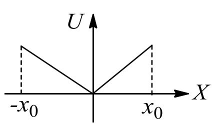
a) Zero
b) $\sqrt{\frac{2E}{m}}$
c) $\sqrt{\frac{E}{m}}$
d) $\sqrt{\frac{3}{2m}}$

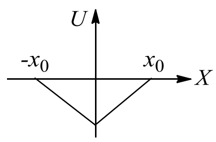
128. In the above question, the average power delivered by gravity is

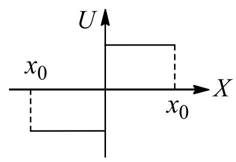
a) $-mg\,u\cos\alpha$
b) $-mgu\sin\alpha$
c) $-\frac{mgu\cos\alpha}{2}$
d) $-\frac{mgu\sin\alpha}{2}$

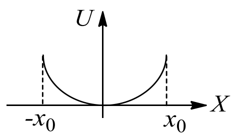
129. Figure shows a plot of the conservative force F in a unidimensional field. The plot representing the function corresponding to the potential energy (U) in the field is



a) 

b) 

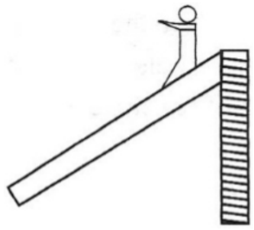
c) 

d) 

130. A 500 kg car, moving with a velocity of 36 kmh^{-1} on a straight road unidirectionally, doubles its velocity in 1 min. The average power delivered by the engine for doubling the velocity is

a) 750 W b) 1050 W c) 1150 W d) 1250 W

131. In a children's park, there is a slide which has a total length of 10 m and a height of 0.8 m. A vertical ladder is attached to the top of the slide. A child of mass 20 kg slides down to the ground. The average friction offered by the slide is three-tenth of his weight. The work done by the slide on the body as he comes down is

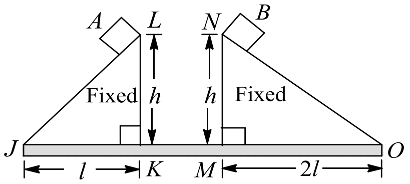


a) 0 J b) +600 J c) −600 J d) +1600 J

132. In the above questions, the work done by frictional force is

a) +1600 J b) −1600 J c) +3200 J d) −3200 J

133. Two identical blocks A and B are placed on two inclined planes as shown in figure. Neglect resistance and other friction



Read the following statements and choose options

Statement I: The kinetic energy of A on sliding to J will be greater than the kinetic energy of B on sliding to O

Statement II: The acceleration of A will be greater than acceleration of B when both are released on the inclined plane

Statement III: The work done by external agent to move the block slowly from position B to O is negative

a) Only statement I is true b) Only statement II is true
c) Only I and III are true d) Only II and III are true

134. A spring is compressed between two toy carts of masses m_1 andm_2. When the toy carts are released, the spring exerts on each toy cart equal and opposite forces for the same small time$t$. If the coefficients of friction μ between the ground and the toy carts are equal, then the magnitude of displacements of the toy carts are in the ration

a) $\frac{s_1}{s_2}=\frac{m_2}{m_1}$ b) $\frac{s_1}{s_2}=\frac{m_1}{m_2}$ c) $\frac{s_1}{s_2}=\left(\frac{m_2}{m_1}\right)^2$ d) $\frac{s_1}{s_2}=\left(\frac{m_1}{m_2}\right)^2$

135. Let r be the distance of a particle from a fixed point to which it is attracted an inverse square law force given by $F=k/r^2$ ($k=$ constant). Let m be the mass of the particle and L be its angular momentum with respect to the fixed point. Which of the following formulae is correct about the total energy of the system

a) $\frac{1}{2}m\left(\frac{dr}{dt}\right)^2-\frac{k}{r}+\frac{L^2}{2mr^2}=$ constant b) $\frac{1}{2}m\left(\frac{dr}{dt}\right)^2-\frac{k}{r}=$ constant
c) $\frac{1}{2}m\left(\frac{dr}{dt}\right)^2+\frac{k}{r}+\frac{L^2}{2mr^2}=$ constant d) None

136. Two trucks A and$B$, one loaded and the other unloaded, are moving and have same kinetic energy. The mass of A is double that of$B$. Brakes (providing same retarding force) are applied to both and are brought to rest. If the distance converted by A before coming to rest is s_1 and that of B is s_2, then

a) $s_1=s_2$ b) $s_1=2s_2$ c) $2s_1=s_2$ d) $s_1=4s_2$

137. A force $\boldsymbol{F}=-K(y\boldsymbol{i}+x\boldsymbol{j})$ (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 F on the particles is

a) $-2\,Ka^2$ b) $2Ka^2$ c) $-Ka^2$ d) Ka^2

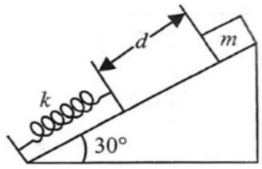
138. A lorry and a car moving with the same K.E. are brought to rest by applying the same retarding force, then
a) Lorry will come to rest in a shorter distance
b) Car will come to rest in a shorter distance
c) Both come to rest in a same distance
d) None of the above

139. The energy required to accelerate a car from rest to 10 ms^{-1} is E. What energy will be required to accelerate the car from 10 ms^{-1} to 20 ms^{-1}?
a) E
b) $3E$
c) $5E$
d) $7E$

140. A particle is projected with a velocity u making an angle θ with the horizontal. The instantaneous power of the gravitational force
a) Varies linearly with time
b) Is constant throughout
c) Is negative for complete path
d) None of these

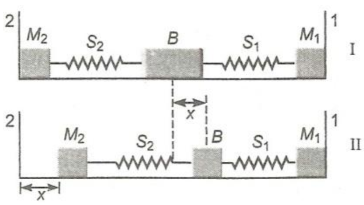
141. The potential energy function associated with the force $\vec{F} = 4xy\hat{\imath} + 2x^2\hat{\jmath}$ is
a) $U = -2x^2y$
b) $U = -2x^2y + \text{constant}$
c) $U = 2x^2y + \text{constant}$
d) No defined

142. A block of 4 kg mass starts at rest and slides a distance d down a friction less incline (angle30°) where it runs into a spring of negligible mass. The block slides an additional 25 cm before it is brought to rest momentarily by compressing the spring. The force constant of the spring is400 Nm^{-1}. The value of d is (take g = 10 ms^{-1})



a) 25 cm b) 37.5 cm c) 62.5 cm d) None of the above

143. A block(B) is attached to two unstretched springs $S_1$and S_2 with springs constants k and $4k$,representively (see Fig. I)The other ends are attached to identical 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 I by small distance x(Fig II) 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) $\frac{1}{4}$

144. When a person stands on a weighing balance, working on the principle of Hooke's law, it shows a reading of 60 kg after a long time and the spring gets compressed by 2.5 cm. If the person jumps on the balance from a height of 10 cm, the maximum reading of the balance will be
a) 60 kg
b) 120 kg
c) 180 kg
d) 240 kg

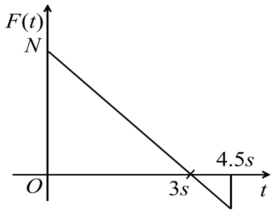
145. The potential energy for a force field $\vec{F}$ is given by$U(x, y) = \cos(x + y)$. The force acting on a particle at position given by coordinates $(0, \pi/4)$ is

a) $-\frac{1}{\sqrt{2}}(\hat{\imath}+\hat{\jmath})$ b) $-\frac{1}{\sqrt{2}}(\hat{\imath}+\hat{\jmath})$ c) $\left(\frac{1}{2}\hat{\imath}+\frac{\sqrt{3}}{2}\hat{\jmath}\right)$ d) $\left(\frac{1}{2}\hat{\imath}-\frac{\sqrt{3}}{2}\hat{\jmath}\right)$

146. A person of mass 70 kg jumps from a stationary helicopter with the parachute open. As he falls through 50 m height, he gains a speed of 20 ms^{-1}. The work done by the viscous air drag is

a) 21000 J b) −21000 J c) −14000 J d) 14000 J

147. 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 seconds is



a) 4.50 J b) 7.50 J c) 5.06 J d) 14.06 J

148. A force of $\vec{F} = 2x\hat{\imath} + 2\hat{\jmath} + 3z^2\hat{k}$ N is acting on particle. Find the work done by this force in displacement the body from (1, 2, 3) m to (3, 6, 1) m

a) −10 J b) 100 J c) 10 J d) 1 J

149. A particle of mass m moves along a circular path a radius r with a centripetal acceleration a_n changing with time t as$a_n = kt^2$, where k is a positive constant. The average power developed by all the forces acting on the particle during the first t_0 seconds is

a) $mkrt_0$ b) $\frac{mkrt_0^2}{2}$ c) $\frac{mkrt_0}{3}$ d) $\frac{mkrt_0}{4}$

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

a) 8 J b) 9 J c) 7 J d) 0.48 J

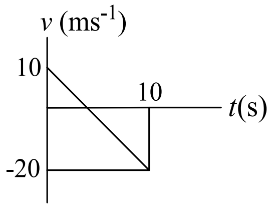
151. Power supplied to a particle of mass 2 kg varies with time as $P = 3t^2/2$ W. Here t is in second. If the velocity of particle at $t = 0$ is $v = 0$, the velocity of particle at time $t = 2$ s will be

a) 1 ms^{-1} b) 4 ms^{-1} c) 2 ms^{-1} d) $2\sqrt{2}$ ms^{-1}

152. The speed v reached by a car of mass m in travelling a distance x, driven with constant power P, is given by

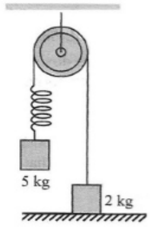
a) $v = \frac{3x\,P}{m}$ b) $v = \left(\frac{3xP}{m}\right)^{1/2}$ c) $v = \left(\frac{3x\,P}{m}\right)^{1/3}$ d) $v = \left(\frac{3x\,P}{m}\right)^{2}$

153. The velocity-time graph of a particle moving in a straight line is shown in figure. Mass of the particle is 2 kg. work done by all the forces acting on the particle in time interval between $t = 0$ to $t = 10$ s is



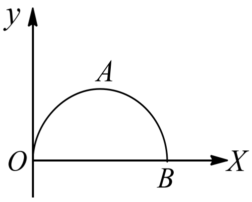
a) 300 J b) −300 J c) 400 J d) −400 J

154. The system shown in figure is released from rest with mass 2 kg in contact with the ground. Pulley and spring are mass less, and friction is absent everywhere. The speed of 5 kg block when 2 kg block leaves the contact with the ground is (force constant of the spring $k = 40$ Nm^{-1} and g = 10 ms^{-2})



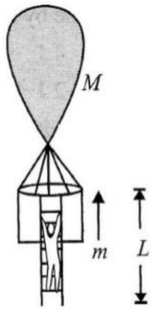
a) $\sqrt{2}\ \text{ms}^{-1}$ b) $2\sqrt{2}\ \text{ms}^{-1}$ c) $2\ \text{ms}^{-1}$ d) $\sqrt{2}\ \text{ms}^{-1}$

155. Given $\vec{F} = (xy^2)\hat{\imath} + (x^2y)\hat{\jmath}$ N. The work done by $\vec{F}$ when a particle is taken alonf the semicircular path OAB where the coordinates of B are (4, 0) is



a) $\frac{65}{3}$J b) $\frac{75}{2}$J c) $\frac{73}{4}$J d) Zero

156. A rope ladder of length L is attached to a balloon of mass$M$. As the man of mass m climbs the ladder into the balloon basket, the balloon comes down by a vertical distance$s$. Then the increase in potential energy of man divided by the increase in potential energy of balloon is



a) $\frac{L-s}{s}$ b) $\frac{L}{s}$ c) $\frac{s}{L-s}$ d) $L-s$

157. An object of mass m slides down a hill of orbitrary shape and after travelling a certain horizontal path stops because of friction. The total vertical height descended is$h$. 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 tangential force must perform to return the object to its initial position along the same path is

a) mgh b) $-mgh$ c) $-2mgh$ d) $2mgh$

Multiple Correct Answers Type

158. A man of mass m is standing on a stationary flat car of mass$M$. The car can move without friction along horizontal rails. The man starts walking with velocity v relative to the car. Work done by him

a) Is greater than $\frac{1}{2}\ mv^2$ if he walks along rails

b) Is less than $\frac{1}{2}\ mv^2$ if he walks along rails

c) In equal to $\frac{1}{2}mv^2$ if he walks normal to rails

d) Can never be less than $\frac{1}{2}mv^2$

159. Choose the correct statement(s) from the following

a) Force acting on a particle for equal time intervals can produce the same change in momentum but different change in kinetic energy

b) Force acting on a particle for equal displacements can produce the same change in kinetic energy but different change in momentum

c) Force acting on a particle for equal time intervals can produce different change in momentum but same change in kinetic energy

d) Force acting on a particle for equal displacement can produce different change in kinetic energy but same change in momentum

160. A simple pendulum of length L and mass (bob) M is oscillating in a plane about a vertical line between angular limit $-\phi$ and $+\phi$. For an angular displacement $\theta(|\theta| < \phi)$, the tension in the string and the velocity of then bob are T and V, respectively. The following relations hold good under the above conditions:

a) $T\cos\theta = M\text{g}$ b) $T - M\text{g}\cos\theta = \frac{MV^2}{L}$

c) The magnitude of the tangential acceleration of the bob $a_T = \text{g}\sin\theta$ d) $T = M\text{g}\cos\theta$

161. 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) $6k$

162. 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 are the work done by non-conservative and conservative forces present in the system, respectively, ΔU is the change in potential energy and 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) $W_{nc} - \Delta U = -\Delta k$

163. 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 advantages and efficiency increase

d) Its efficiency increases, but its mechanical advantage decreases

164. Mark the correct statement(s)

a) The work-energy theorem is valid only for particles

b) The work-energy theorem is an invariant law of physics

c) The work-energy theorem is valid only in inertial frames of reference

d) The work-energy theorem can be applied in non-inertial frames of reference too

165. The kinetic energy of a particle continuously increases with time. Then

a) The resultant force on the particle must be parallel to the velocity at all instants

b) The resultant force on the particle must be at an angle less than 90° with velocity all the times

c) Its height above the ground level must continuously decrease

d) The magnitude of its linear momentum is increasing continuously

166. 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 its lowest position, and has in speed u. The magnitude of the change in its velocity as it reaches a position where the string is horizontal is

a) $\sqrt{u^2 - 2hL}$ b) $\sqrt{2\text{g}L}$ c) $\sqrt{u^2 - \text{g}L}$ d) $\sqrt{2(u^2 - \text{g}L)}$

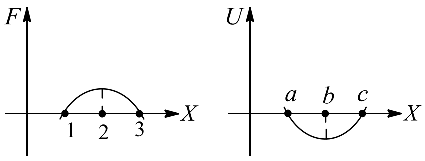
167. Work done by the force of friction

a) Can be positive b) Can be negative c) Can be zero d) Any of these

168. Tow masses of 1 g and 4 g are moving with equal kinetic energies. The ratio of the magnitudes of their momenta is

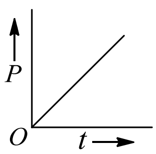
a) 4:1 b) $\sqrt{2}:1$ c) 1:2 d) 1:16

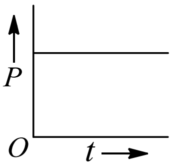
169. Referring the graphs, which of the flowing is/re correct?

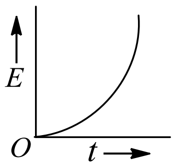


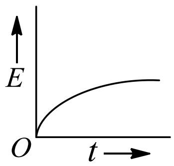
a) The particle has stable equilibrium at points 3 and b
b) The particle is in neutral equilibrium at points b and 2
c) No power is delivered by the force on the particle at points 1, 3 and b
d) The particle has least kinetic energy at position 1

170. A vehicle is driven along a straight horizontal track by a motor which exerts a constant driving force. The vehicle starts from rest at $t = 0$ and the effects of friction and air resistance are negligible. If the kinetic energy of the vehicle at time t is E and power developed by the motor is$P$, which of the following graphs are correct?

a) 

b) 

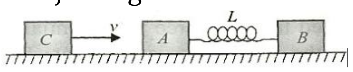
c) 

d) 

171. A ball hits the floor and rebounds after an inelastic collision. In this case
a) The momentum of the ball just after the collision is the same as that just before the collision
b) The mechanical energy of the ball remains the same in the collision
c) The total momentum of the ball and the earth is conserved
d) The total energy of the ball and the earth is conserved

172. Which one of the following statement does not hold good when two balls of masses m_1 and m_2 undergo elastic collision
a) When $m_1 << m_2$ and m_2 at rest, there will be maximum transfer of momentum
b) When $m_1 >> m_2$ and m_2 at rest, after collision the ball of mass m_2 moves with four times the velocity of m_1
c) When $m_1 = m_2$ and m_2 at rest, there will be maximum transfer of K.E.
d) When collision is oblique and m_2 at rest with $m_1 = m_2$ after collision the balls move in opposite directions

173. Two blocks Aa and B, each mass m, are connected by a mass less spring of nutural length L and spring constant k. The blocks are initially resting on a smooth horizontal floor with the spring at its natural length as shown in figure. A third identical block C, also of mass m moves on the floor with a speed v alojng the line joining A and B and collides with A, then



a) The KE of Ab system a maximum compression of the spring is zero
b) The KE of the AB system at maximum compression of the spring is $(1/4)mv^2$
c) The maximum compression of the spring is $v\sqrt{\frac{m}{k}}$
d) The maximum compression of the spring is $v\sqrt{\frac{m}{2k}}$

174. Two balls, having linear momenta $\vec{p}_1 = p\hat{\imath}$ and $\vec{p}_2 = -p\hat{\imath}$, undergo a collision in a free space. There is no external force acting on the balls. Let $\vec{p}_1$ and $\vec{p}_2$ be their final momenta. The following option(s) is (are) NOT ALLOWED for any non-zero value of $p, a_1, a_2, b_1, b_2, c_1$ and c_2
a) $\vec{p}_1 = a_1\hat{\imath} + b_1\hat{\jmath} + c_1\hat{k}, \vec{p}_2 = a_2\hat{\imath} + b_2\hat{\jmath}$
b) $\vec{p}_1 = c_1\hat{k}, \vec{p}_2 = c_2\hat{k}$
c) $\vec{p}_1 = a_1\hat{\imath} + b_1\hat{\jmath} + c_1\hat{k}, \overline{p}_2 = a_2\hat{\imath} + b_2\hat{\jmath} - c_2\hat{k}$
d) $\vec{p}_1 = a_1\hat{\imath} + b_1\hat{\jmath}, \overline{p}_2 = a_2\hat{\imath} + b_1\hat{\jmath}$

175. A block is suspended by an ideal spring of force constant$k$. If the block is pulled down by applying a constant force F and if maximum displacement of the block from its initial position of rest is δ, then
a) $\frac{F}{k} < \delta > \frac{2F}{k}$
b) $\delta = \frac{2F}{k}$

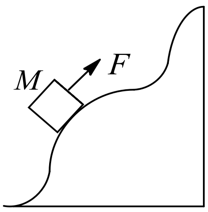
c) Work done by force F is equal to $F\delta$
d) Increase in energy stored in the spring is $\frac{1}{2}k\delta^2$

176. Work done by force of friction
a) Can be zero
b) Can be positive
c) Can be negative
d) Any of these

177. A particle is acted upon by a force of constant magnitude which I always perpendicular to the velocity of the particle. The motion of the particle4 takes place in a plane. It follows that
a) Its velocity is constant
b) Its acceleration is constant
c) Its kinetic energy is constant
d) It moves in a circular path

178. A particle of mass m is moving in a circular path of constant radius r such that its centripetal acceleration a_c varies with time t as $a_c = k^2rt^2$, where k is a constant. The power delivered to the particles by the force acting on it is
a) $2\pi mk^2r^2t$
b) mk^2r^2t
c) $\frac{(mk^2r^2t5)}{3}$
d) Zero

179. A body of mass M was slowly hauled up a rough hill by a force F which at each point was directed along a tangent to the hill. Work done by the force



a) Is independent of the shape of trajectory
b) Depends upon the vertical component of displacement but is independent of horizontal component
c) Depends upon both the components
d) Does not depend upon the coefficient of friction

180. A charged particle X moves directly towards another changed particle Y. For the 'X' plus Y' system, the total momentum is p and the total energy is E
a) p and E are conserved if both X and Y are free to move
b) (a)is true only if X and Y have similar changes
c) If Y is fixed, E is conserved but not P
d) If Y is fixed, neither E nor P is conserved

181. For an isolated system in the absence of any dissipative effect
a) KE is conserved
b) PE is conserved
c) Energy is conserved
d) ME is conserved

182. If force is always perpendicular to motion
a) KE remains constant
b) Work done $= 0$
c) Speed is constant
d) Velocity is constant

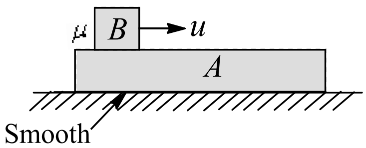
183. In case of explosion of a bomb, which of the following change?
a) Kinetic energy
b) Mechanical energy
c) Chemical energy
d) Energy

184. A body is moved along a straight line by a machine delivering constant power. The distance moved by the body in time t ism proportional to
a) $t^{1/2}$
b) $t^{3/4}$
c) $t^{3/2}$
d) t^2

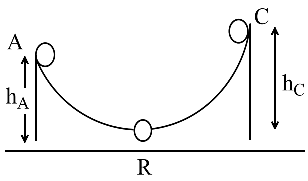
185. The potential energyφ, in joule, of particle of mass 1 kg, moving in the $x - y$ plane, obeys the law$\varphi = 3x + 4y$, where (x, y) are the coordinates of the particle in meter. If the particle is at rest at (6, 4) at time $t = 0$, then
a) The particle has constant acceleration
b) The work done by the external forces, the position of rest of the particle and the instant of the particle crossing the x-axis is 25 J
c) The speed of the particle when it crosses the y-axis is 10 ms^{-1}
d) The coordinate of the particle at time $t = 4$ s are $(-18, -28)$

186. When work done by force gravity is negative,
a) PE increases
b) KE may or may not change
c) PE remains constant
d) KE must change

187. A block hangs freely from the end of a spring. A boy then slowly pushes the block upwards so that the spring becomes strain free. The gain in gravitational potential energy of the block during this process is not equal to
a) The work done by the boy against the gravitational force acting on the block
b) The loss of energy stored in the spring minus the work done by the tension in the spring
c) The work done on the block by the boy plus the loss of energy stored in the spring
d) The work done on the block by the boy minus the work done by the tension in the spring plus the loss of energy stored in the spring
188. When work done by a particle is positive
a) KE remains constant b) Momentum increases c) KE decreases d) KE increases
189. In which of the following cases no work is done by the force?
a) A man carrying a bucket of water, walking on a level road with a uniform velocity
b) A drop of rain falling vertically with a constant velocity
c) A man whirling a stone tied to a string in a circle with a constant speed
d) A man walking upon a staircase
190. A point mass of 1 kg collides with a stationary point mass of 5 kg. After their collision, the 1 kg mass reverses its direction and moves with a speed of $2ms^{-1}$. Which of the following statement(s) is (are) correct for the system of these two masses
a) Total momentum of the system is 3 $kg\ ms^{-1}$
b) Momentum of 5 kg mass after collision is 4 $kg\ ms^{-1}$
c) Kinetic energy of the centre of mass is 0.75 J
d) Total kinetic energy of the system is 4 J
191. A force $F = -K(y\hat{i} + x\hat{j})$ (where K is positive constant) acts on a particle moving in the $x - y$ plane. Starting from the origin, the particle is taken along the positive x-axis to the point $(a, 0)$, and then parallel to the y-axis to the point (a, a). The total work done by the force F on the particle is
a) $-Ka^2$ b) $2Ka^2$ c) $-Ka^2$ d) Ka^2
192. A long block A is at rest on a smooth horizontal surface. A small block B whose amss is half of mass of A I splaced on A at one end and is given an initial velocity u as shown. The coefficient of friction between the blocks is μ



a) Finally both move with a common velocity $2u/3$
b) Acceleration of B relative to A initally is $3\mu g/2$ towards left
c) Magnitude of total work done by friction is equal to final kinetic energy of the system
d) The ratio of initial to final momentum of the system is 1
193. A wind-powered generator converts wind energy into electrical energy. Assume that the generator converts a fixed 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
194. Mark the correct statement(s)
a) Total work done by internal forces of a system on the system is always zero
b) Total work done by internal forces of a system on the system is sometimes zero
c) Total work done by internal forces acting between the particles of a rigid body is always zero
d) Total work done by internal forces acting between the particles of a rigid body is sometimes zero
195. A ball moves over a fixed track as shown in the figure. From A to B the ball rolls without slipping. Surface BC is frictionless. K_A, K_B and K_C are kinetic energies of the ball at A, B and C, respectively, Then



a) $h_A > h_C : K_B > K_C$ b) $h_A > h_C : K_C > K_A$ c) $h_A = h_C : K_B = K_C$ d) $h_A < h_C : K_A > K_C$

196. A body of mass 1 kg is taken infinity to a point$P$. When the body reaches that point, it has a speed of2 ms^{-1}. The work done by the conservative force is -5 J. Which of the following is true (assuming non-conservative and pseudo-forces to be absent)

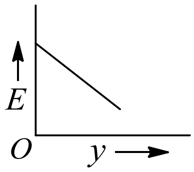
a) Work done by the applied force is $+7$ J

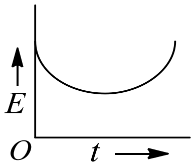
b) The total energy possessed by the body at P is $+7$ J

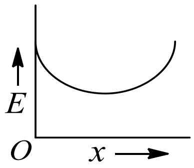
c) The potential energy possessed by the body is P is $+5$ J

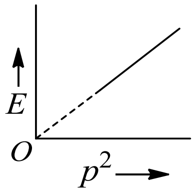
d) Work done by all forces together is equal to the change in kinetic energy

197. A particle is projected from a point at an angle with the horizontal at $t = 0$. At an instant$t$, if p is linear momentum, x is horizontal displacement, y is vertical displacement, and E is kinetic energy of the particle, then which of the following graphs are correct?

a) 

b) 

c) 

d) 

198. 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

199. Which of the following statements is/are correct about work?

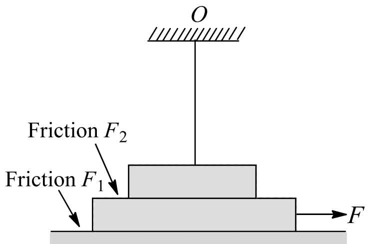
a) In a certain reference frame $W_{\text{pseudo force}} + W_{\text{conservation force}} + W_{\text{non-conservation force}} + W_{\text{other forces}} = \Delta K$

b) Work done by friction is always negative

c) Work done by a force is defined as the dot product of the force and the displacement of the point of application of force

d) Work done by conservative force in moving a body from A to B = potential energy of the body at A − potential energy of the body at B

200. A horizontal plane supports a plank with a block placed on it. A light elastic string is attached to the block, which is attached to a fixed point$O$. Initially, the cord is unstretched and vertical. The plank is slowly shifted to right until the block starts sliding over it. It occurs at the moment when the cord deviates from vertical by an angle$\theta = 0°$. Work done by the force F equals



a) Energy lost against friction F_1 plus strain energy in cord

b) Work done against total friction acting on the plank alone

c) Work done against total friction acting on the plank plus strain energy in the cord

d) Work done against total friction acting on the plank plus strain energy in the cord minus work done by friction acting on the block

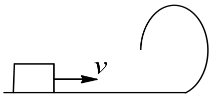
201. When a bullet is fired from a gun
a) The kinetic energy of the bullet is more that of the gun
b) The acceleration of the bullet is more than that of the gun
c) The momentum of the bullet is more than that of the gun
d) The velocity of the bullet is more than that of the gun

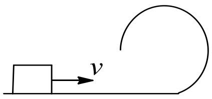
202. Select the correct option (s)
a) A single external force acting on a particle necessarily changes its momentum and kinetic energy
b) A single external force acting on a particle necessarily changes its momentum
c) The work-energy theorem is valid for all types of forces: internal, external, conservative as well as non-conservative
d) The kinetic energy of the system can be increased without applying any external force on the system

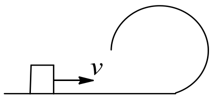
203. Internal forces can change
a) Kinetic energy b) Mechanical energy c) Energy d) Momentum

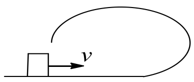
204. No work is done by a force on an object if
a) The force is always perpendicular to its velocity
b) The force is always perpendicular to its acceleration
c) The object is stationary but the point of applicable of the force moves
d) The object moves in such a way that the point of application of the force remains fixed

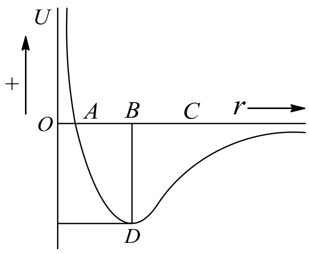
205. Which of the following is/are conservative force(s)?
a) $\vec{F} = 2r^3\vec{r}$ b) $\vec{F} = -\frac{5}{r}\hat{r}$
c) $\vec{F} = \frac{3(x\hat{\imath} - y\hat{\jmath})}{(x^2+y^2)^{3/2}}$ d) $\vec{F} = \frac{(3y\hat{\imath} + x\hat{\jmath})}{(x^2+y^2)^{3/2}}$

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

b) 

c) 

d) 

207. The potential energy curve for interaction between two molecules is shown in figure. Which of the following statements are true?


a) The molecules have maximum attraction for $r = OA$
b) The molecules have maximum kinetic energy for $r = OB$
c) The intermolecular force is zero for $r = OB$
d) For the gaseous state, the depth BD of the potential energy curve is much smaller than KT

208. One of the forces acting on a particle is conservative, then
a) Its work is zero when the particle moves exactly once around any closed path
b) Its work equals the change in the kinetic energy of the particle
c) It doesn't obey Newton's second law
d) Its work depends on the end points of the motion, not on the path in between

209. When two blocks connected by a spring move towards each other under mutual interaction,
a) Their velocities are equal and opposite
b) Their accelerations are equal and opposite
c) The forces acting on them are and opposite
d) Their momenta are equal and opposite

210. A set of n identical cubical blocks lies at rest parallel to each other along a line on a smooth horizontal surface. The separation between the near surfaces of any two adjacent blocks is L. The block at one end is given a speed v towards the next one at time $t = 0$. All collisions are completely inelastic, then

a) The last block starts moving at $t = \frac{(n-1)L}{v}$

b) The last block starts moving at $t = \frac{n(n-1)L}{2v}$

c) The centre of mass of the system will have a final speed v

d) The centre of mass of the system will have a final speed $\frac{v}{n}$

211. Which of the following can be negative?

a) KE b) PE c) Mechanical energy d) Energy

Assertion - Reasoning Type

This section contain(s) 0 questions numbered 212 to 211. Each question contains STATEMENT 1(Assertion) and STATEMENT 2(Reason). Each question has the 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

a) Statement 1 is True, Statement 2 is True; Statement 2 **is** correct explanation for Statement 1

b) Statement 1 is True, Statement 2 is True; Statement 2 **is not** correct explanation for Statement 1

c) Statement 1 is True, Statement 2 is False

d) Statement 1 is False, Statement 2 is True

212

Statement 1: If two protons are brought near one another, the potential energy of the system will increase

Statement 2: The change on the proton is $+1.6 \times 10^{-19} C$

213

Statement 1: Stopping distance $= \frac{\text{Kinetic energy}}{\text{Stopping force}}$

Statement 2: Work done in stopping a body is equal to KE of the body

214

Statement 1: Work done by friction on a body sliding down an inclined plane is positive

Statement 2: Work done is greater than zero, if angle between force and displacement is acute or both are in same direction

215

Statement 1: A spring has potential energy, both when it is compressed or stretched

Statement 2: In compressing or stretching, work is done on the spring against the restoring force

216

Statement 1: If a particle of mass m is connected to a light rod and whirled is a vertical circle of radius R, then to complete the circle, the minimum velocity of the particle at the bottom point is $\sqrt{5gR}$

Statement 2: Mechanical energy is conserved and in case of the minimum velocity at the bottom point, the velocity at the top point will be zero

217

Statement 1: Comets move around the sun in elliptical orbits. The gravitational force on the comet due to sun is not normal to the comet's velocity but the work done by the gravitational force over every complete orbit of the comet is zero

Statement 2: Gravitational force is a non conservative force

218

Statement 1: Work done in moving a body over a closed loop is zero for every force in nature

Statement 2: Work done does not depend on nature of force

219

Statement 1: In a circular motion, work done by centripetal force is not zero always

Statement 2: If the speed of a particle increases or decreases in circular motion, net force acting on the particle does not remain towards centre

220

Statement 1: According to law of conservation of mechanical energy change in potential energy is equal and opposite to the change in kinetic energy.

Statement 2: Mechanical energy is not conserved.

221

Statement 1: When two moving bodies collide, their temperatures rise.

Statement 2: The potential energy of the colliding bodies converts into heat energy.

222

Statement 1: Two springs of force constants k_1 and k_2 are stretched by the same force. If $k_1 > k_2$, then work done in stretching the first (W_1) is less than work done in stretching the second (W_2)

Statement 2: $F = k_1x_1 = k_2x_2 \therefore \frac{x_1}{x_2} = \frac{k_2}{k_1} \frac{W_1}{W_2} = \frac{\frac{1}{2}k_1x_1^2}{\frac{1}{2}k_2x_2^2} = \frac{k_1}{k_2}\left(\frac{k_2}{k_1}\right)^2 = \frac{k_2}{k_1}$ As $k_1 > k_2, W_1 < W_2$

223

Statement 1: Kinetic energy of a body is quadrupled, when its velocity is doubled

Statement 2: Kinetic energy is proportional to square of velocity

224

Statement 1: A spring has potential energy, Whether it is compressed or stretched.

Statement 2: In compressing or stretching work is done on the spring against the restoring force.

225

Statement 1: The internal potential energy of a certain amount of liquid when spread out in a thin layer is more than that of the same amount of liquid in the shape of a sphere

Statement 2: The potential energy decreases on account of decreased intermolecular distance

226

Statement 1: Mass and energy are not conserved separately, but are conserved as a single identity called mass energy.

Statement 2: This is because one can be obtained at the cost of the other as per Einstein equation, $E=mc^2$.

227

Statement 1: According to law of conservation of mechanical energy change in potential energy is equal and opposite to the change in kinetic energy

Statement 2: Mechanical energy is not a conserved quantity

228

Statement 1: Work done by friction depends upon displacement of the body

Statement 2: Frictional force is non-conservative

229

Statement 1: When the force retards the motion of a body, the work done is zero

Statement 2: Work done depends on angle between force and displacement

230

Statement 1: A weight lifter does not work in holding the weight up

Statement 2: Work done is zero because distance moved is zero

231

Statement 1: In an elastic collision of two bodies, the momentum and energy of each body is conserved

Statement 2: If two bodies stick to each other, after colliding, the collision is said to be perfectly elastic

232

Statement 1: A body is connected to a straight and if it just complete 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 the particle is non-zero

233

Statement 1: Wire through which current flows gets heated

Statement 2: When current is drawn from a cell, chemical energy is converted into heat energy

234

Statement 1: Power developed in circular motion is always zero

Statement 2: Work done in case of circular motion is zero

235

Statement 1: The changes in the kinetic energy of a particle is equal to the work done on it by the net force

Statement 2: The change in kinetic energy is equal to the work done only in case of a system of one particle

236

Statement 1: Power of machine gun is determined by both, the number of bullet fired per second and kinetic energy of bullets

Statement 2: Power of any machine is defined as work done (by it) per unit time

237

Statement 1: Work is always same in all the reference frames as it is an invariant physical quantity

Statement 2: Work is a dot product of force and displacement and, therefore, work is variant because force and displacement are dependent on frames of reference

238

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

239

Statement 1: The change in kinetic energy of a particle is equal to the work done on it by the net force

Statement 2: Change in kinetic energy of particle is equal to the work done only in case of a system of one particle

240

Statement 1: The kinetic energy of a system can be increased without applying any external force on the system

Statement 2: Single external force acting on a particle necessarily changes its kinetic energy

241

Statement 1: Energy released when a mass of one microgram disappears in a process is 9×10^7 J

Statement 2: It follows from $E = \frac{1}{2}mv^2$

242

Statement 1: Mass and energy are not conserved separately, but are conserved as a single entity called mass-energy

Statement 2: Mass and energy conservation can be obtained by Einstein equation for energy

243

Statement 1: Two particles moving in the same direction do not lose all their energy in a completely inelastic collision

Statement 2: Principle of conservation of momentum holds true for all kinds of collisions

244

Statement 1: A car and a heavy lorry moving on a road have same speed. Same braking force is applied and both stop in same distance

Statement 2: Same fore will cause different retardation in two vehicles

245

Statement 1: When a gas is allowed to expand, work done by gas is positive

Statement 2: Force due to gaseous pressure and displacement (of piston) are in the same direction

246

Statement 1: The work done by a conservative force during a round trip is always zero

Statement 2: No force is required to move a body in its round trip

247

Statement 1: A heavy weight is suspended from a string. A person raises the weight slowly till the spring becomes slack. The work done by the person in$W$. The energy stored on the stretched spring was$E$. The gain in gravitational potential energy is $(W + E)$

Statement 2: The work done by the spring force is always negative

248

Statement 1: A quick collision between two bodies is more violent than slow collision, even when initial and final velocities are identical

Statement 2: The rate of change of momentum determines that force is small or large

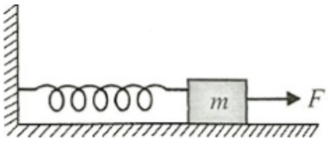
249

Statement 1: Mass and energy are not conserved separately, but are conserved as a single entity called 'mass-energy'

Statement 2: This is because one can be obtained at the cost of the other as per Einstein equation. $E = mc^2$

250

Statement 1: One end of an ideal mass less spring is connected to a fixed vertical wall and the other end has a block of mass m initially at rest on a smooth horizontal surface. The spring is initially in natural length. Now a horizontal force F acts on the block as shown. Then the maximum extension in spring is equal to the maximum compression in the spring



Statement 2: To compress and to expand an ideal un stretched spring by equal amount, same work is to be done on the spring

251

Statement 1: In an elastic collision between two bodies, the relative speed of the bodies after collision is equal to the relative speed before the collision

Statement 2: In an elastic collision, the linear momentum of the system is conserved

252

Statement 1: Mountain roads rarely go straight up the slope

Statement 2: Slope of mountains are large therefore more chances of vehicle to slip from roads

253

Statement 1: If a light body and heavy body have equal kinetic energies, momentum is greater for the heavy body.

Statement 2: If a light body and heavy body have same momentum, the light body will possess more kinetic energy.

254

Statement 1: The rate of change of total momentum of a many particle system is proportional to the sum of the internal forces of the system

Statement 2: Internal forces can change the kinetic energy but not the momentum of the system

255

Statement 1: If a spring is compressed, energy is stored in a spring and when it is elongated, energy is released

Statement 2: The energy stored in a spring is proportional to the square of linear deformation of spring

256

Statement 1: Heavy water is used as moderator in nuclear reactor

Statement 2: Water cools down the fast neutrons

257

Statement 1: A light body and heavy body have same momentum. Then they also have same kinetic energy

Statement 2: Kinetic energy does not depend on mass of the body

258

Statement 1: Graph between potential energy of a spring versus the extension or compression of the spring is a straight line

Statement 2: Potential energy of a stretched or compressed spring, proportional to square of extension or compression

259

Statement 1: Work done by or against gravitational force in moving a body from one point to another is independent of the actual path followed between the two points

Statement 2: Gravitational forces are conservative forces

260

Statement 1: In case of bullet fired from gun, the ratio of kinetic energy of gun and bullet is equal to ratio of mass of bullet and gun

Statement 2: In firing, momentum is conserved

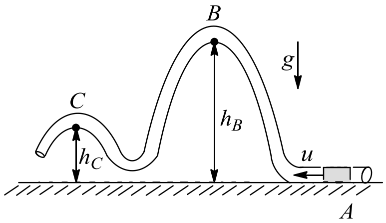
261

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 titled 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

262

Statement 1: A small block of mass m is projected with some speed from point A on a smooth vertical tube track of small diameter as shown in figure. The vertical heights of points B and C from point of projection are h_B and h_C such that $h_B = 2h$ and $h_C = h$. Then the minimum possible speed of the block at point C is $\sqrt{2gh}$ (where g is acceleration due to gravity)

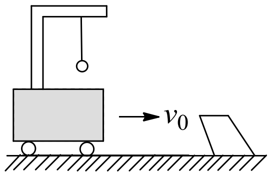


Statement 2: The minimum speed of the block at point C in situation given in Statement I depends on $h_B - h_C$

Matrix-Match Type

This section contain(s) 0 question(s). Each question contains Statements given in 2 columns which have to be matched. Statements (A, B, C, D) in **columns I** have to be matched with Statements (p, q, r, s) in **columns II.**

263. 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 speedv_0. The vehicle is suddenly stopped by a bumper and the bob on the rope swings out a maximum angle of60°. Match the following



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

CODES :

	A	**B**	**C**	**D**
a)	b	d	a	c
b)	d	a	c	b
c)	a	c	b	d
d)	c	b	d	a

264. When a body is moving vertically up with constant velocity, then match the following

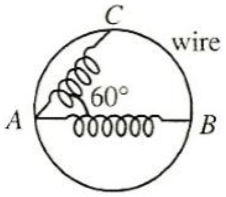
	Column-I		Column- II
(A)	Work done by lifting force is	(p)	Negative
(B)	Total work done by all the forces is	(q)	Positive

(C)	Work done by gravity	(r)	Zero
(D)	Work done by lifting force + work done by gravity force	(s)	Highest positive values

CODES :

	A	**B**	**C**	**D**
a)	a	c	d	b
b)	b	c	a	c
c)	a	c	a	c
d)	b	a	d	a

265. A small ring of mass m passes through a smooth wire bent in the form of a horizontal circle. The ring is connected to a spring whose other end is fixed at A on the wire as in figure



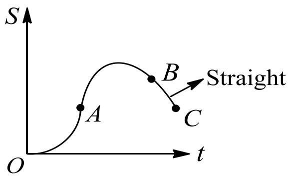
The natural length of the spring is R and the spring constant is mg/R, where m is the mass of the ring and R is the radius of the circle. Initially, the ring is released from rest from position B and it moves towards C as shown in figure. (N is the Normal reaction between wire and ring, V is the speed f the ring). Match the following

	Column-I		**Column- II**
(A)	$N = mg$	(p)	At position B
(B)	$N = 0$	(q)	At position C
(C)	$N = \sqrt{2}\, mg$	(r)	Somewhere between position B and position C
(D)	$v = \sqrt{gR}$	(s)	Never

CODES :

	A	**B**	**C**	**D**
a)	b	a,b	c	d
b)	a,b	c	d	b
c)	c	d	b	a,b
d)	d	b	a,b	c

266. The displacement-time graph of a body acted upon by some forces is shown in figure. For this situation, match the entries of Column I with the enteries of Column II

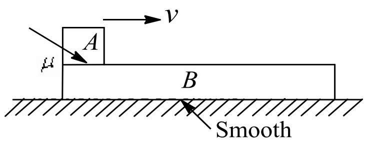


Column-I		Column- II	
(A)	For OA, the total work done by all forces together is	(p)	Always positive
(B)	Fro OA, the work done by few of the acting forces is	(q)	Can be positive
(C)	For AB, the work done by few of the acting forces is	(r)	Zero or can be zero
(D)	For BC, the work done by all forces together is	(s)	Can be negative

CODES :

	A	B	C	D
a)	a	b,c,d	b,c,d	c
b)	a,b,d	b	b,c	d
c)	b,c	c	d	a
d)	b,c,d	c	a	a,c

267. In figure, block A is kept on a larger block$B$. Both are initially at rest. Friction exists between the blocks but there is no friction between B and floor. An impulse gives block A a velocity v as shown. For some displacement after this, match the entries of Column I with of Column II

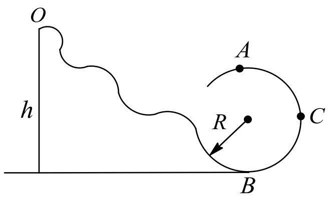


Column-I		Column- II	
(A)	Work done by friction on B	(p)	Positive
(B)	Work done by friction on A	(q)	Negative
(C)	Net work done by friction on A and B	(r)	Zero
(D)	Work done by friction on B in the frame of A	(s)	Positive, negative and zero

CODES :

	A	B	C	D
a)	a	c	d	b
b)	a	b	b	b
c)	c	b	d	a
d)	a	c	d	a

268. A particle is released from height h on a smooth track terminating in a circular path of radius$R$. A and C are points at top and at horizontal level of centre, respectively, of the circular path. Column I represents the different values of height of inclined plane and Column II gives the conditions during the motion of the particle



Column-I		Column- II	
(A)	If $h = 3.2\ R$	(p)	The particle is able to complete vertical circular motion
(B)	If $h = 2.7\ R$	(q)	The force exerted by the particle on the track at point A is zero
(C)	If $h = 2.5\ R$	(r)	The force exerted by the particle on the track at point A is more than its weight
(D)	If $h = 4R$	(s)	The force exerted by the particle on the track at point C is more than its weight

CODES :

	A	**B**	**C**	**D**
a)	A,c	a,d	a,b,d	a,c,d
b)	a,d	a,b,d	a,c,d	a,c
c)	a,b,d	a,c,d	a,c	a,d
d)	a,c,d	a,c	a,d	a,b,d

269. A small object of mass 0.5 kg is attached to an end of a mass less 2 m long rope. It is rotated under gravity in a vertical circle with the other end of the rope being at the centre of the circle. The motion is started from the lowest point. Match columns I and II

Column-I		Column- II	
(A)	If the speed of the object at lowest point is 3.5 ms^{-1}	(p)	There will be some point on the circle at which speed of the object is zero but tension in the rope is not zero
(B)	If the speed of the object at lowest point is 8 ms^{-1}	(q)	There will be some point on the circle at which tension in the rope is zero but speed of the object is not zero
(C)	If the maximum tension in the rope is 15 N	(r)	The object will not be able to reach the highest point
(D)	If the maximum tension in the rope is 30 N	(s)	The object will be able to reach the highest point

CODES :

	A	**B**	**C**	**D**
a)	a	b,d	a,c	b,c
b)	b,d	a,c	b,c	a
c)	a,c	b,c	c	b,d
d)	b,c	c	b,d	a,c

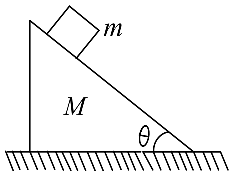
270. A man pushes a block of 30 kg along a level floor at a constant speed with a force directed at 45° below the horizontal. If the coefficient of friction is 0.20, then match the following

	Column-I		Column- II
(A)	Work done by all forces exerted by the surface on the block in 20 m	(p)	Zero
(B)	Work done by the force of gravity	(q)	−1500 J
(C)	Work done by the man on the block in pushing it through 10 m	(r)	750 J
(D)	Net force on the block	(s)	30 J

CODES :

	A	**B**	**C**	**D**
a)	b	a	c	a
b)	c	a	d	b
c)	c	a	d	d
d)	c	d	c	a

271. A block of mass m lies on wedge of mass$M$. The wedge in turn lies on a smooth horizontal surface. Friction is absent everywhere. The wedge-block system in released from rest. All situations given in Column I are to be estimated in duration the block undergoes a vertical displacement h starting from rest. Match the statements in Column I with the results in Column II. (g is acceleration due to gravity)



	Column-I		Column- II
(A)	Work done by normal reaction acting on the block is	(p)	Positive
(B)	Work done by normal reaction (exerted by block) acting on the wedge is	(q)	Negative
(C)	The sum of work done by normal reaction on the block and work done by normal on wedge	(r)	Zero
(D)	Net work done by all forces on the block is	(s)	Less than mgh in magnitude

CODES :

	A	**B**	**C**	**D**
a)	A,d	a	c,d	b
b)	c,d	a,d	a,c	b,d
c)	b,d	a,d	c,d	a,d
d)	a,c	a,d	c,d	b,d

272. A chain of length l and mass m lies on the surface of a smooth sphere of radius $R > l$ with one end tied to the top of the sphere

Column-I		Column- II	
(A)	Gravitational potential energy w.r.t. centre of the sphere	(p)	$\frac{Rg}{l}\left[1-\cos\left(\frac{l}{R}\right)\right]$
(B)	The chain is released and slides down, its KE when it has slid by θ	(q)	$\frac{2Rg}{l}\left[\sin\left(\frac{l}{R}\right)+\sin\theta-\sin\left(\theta+\frac{l}{R}\right)\right]$
(C)	The initial tangential acceleration	(r)	$\frac{MR^{2g}}{l}+\sin\left(\frac{l}{R}\right)$
(D)	The radial acceleration a_r	(s)	$\frac{Mr^2g}{l}\left[\sin\left(\frac{l}{R}\right)+\sin\theta-\sin\left(\theta+\frac{l}{R}\right)\right]$

CODES :

	A	B	C	D
a)	d	a	b	c
b)	a	b	c	d
c)	b	c	d	a
d)	c	d	a	b

Linked Comprehension Type

This section contain(s) 36 paragraph(s) and based upon each paragraph, multiple choice questions have to be answered. Each question has atleast 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

Paragraph for Question Nos. 273 to -273

The stopping distance for vehicle is obtained by dividing their kinetic energy by the stopping force applied. If a car of mass m_c and a bus of mass m_b, having kinetic energies K_c and K_b are stopped under the action of the same retarding force in distance x_c and x_b in time t_c and t_b respectively, then

(i)For $K_c = K_b, x_c = x_b$ and $\frac{t_c}{t_b} = \left(\frac{m_c}{m_b}\right)^{1/2}$

ie, bus would take longer time to stop, but they would cover the same distance before stopping.

(ii)If $p_c = p_b$, then $\frac{x_c}{x_b} = \frac{m_b}{m_c}$ and $\frac{t_c}{t_b} = 1$

ie, stopping distance for car is more than the bus, though they take the same time.

Three cars $A, B\ C$ having masses 1000 kg, 2000 kg and 2500 kg are moving with velocities $10\sqrt{2}\ \text{ms}^{-1}$, $10\ \text{ms}^{-1}$, and $8\ \text{ms}^{-1}$ respectively. Exactly same force is applied to stop the cars, A and B. Time taken to stop and the distances travelled before stopping are measured. Similar measurements are made by applying same opposite force on the cars B and C

273. If car A takes 5 s to stop, the time taken by car A to stop will be

a) 5 s   b) $5\sqrt{2}$ s   c) $5/\sqrt{2}$ s   d) 2.5 s

Paragraph for Question Nos. 274 to - 274

In a conservative force field, we can find the radial component of force F from the potential energy function (U) using the relation $F = \frac{dU}{dr}$. Positive value of F mean repulsive forces and $vice - versa$. We can find the equilibrium position, where force is zero. We can also calculate ionisation energy, which is the work done to move the particle from a certain position to infinity.

Let us consider a particle bound to a certain point at a distance r from the centre of the force. The potential energy function of the particle is given by $U(r) = \frac{A}{r^2} - \frac{B}{r}$, where A and B are positive constants

274. The nature of equilibrium is
a) Neutral
b) Stable
c) Unstable
d) Cannot the predicted

Paragraph for Question Nos. 275 to - 275

Two unequal masses are tied together with a cord with a compressed spring in between

275. When the cord is burnt with a match releasing the spring, the two masses fly apart with equal
a) Kinetic energy
b) Speed
c) Momentum
d) Acceleration

Paragraph for Question Nos. 276 to - 276

A body of mass 2 kg starts from rest and moves with uniform acceleration. It acquires a velocity 20 ms^{-1} in 4 s

276. The power exerted on the body at 2 s is
a) 50 W
b) 100 W
c) 150 W
d) 200 W

Paragraph for Question Nos. 277 to - 277

Sand particles drop vertically at the rate of 2 kgs^{-1} on a conveyor belt moving horizontally with a velocity of 0.2 ms^{-1}

277. The extra force required to keep the belt moving is
a) 0.4 N
b) 0.08 N
c) 0.04 N
d) 0.2 N

Paragraph for Question Nos. 278 to - 278

A ladder of length l carrying a man of mass m at its end is attached to the basket of a balloon of mass$M$. The entire system is in equilibrium in the air. As the man climbs up the ladder into the balloon, the balloon descends by a height h

278. The potential energy of the man
a) Increases by $mg(l - h)$
b) Increases by mgl
c) Increases by mgh
d) Increases by $mg(2l - h)$

Paragraph for Question Nos. 279 to - 279

A single conservation force $F(x)$ acts on a 1.0 kg particle that moves along the x-axis. The potential energy $U(x)$ is given by $U(x) = 20 + (x - 2)^2$ where x is in meters. At $x = 5.0$ m, the particle has a kinetic energy of 20 J

279. What is the mechanical energy of the system?

a) 35 J b) 64 J c) 86 J d) 49 J

Paragraph for Question Nos. 280 to - 280

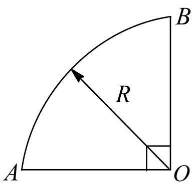
A 1.5 kg block is initially at rest on a horizontal frictionless surface when a horizontal force in the positive direction of x-axis is applied to the block. The force is given by $\vec{F} = (4 - x^2)\hat{\imath}$ N, when x is in meter and the initial position of the block is $x = 0$

280. The maximum kinetic energy of the block between $x = 0$ and $x = 2.0$ m is

a) 2.33 J b) 8.67 J c) 5.33 J d) 6.67 J

Paragraph for Question Nos. 281 to - 281

A constant force F acts on a moving body along a smooth quarter circular arc of radius F fixed on horizontal surface. Calculate the work done by force F from A t6o B. If force F

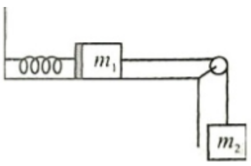


281. Always points towards B

a) $F(2\,R)$ b) $F(\sqrt{2}\,R)$ c) $\pi F(\sqrt{2}\,R)$ d) $F\ (2R)$

Paragraph for Question Nos. 282 to - 282

In figure the mass m_1 rests on a rough table. Now m_1 is pushed against the spring by x to which it is not attached. The force contact of the spring is k and coefficient of friction is μ_k



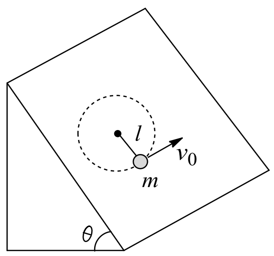
282. The speed of the blocks after the spring is released and m_2 has fallen a distance of $h > x$ is

a) $\sqrt{\dfrac{kx^2 + 2m_2gh - 2\mu_k m_1 gh}{2(m_1 + m_2)}}$ b) $\sqrt{\dfrac{kx^2 + 2m_2gh - 2\mu_k m_1 gh}{m_1 + m_2}}$

c) $\sqrt{\dfrac{kx^2 + m_2gh - 2\mu_k m_1 gh}{m_1 + m_2}}$ d) $\sqrt{\dfrac{kx^2 + 2m_2gh - \mu_k m_1 gh}{m_1 + m_2}}$

Paragraph for Question Nos. 283 to - 283

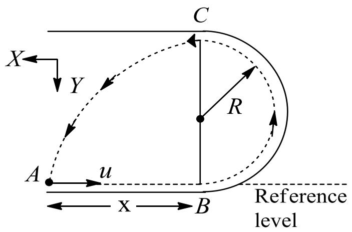
A pendulum bob swings along a circular path on a smooth inclined plane as shown in figure where $m = 3$ kg, $l = 0.75$ m, $\theta = 37°$. At the lowest point of the circle the tension in the string $T = 274$ N. Take $g = 10\ ms^{-2}$



283. The speed of the bob at the lowest point is
a) 9.2 ms^{-1} b) 9 ms^{-1} c) 6.5 ms^{-1} d) 8 ms^{-1}

Paragraph for Question Nos. 284 to - 284

A small ball is rolled with speed u from point A along smooth circular track as shown in figure. If $x = 3R$, then



284. Determine the required speed u so that the ball; returns to A, the point of projection after passing through C, the highest point
a) $\frac{3}{2}\sqrt{gR}$ b) $\frac{1}{2}\sqrt{gR}$ c) $\frac{5}{3}\sqrt{gR}$ d) $\frac{5}{2}\sqrt{gR}$

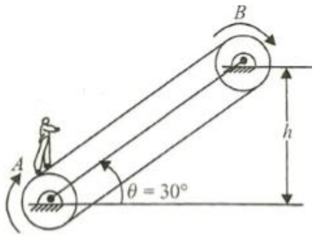
Paragraph for Question Nos. 285 to - 285

A man of mass m speeds up while running from rest to a speed v in a straight track along an inclined plane, after rising through a height h
W_{gravity} = work done by gravity on the man
W_{friction} =work done by friction on the man
W_{man} = work done by man

285. Which of the following options is correct regarding the various work done?
a) $W_{\text{gravity}} = -mgh$ b) $W_{\text{friction}} > 0$ c) $W_{\text{man}} = mgh + \frac{1}{2}mv^2$ d) $W_{\text{friction}} = 0$

Paragraph for Question Nos. 286 to - 286

A boy of mass m climbs up a conveyor belt with a constant acceleration. The speed of the belt is $v = \sqrt{\frac{gh}{6}}$ and the coefficient of friction between the boy and conveyor belt is $\mu = \frac{5}{3\sqrt{3}}$. The boy starts from A and moves with the maximum possible acceleration till the reaches the highest point B

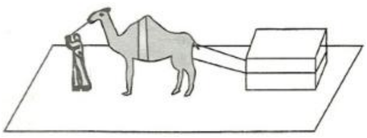


286. The time taken by the boy to reach the highest h is

a) $\sqrt{\frac{2h}{g}}$ b) $\sqrt{\frac{6h}{g}}$ c) $2\sqrt{\frac{h}{g}}$ d) None of above

Paragraph for Question Nos. 287 to - 287

Ram and Ali have been fast friends since childhood. Ali neglected studies and now has no means to earn money other than a camel whereas Ram has becomes an engineer. Now both are working in the same factory. Ali uses camel to transport the load within the factory



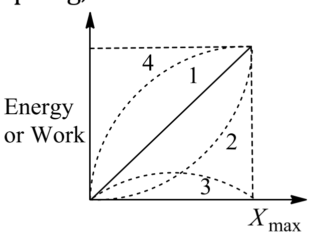
Due to low salary and degradation in health of camel, Ali becomes worried and meets his friend Ram and discusses his problem. Ram collected some data and with some assumptions concluded the following
i.The load used in each trip is 1000 kg and has friction coefficient $\mu_k = 0.1$ and $\mu_s = 0.2$
ii.Mass of camel is 500 kg
iii.Load is accelerated for first 50 m with constant acceleration, then it is pulled at a constant speed of 5 ms^{-1} for 2 km and at last stopped with constant retardation in 50 m
iv.From biological data, the rate of consumption of energy of camel can be expressed as $P = 18 \times 10^3\ V + 10^4 Js^{-1}$ where P is the power and v is the velocity of the camel. After calculation on different issues, Ram suggested proper food, speed of camel, etc. to his friend. For the welfare of Ali, Ram wrote a letter to the management to increase his salary
(Assuming that the camel exerts a horizontal force on the load):

287. Sign of work done by the camel on the load during parts of motion: acceleration motion, uniform motion and retarded motion, respectively are

a) + ve, +ve , + ve b) + ve , +ve , −ve c) + ve , zero, −ve d) + ve, zero, +ve

Paragraph for Question Nos. 288 to - 288

A spring lies along the x-axis attached to a wall at one end and a block at the other end. The block rests on a friction less surface at$x = 0$. A force of constant magnitude F is applied to the block begins to compress the spring, until the block comes to a maximum displacement $x_{\max}$



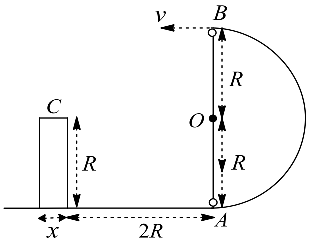
288. During the displacement, which of the curves shown in the graph best represents the kinetic energy of the block?

a) 1 b) 2 c) 3 d) 4

Paragraph for Question Nos. 289 to - 289

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

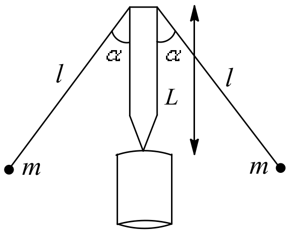
289. The velocity given is the ball at point A so that it may hit the top of the building is



a) $\sqrt{4gR}$ b) $\sqrt{2gR}$ c) $\sqrt{gR}$ d) $\sqrt{6gR}$

Paragraph for Question Nos. 290 to - 290

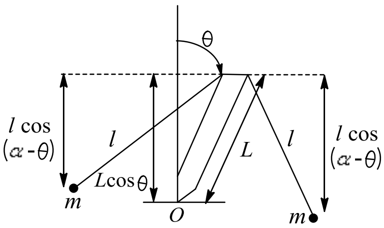
The teeter toy consists of two identical weights which hang from a peg on dropping arms as shown. The arrangement is unexpectedly stable-the toy can be spun or oscillated with little danger or topping over. We can see why this is so by looking at its potential energy. For simplicity, we shall consider only oscillating motion in the vertical plane



Let us evaluate the potential energy when the teeter toy is at angleθ, as shown in sketch. If we take the zero of gravitational potential energy at the pivot (point O), we have

$U(\theta) = mg[L\cos\theta - l\cos(\alpha+\theta)] + mg[L\cos\theta - l\cos(\alpha-\theta)]$

$= 2\,mg\cos\theta\,[L - l\cos\alpha]$



For equilibrium, b

$$\frac{dU}{d\theta} = -2mg\sin\theta\,(L - l\cos\alpha) = 0$$

$\Rightarrow \sin\theta = 0$ or $\theta = 0$, we expect symmetry

To investigate the stability of the equilibrium position, we must examine the second derivation of the potential energy. We have

$$\frac{d^2U}{d\theta^2} = -2\,mg\cos\theta\,[L - l\cos\theta]$$

At equilibrium, $\left.\frac{d^2U}{d\theta^2}\right|_{\theta=0} = -2mg\,[L - l\cos\alpha]$

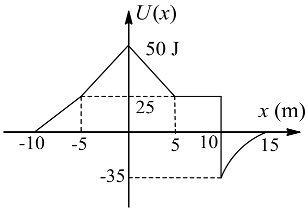
For the second derivation to be positive, we have $L - l\cos\alpha < 0$ or $L < l\cos\alpha$

In order for the teeter toy to be stable, the weights must hang below the pivot

290. The stability of teeter toy at $\theta = 0$ refers to
   a) Minimum potential energy
   b) Maximum potential energy
   c) Optimum potential energy
   d) Constant potential energy

Paragraph for Question Nos. 291 to - 291

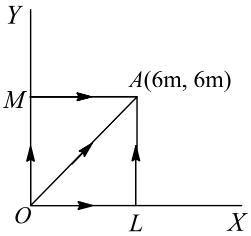
Figure shows the variation of potential energy of a particle as function of x, the x-cocordinte of the region. It has been assumed that potential energy depends only on x. For all other values of x, U is zero, i.e., $x < -10$ and $x > 15, U = 0$



291. If the total mechanical energy of the particle is 25 J, then it can be found in region
   a) $-10 < x < -5$ and $6 < x < 15$
   b) $-10 < x < 0$ and $6 < x < 10$
   c) $-5 < x < 6$
   d) $-10 < x < 10$

Paragraph for Question Nos. 292 to - 292

Force acting on a particle moving in the $x - y$ plane is $\vec{F} = (y^2\hat{\imath} + x\hat{\jmath})$ N, x and y are in meter. As shown in figure, the particle moves from the origin O to point$A(6m, 6m)$. The figure shows three paths, OLA, OMA, and OA for the motion of the particle from O to A



(A)

292. Which of the following is correct?
   a) There is equal probability for the force being conservation or non-conservative
   b) Conservative or non-conservative nature of force cannot be predicted on the basis of given information
   c) The given force is non-conservation
   d) The given force is conservation

Paragraph for Question Nos. 293 to - 293

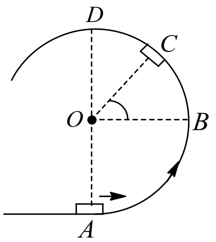
The brothers of Iota, Eta and Pi fraternity have built a platform, supported at all four corners, by vertical springs in the basement of their flat house. A brave fraternity brother wearing a football helmet stands in the middle of the paltform, his weight compresses the springs by 0.18 m. Then four of his fraternity brothers, pushing down at down at the corners of the platform, compress the springs by another 0.53 m until the top of the brave brother helmet is 0.9 m below the basement ceiling. They then simultaneously release the platform. Ignore the masses of spring and platform

293. Find the velocity with which the fraternity brother's helmet hits the ceiling

a) 3.14 ms^{-1} b) 2.89 ms^{-1} c) 2.93 ms^{-1} d) 4.13 ms^{-1}

Paragraph for Question Nos. 294 to - 294

A small block of mass m is pushed on a smooth track from position A with a velocity $2/\sqrt{5}$ times the minimum velocity required to reach point$D$. The block will leave the contact with track at the point where normal force between them becomes zero



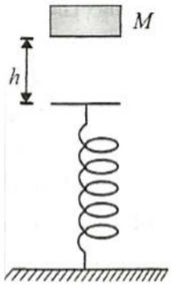
294. At what angle θ with a horizontal does not block gets separated from the track?

a) $\sin^{-1}\left(\frac{1}{3}\right)$ b) $\sin^{-1}\left(\frac{3}{4}\right)$

c) $\sin^{-1}\left(\frac{2}{3}\right)$ d) Never leaves contact with the track

Paragraph for Question Nos. 295 to - 295

A block of mass M kg is dropped onto a vertical spring of force constant$k$ Nm^{-1}. The block strikes to the spring, and the spring compresses x m before coming momentarily to rest

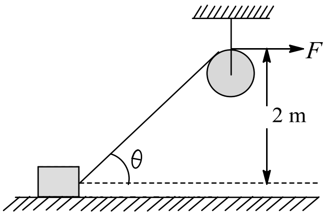


295. During the compression of the spring, the work done by the force of gravity is

a) Mgx b) $\left(\frac{1}{2}\right)kx^2$ c) $-\left(\frac{1}{2}\right)kx^2$ d) $Mgx+\left(\frac{1}{2}\right)kx^2$

Paragraph for Question Nos. 296 to - 296

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 friction less horizontal surface. Take initial instant as $\theta = 30°$ and final instant as $\theta = 30°$. For the time between these two instants, answer the following questions?

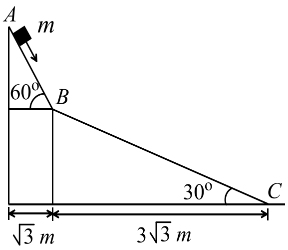


296. Net work done by force F on the block is

a) $\frac{50}{3}$ J   b) $\frac{100}{3}$ J   c) 75 J   d) None of these

Paragraph for Question Nos. 297 to - 297

A small block of mass M moves on a frictionless surface of an inclined plane, as shown in figure. The angle of the incline suddenly changes from 60° to 30° at point B. The block is initially at rest at A. Assume that collisions between the block and the incline are totally inelastic ($g = 10m/s^2$)



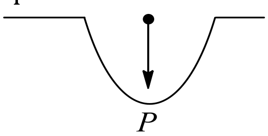
297. The speed of the block at point B immediately after it strikes the second incline is

a) $\sqrt{60}\ m/s$ b) $\sqrt{45}\ m/s$ c) $\sqrt{30}\ m/s$ d) $\sqrt{15}\ m/s$

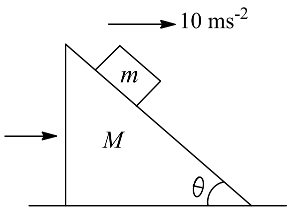
Integer Answer Type

298. A man slowly pulls a bucket of water from a well of depth $h = 20$ m.The mass of the uniform rope and bucket full of water are $m = 200$ gm and M 19.9 kg, respectively. Find the work done (in kJ) by the man

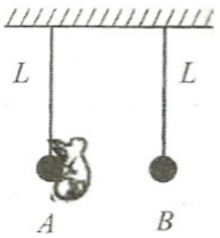
299. A car travelling on a smooth road passes through a curved portion of the road in the form of an arc of circle of radius 10 m. If the mass of car is 120 kg, find the reaction (in kN) on car at lowest point P where its speed is 20 ms^{-1}



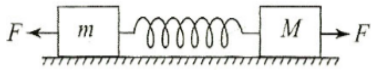
300. In the figure shown all the surfaces are frictionless, and mass of the block is $m = 100$ g. The block and the horizontal acceleration of 10 ms^{-2} by applying the force on the wedge, so that the block does not slip on the wedge. Then find the work done in joules by the normal force in ground frame on the block is 1 s



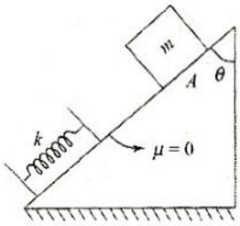
301. An insect jumps from ball A onto ball$B$, which are suspended from inextensible light strings each of length $L = 8$ cm. The mass of each ball and insert is same. What should be the minimum relative velocity (inms^{-1}) of jump of insect w.r.t. ball A, if both the balls manage to complete the full circle?



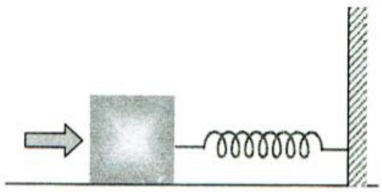
302. In the situation shown in figure all contact surfaces are smooth. The force constant of the spring is$K$. Two forces F are applied as shown. the maximum elongation produced in the spring is how many times of F/K (initially the spring is relaxed)?



303. A block of mass m is released from rest at point A. The compression in spring (force constant$k$) when the speed of block is maximum is found to be $nmg\cos\theta/4k$. What should be the value of$n$?

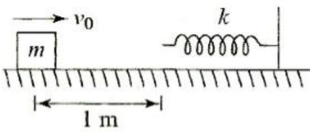


304. A block of mass 0.18 kg is attached to a spring of force-constant 2 N/m. The coefficient of friction between the block and the floor is 0.1. Initially the block is at rest and the spring is un-stretched. An impulse is given to the block as shown in the figure. The block slides a distance of 0.06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



305. The PE of a certain spring when stretched from natural length through a distance 0.3 m is 5.6 J. Find the amount of work in joule that must be done on this spring to stretch it through an additional distance 0.15 m

306. A block of mass $m = 0.14$ kg is moving with velocity v_0 towards a mass less unstretched spring of force constant$K = 10\ Nm^{-1}$. Coefficient of friction between the block and the ground is $\mu = 1/2$



Find the maximum value of compression in the spring (in cm), so that after pressing the spring the block does not return back but stops there permanently

: ANSWER KEY :

1)	d	2)	a	3)	d	4)	a
5)	c	6)	b	7)	b	8)	d
9)	b	10)	c	11)	b	12)	b
13)	c	14)	c	15)	d	16)	c
17)	b	18)	d	19)	b	20)	c
21)	a	22)	b	23)	c	24)	a
25)	b	26)	c	27)	c	28)	b
29)	a	30)	c	31)	d	32)	c
33)	c	34)	d	35)	b	36)	c
37)	b	38)	c	39)	b	40)	b
41)	b	42)	b	43)	c	44)	d
45)	a	46)	c	47)	d	48)	c
49)	b	50)	c	51)	b	52)	c
53)	b	54)	c	55)	c	56)	d
57)	a	58)	c	59)	b	60)	d
61)	c	62)	d	63)	b	64)	a
65)	c	66)	a	67)	d	68)	a
69)	c	70)	b	71)	c	72)	a
73)	a	74)	b	75)	b	76)	c
77)	a	78)	a	79)	d	80)	d
81)	b	82)	d	83)	a	84)	c
85)	c	86)	c	87)	b	88)	b
89)	c	90)	c	91)	c	92)	a
93)	b	94)	a	95)	b	96)	c
97)	a	98)	a	99)	c	100)	d
101)	a	102)	a	103)	a	104)	d
105)	a	106)	a	107)	c	108)	b
109)	d	110)	d	111)	d	112)	c
113)	a	114)	b	115)	d	116)	a
117)	a	118)	c	119)	b	120)	b
121)	c	122)	b	123)	d	124)	b
125)	b	126)	b	127)	a	128)	d
129)	d	130)	d	131)	c	132)	d
133)	d	134)	c	135)	a	136)	a
137)	c	138)	c	139)	b	140)	a
141)	b	142)	b	143)	c	144)	d
145)	b	146)	b	147)	c	148)	a
149)	b	150)	a	151)	c	152)	c
153)	a	154)	b	155)	d	156)	a
157)	d	1)	b,c	2)	a,b	3)	
	b,c	4)	b				
5)	a,b,c	6)	b	7)	b,d	8)	
	b,d						
9)	d	10)	a,b,c,d	11)	c	12)	
	a,c,d						
13)	a,c	14)	c,d	15)	b,d	16)	

	b,d						
17)	a,d	18)	b,c	19)	a,b,c,d	20)	
	c,d						
21)	b	22)	a,c	23)	a,c	24)	
	c,d						
25)	a,b,c	26)	a,b,c	27)	c	28)	
	a,b,c,d						
29)	a,b	30)	a,b,d,e	31)	b,d	32)	
	a,b,c						
33)	a,c	34)	d	35)	b,d	36)	c
37)	b,c	38)	a,b,d	39)	a,b,c,d	40)	
	a,b,c,d						
41)	b,d	42)	a,c,d	43)	a,b,d	44)	
	a,b,d						
45)	b,c,d	46)	a,b	47)	a,d	48)	
	a,c						
49)	a	50)	b,c,d	51)	a,d	52)	
	c,d						
53)	b,d	54)	b,c,d	1)	b	2)	a
	3)	e	4)	a			
5)	d	6)	c	7)	d	8)	d
9)	c	10)	a	11)	a	12)	a
13)	a	14)	b	15)	a	16)	c
17)	d	18)	e	19)	a	20)	d
21)	d	22)	c	23)	a	24)	c
25)	a	26)	d	27)	a	28)	c
29)	c	30)	c	31)	a	32)	b
33)	d	34)	a	35)	c	36)	c
37)	a	38)	a	39)	d	40)	b
41)	a	42)	a	43)	e	44)	d
45)	c	46)	d	47)	e	48)	a
49)	a	50)	c	51)	a	1)	d
	2)	b	3)	b	4)	a	
5)	b	6)	a	7)	c	8)	a
9)	c	10)	d	1)	c	2)	b
	3)	c	4)	b			
5)	a	6)	a	7)	d	8)	c
9)	b	10)	b	11)	d	12)	d
13)	a,c,d	14)	b	15)	a	16)	c
17)	d	18)	a	19)	a	20)	c
21)	a	22)	c	23)	a	24)	b
25)	b	1)	4	2)	6	3)	5
	4)	8					
5)	2	6)	4	7)	4	8)	7
9)	7						

: HINTS AND SOLUTIONS :

1 **(d)**

$W = \int \vec{F}.d\vec{s} = \int_{s_1}^{s} \frac{k}{s} ds = k \text{ In}\left(\frac{s}{s_1}\right)$

2 **(a)**

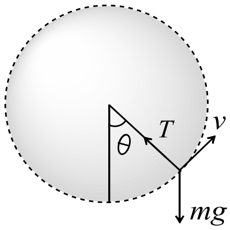
$\frac{mv^2}{R} = \frac{1 \times 4^2}{1} = 16 \text{ N}$

$mg = 1 \times 10 = 10\ N\ \Rightarrow T = mg\cos\theta + \frac{mv^2}{R}$

$6 = 10\cos\theta + 16$

$\text{cosec}\ \theta = -1$

$\theta = -180°$



3 **(d)**

As the speed of mass is uniform hence, net power will be zero.

4 **(a)**

Decrease in height : $h = 14 - 7 = 7$ m

Also KE at C = Loss in PE= $mgh = 140$ J

5 **(c)**

Work done by friction:

$W = (\mu mg\cos\theta)S$

$= (\mu mg\cos\theta)\frac{h}{\sin\theta} = \mu mgh\cot\theta$

Now $\cot\theta_1 = \cot 30° = \sqrt{3}$

$\cot\theta_2 = \cot 60° = \frac{1}{\sqrt{3}}$

i.e., kinetic energy ($KE = mgh - W$) in first case will be less or $K_1 < K_2$

6 **(b)**

Force method:

From P to Q: $v^2 = 0^2 + 2a_1s_1$

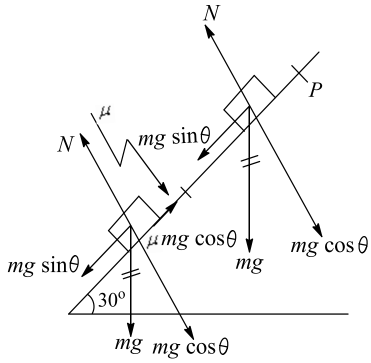
Where $a_1 = \text{g}\sin 30°, s_1 = 1$ m

And from Q to R: $0^2 = v^2 + 2a_2s_2$

Where $a_2 = \text{g}\sin 30° - \mu\text{g}\cos 30°, s_2 = 2$ m

Solve to get $\mu = \sqrt{3}/2$

Work-energy method:



In terms of energy considerations you can summarize the whole process as loss in gravitational potential energy of the block=work done against friction, or

$(mg) \times (3\sin 30°) = (\mu mg\cos\theta) \times$

$3 \times 1/2\ \mu \times \frac{\sqrt{3}}{2} \times 2 \quad \Rightarrow \quad \mu = \frac{\sqrt{3}}{2}$

7 **(b)**

From $v = \omega r$, speed of B will be double of A, hence KE of B is 4 times that of A

8 **(d)**

When a number of forces act on a body and the body is in static or dynamic equilibrium (it means $F_{\text{net}} = 0$), then individual forces may do the work, but net work done by all the forces will be zero, because KE of body is not changing

$Note$: $In\ such\ a\ situation, if\ work\ done\ by\ some$ $then\ by\ others\ is\ equally\ negative, so\ that\ net\ w$

9 **(b)**

Given that $K = as^2$ or $\frac{1}{2}mv^2 = as^2$ (i)

or $mv^2 = 2as^2$

Differentiating w.r.t. time, we get

$n2v \times \frac{dv}{dt} = 2a \times 2s \times \frac{ds}{dt}$

But $\frac{ds}{dt} = v$

So $2m\frac{dv}{dt} = 4as$ or $m\frac{dv}{dt} = 2as$

Now, $m\frac{dv}{dt}$ =tangential force= F_t

$F_t = 2as$

Centripetal force = $F_r = \frac{mv^2}{R} = \frac{2as^2}{R}$

$F_{\text{net}} = \sqrt{F_t^2 + F_r^2} = \sqrt{(2as)^2 + \left(\frac{2as^2}{R}\right)^2}$

$= 2as\sqrt{1 + \frac{s^2}{R^2}}$

10 **(c)**

Here work done by the person is positive, because energy of the person will decrease in lifting the bucket. It means work done on the person should be negative. Also if work done on the person were positive, then his energy should have been increased

11 **(b)**

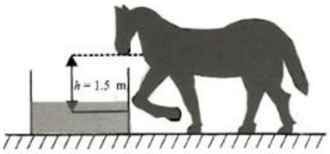
Loss in PE= $mgr = 2 \times 10 \times 1 = 20$ J

But gain in KE $= \frac{1}{2} \times 2 \times 4^2 = 16$ J

Frictional work= $16 - 20 = -4$ J

12 **(b)**

The mass of water is $m = 1 \times 10^3$ kg



The increase in potential energy of water is

$mgh = (1 \times 10^3)(10)1.5 = 15$ kJ

13 **(c)**

Zero, because there is no displacement in the direction of force. Centripetal force does not do work

14 **(c)**

Total gravitational energy gained is

Work done+ energy released by the spring

$= W + E$

15 **(d)**

Factual

16 **(c)**

At point C the potential energy is minimum, hence it is a point of stable equilibrium. Also, from C to A, the slope is negative, i.e.,

$\frac{dU}{dr} < 0$

Hence, the force of interaction between the particles is repulsive between points C and A

17 **(b)**

Using $P = Fv$, we get

$P = Fr\omega \quad (\therefore\ v = r\omega)$

Here $F = \mu N$ (where N is the normal reaction)

$= \mu F'g \quad (\therefore\ 1\ kgf = g$ newton)

$P = \mu F' g r\omega = 2\pi\mu n F' gr \quad (\therefore\ \omega = 2\pi r)$

18 **(d)**

$F - f = ma$ or $F = f + ma$

$v = at$

Instantaneous power, $P = Fv = (f + ma)v$

$= (\mu\, mg + ma)v = m(a + \mu g)at$

19 **(b)**

We know that $dU = -dW$

Where dU is the change in potential energy

And dW is the work done by conservative forces

Hence, work done by conservation forces on a system is equal to the negative of the change in potential energy

20 **(c)**

In this case, work will be done by the force which will increase the kinetic energy

21 **(a)**

Let the velocity of wedge be v

Loss in PE=Gain in KE

$$mgR\cos 45° = \frac{1}{2}mv^2 + \frac{1}{2}m(v_1\cos 45° - v)^2 + \frac{1}{2}m(v_1 \sin 45°)$$

From conservation of linear momentum

$m(v_1 \cos 45° - v) = mv$

Here v_1 is the velocity of ball w.r.t. wedge. Solve to get

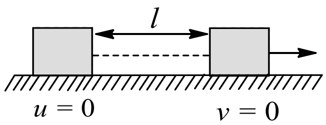
$$v = \left(\frac{gR}{3\sqrt{2}}\right)^{\frac{1}{2}}$$

22 **(b)**

Applying work-energy theorem on the block, we get

$Fl - \frac{1}{2}kl^2 = 0$

$l = \frac{2F}{k}$ or work done $= Fl = \frac{2F^2}{k}$



23 **(c)**

$F_{\text{ext}} = 0$; therefore, $W_{\text{ext}} = \vec{F}_{\text{ext}}.\vec{s} = 0$

By work-energy theorem: $W = K_F - K_1$

$W_{\text{ext}} + W_{\text{int}} = 0 - \left(\frac{1}{2}mv^2 + \frac{1}{2}mv^2\right)$

$W_{\text{int}} = -mv^2 = -5 \times 2^2 = -20$ J

24 **(a)**

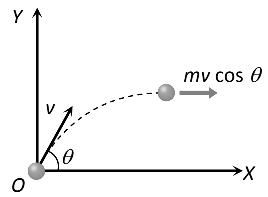
Shell is fired with velocity v at an angle θ with the horizontal

So its velocity at the highest point

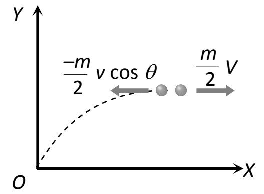
= horizontal component of velocity $= v\cos\theta$

So momentum of shell before explosion

$= mv\cos\theta$



When it breaks into two equal pieces one piece retraces its path to the canon, then other part moves with velocity V



So momentum of two pieces after explosion

$= \frac{m}{2}(-v\cos\theta) + \frac{m}{2}V$

By the law of conservation of momentum

$mv\cos\theta = \frac{-m}{2}v\cos\theta + \frac{m}{2}V \Rightarrow V = 3v\cos\theta$

25 **(b)**

Net work done$= +3200\text{ J} - 3200\text{J} = 0\text{J}$

26 **(c)**

Let the particle be dropped from a height h and the spring be compressed by$y$. According to the conservation of mechanical energy, loss in PE of the particle = gain in elastic potential energy of the spring

$mg(h+y) = \frac{1}{2}ky^2$

Now, as the particle and spring are same for second case,

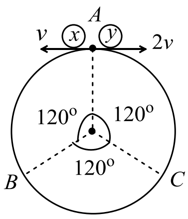
$\frac{h_1+y_1}{h_2+y_2} = \left(\frac{y_1}{y_2}\right)^2$ or $\left(\frac{0.24+0.01}{h_2+0.04}\right) = \left(\frac{0.01}{0.04}\right)^2$

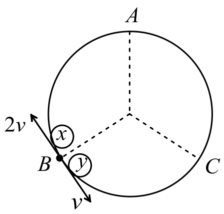
Solving, we get $h_2 = 3.96$ m

27 **(c)**

Let initially particle x is moving in anticlockwise direction and y in clockwise direction

As the ratio of velocities of x and y particles are $\frac{v_x}{v_y} = \frac{1}{2}$, therefore ratio of their distance covered will be in the ratio of 2 : 1. It means they collide at point B





After first collision at B, velocities of particles get interchanged, *i.e.*, x will move with $2v$ and particle y with v

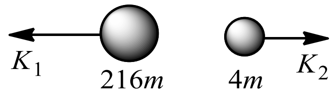
Second collision will take place at point C. Again at this point velocities get interchanged and third collision take place at point A

So, after two collision these two particles will again reach the point A

28 **(b)**

Given that,

$K_1 + K_2 = 5.5\ MeV \quad \ldots(i)$



From conservation of linear Momentum

Or $\quad \sqrt{2K_1(216m)} = \sqrt{2k_2(4m)}$

Or $\quad k_2 = 54\,K_1 \quad \ldots(ii)$

Solving Eq.(i)& (ii),we get

$k_2 = KE$ of $\alpha - particle = 5.4Me\ V$.

29 **(a)**

Let at any time, the speed of the block along the incline upwards be v

Then from Newton's second law,

$\frac{P}{v} - mg\sin\theta - \mu mg\cos\theta = \frac{mdv}{dt}$

The speed is maximum when $\frac{dv}{dt}$ =0

$v_{\max} = \frac{P}{mg\sin\theta + \mu\,mg\cos\theta}$

30 **(c)**

The spring will exert maximum force when the ball is at its lowest position. If ball has descended through a distance x to reach the position,

$mgx = \left(\frac{1}{2}\right)kx^2$ or $x = 2mg/K \quad$ (i)

For the block B to leave contact spring force

$Kx = Mg \quad$ (ii)

Comparing (i) and (ii), $m = M/2$

31 **(d)**

Velocity of a projectile at any instant of time (t) is

$V^2 = v_x^2 + v_y^2 = (u\cos\theta)^2 + \left(u\sin\theta - g\frac{x}{u\cos\theta}\right)^2$

$\therefore\ \text{KE} = \frac{1}{2}mu^2 - mgx\tan\theta + \frac{mg^2x^2}{u^2\cos^2\theta}$

The given equation represents the equation of a parabola

Note: *Answer cannot be (b) as KE of a projectile*

32 **(c)**

$P = \sqrt{2mE}$. If E are same then $P \propto \sqrt{m}$

$\Rightarrow \frac{P_1}{P_2} = \sqrt{\frac{m_1}{m_2}} = \sqrt{\frac{1}{4}} = \frac{1}{2}$

33 **(c)**

Let us assume that the displacement of the body is directly proportional to t^n, i.e.

$s = Kt^n, v = \frac{ds}{dt} = Knt^{n-1}$

And $a = \frac{dv}{dt} = Kn(n-1)t^{n-2}$

Force $F = ma = mKn(n-1)t^{n-2}$

Power, $P = Fv = [mKn(n-1)t^{n-2}][Knt^{n-1}]$

$= mKn^2(n-1)t^{2n-3}$

As power is constant, i.e., independent of time, hence

$2n - 3 = 0$ or $n = \frac{3}{2}$ or $s \propto t^{\frac{3}{2}}$

34 **(d)**

Potential energy of the particle $U = k(1 - e^{-x^2})$

Force on particle $F = \frac{-dU}{dx} = -k[-e^{-x^2} \times (-2x)]$

$$F = -2kxe^{-x^2} = -2kx\left[1 - x^2 + \frac{x^4}{2!} - \cdots\right]$$

For small displacement $F = -2kx$

$\Rightarrow F \propto -x$ *i.e.* motion is simple harmonic motion

35 **(b)**

Here $x = (t-3)^2 = t^2 - 6t + 9$

$$v = \frac{dx}{dt} = 2t - 6$$

At $t = 0, v = 2 \times 0 - 6 = -6$

At $t = 6$ s, $v = 2 \times 6 - 6 = +6$

Initial and final KE are same, hence no work is done

36 **(c)**

From the above question, $s \propto KE_i$

If KE is doubles, s is also doubled

37 **(b)**

$$K = \frac{\text{Mass}}{\text{Length}} = \frac{dm}{dx}, v = \text{speed of water}$$

$$KE = \frac{1}{2}mv^2$$

$$\Rightarrow \frac{d}{dt}(KE) = \frac{1}{2}\left(\frac{dm}{dt}\right)v^2 = \frac{1}{2}\left(\frac{dm}{dx}.\frac{dx}{dt}\right)v^2$$

$$= \frac{1}{2}kvv^2 = \frac{kv^3}{2}$$

Alternative method:

Let in time t, L Length of water come out

Then $t = \frac{L}{v}$

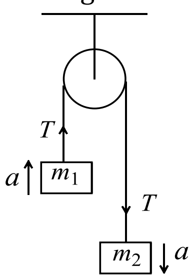
Mass of water that comes out in time t: $m = kL$

KE imparted per unit time$= \left(\frac{1}{2}\right)\frac{mv^2}{t}$

$$= \left(\frac{1}{2}\right)\frac{kLv^2}{(L/v)} = \left(\frac{1}{2}\right)kv^3$$

38 **(c)**

In the given condition tension in the string



$$T = \frac{2m_1m_2}{m_1 + m_2}g = \frac{2 \times 0.36 \times 0.72}{1.08} \times 10$$

$T = 4.8\ N$

And acceleration of each block

$$a = \left(\frac{m_2 - m_1}{m_1 + m_2}\right)g = \left(\frac{0.72 - 0.36}{0.72 + 0.36}\right)g = \frac{10}{3}\ m/s^2$$

Let 'S' is the distance covered by block of mass $0.36\ kg$ in first sec

$$S = ut + \frac{1}{2}\ at^2 \Rightarrow S = 0 + \frac{1}{2}\left(\frac{10}{3}\right) \times 1^2$$

$$= \frac{10}{6}\ meter$$

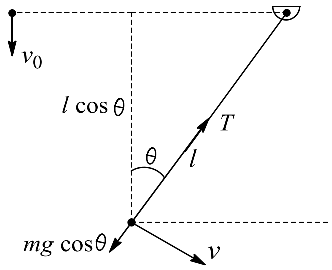
$\therefore$ Work done by the string $W = TS = 4.8 \times \frac{10}{6}$

$\Rightarrow W = 8\ Joule$

39 **(b)**

$$\frac{P_A}{P_B} = \frac{t_B}{t_A} = \frac{15}{20} = \frac{3}{4}$$

40 **(b)**



$$v^2 = v_0^2 + 2gl\cos\theta$$

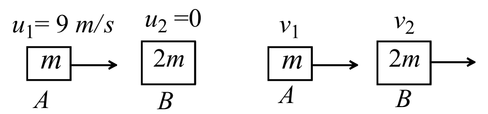
$$T = mg\cos\theta + \frac{mv^2}{l}$$

Given $T = 2\ mg$

$$2\ mg = mg\cos\theta + \frac{m}{l}(v_0^2 + 2gl\cos\theta)$$

$$\Rightarrow \cos\theta = \frac{1}{4}$$

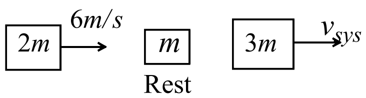
41 **(b)**



Before elastic collision After elastic collision

$$v_2 = \frac{2m_1v_1}{m_1 + m_2} = \frac{2 \times m \times 9}{m + 2m} = 6\ m/s$$

i.e. After elastic collision B strikes to C with velocity of $6\ m/s$. Now collision between B and C is perfectly inelastic



By the law of conservation of momentum

$2m \times 6 + 0 = 3m \times v_{sys}$

$\Rightarrow v_{sys} = 4\ m/s$

42 **(b)**

If a liquid of density ρ is flowing through a pipe of corss section A at speed V, the mass coming out per second will be

$$\left(\frac{dm}{dt}\right) = \rho AV$$

In order to get n times water in the same time, we get

$$\left(\frac{dm}{dt}\right) = n\left(\frac{dm}{dt}\right)$$

i.e., $A'V'\rho' = nAV\rho$

But as pipe and liquid are same, $\rho' = \rho, A' = A$

$V' = NV,$

So $\frac{F}{F} = \frac{V'\left(\frac{dm}{dt}\right)}{V\left(\frac{dm}{dt}\right)} = \frac{nV\frac{ndm}{dt}}{V\left(\frac{dm}{dt}\right)} = n^2$

or $F' = n^2 F$

$\frac{P'}{P} = \frac{FV'}{FV} = \frac{(n^2F)(nV)}{FV}$ or $P' = n^3 P$

43 **(c)**

$a_c = \frac{v^2}{r} = k^2rt^2$ or $v = krt$

$\text{KE} = \frac{1}{2}mv^2 = \frac{1}{2}mk^2r^2t^2$

Buy work-energy theorem

$W = \Delta K = \frac{1}{2}mk^2r^2t^2 - 0$

$P = \frac{dW}{dt} = mk^2r^2t$

Alternative Method: $a_1 = \frac{dv}{dt} = kr$

Power is given by tangential force only. So power $= F_{tv} = ma_{tv} = mk^2r^2t$

Power of centripetal force is zero

44 **(d)**

$a = \frac{v}{t_1}$

Displacement after time t is

$S = \frac{1}{2}at^2 = \frac{1}{2}\frac{v}{t_1}t^2$

$W = FS = maS = m\frac{v}{t_1}\frac{1}{2}\frac{v}{t_1}t^2 = \frac{1}{2}mv^2\left(\frac{t}{t_1}\right)^2$

45 **(a)**

Spring Q has lesser force constant than$P$. So Q will develop less restoring force than P. As a result, Q wi8ll suffer more extension. Since force is same in both the cases, more work will be done on Q

46 **(c)**

Instantaneous force $= mg + (vdm/dt)$, where mg is the force needed for supporting the weight of already hanging section of the rope and vdm/dt is the force needed to supply momentum to the portion of the rope which is to be pulled up

$(mg)_{\max} = (\lambda l)\text{g}, \frac{dm}{dt} = \lambda v$

Hence $F_{\max} = \lambda l\text{g} + \lambda v^2$ and $P_{\max} = \lambda l\text{g}v + \lambda v^3$

47 **(d)**

$\vec{s} = \hat{\imath} + 5\hat{\jmath} + 4\hat{k} = \frac{1}{2}\left(\frac{\vec{F}_1 + \vec{F}_2}{m}\right)(2)^2$ (i)

$\vec{F}_1 = \frac{9(2i - 2j + k)}{\sqrt{2^2 + 2^2 + 1}} = 6i - 6j + 3k$ (ii)

From (i) and (ii), $\vec{F}_2 = -2\hat{\imath} + 26\hat{\jmath} + 13\hat{k}$

Work done by $\vec{F}_2$: $W = \vec{F}_2 . \vec{s} = 180$ J

48 **(c)**

$P = Fv = M\frac{dv}{dt}v$

Hence, $vdv = \frac{P}{m}dt$

On integration, we find $v \propto \sqrt{t}$

49 **(b)**

Minimum force is $mg\sin\theta$. So minimum power is given by

$P = mg\sin\theta\, v$ or $v = \frac{P}{mg\sin\theta}$

or $v = \frac{9000\times 20}{1200\times 10\times 1}\text{ms}^{-1} = 15\text{ ms}^{-1}$

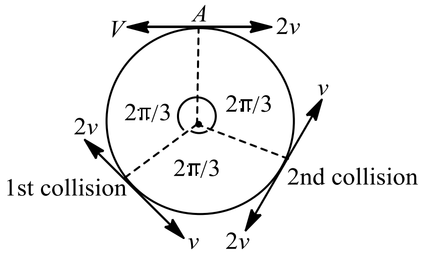
$= 15 \times \frac{18}{5} = 54\text{ km h}^{-1}$

50 **(c)**

A s first collision one particle having speed 2v will rotate

$240°\left(or\frac{4\pi}{3}\right)$while other particle having speed v will rotate

$120°\left(or\frac{2\pi}{3}\right)$. At first collision they will exchange their velocities. Now as shown in figure, after two collisions they will again reach at point A.



51 **(b)**

Solve this question relative to the frame (car) of reference. For maximum velocity (relative to frame), the block must be in equilibrium position

Let x_0 be the equilibrium elongation in spring, then

$ma = kx_0$

From work-energy theorem,

$\frac{mv^2}{2} - 0 = -\frac{kx_n^2}{2} + ma \times x_0$

Solving the above equation, we get $v = a\sqrt{\frac{m}{k}}$

This equation is an application of using the work-energy theorem in non-inertial frame of reference

52 **(c)**

According to the law of conservation of energy, elastic potential energy stored in the spring=gravitational potential energy acquired by shot

$\frac{1}{2}kx^2 = mgh$ or $h = \frac{kx^2}{2mg}$

53 **(b)**

Displacement: $\vec{s} = \vec{r}_2 - \vec{r}_1$, now find $W = \vec{F}.\vec{s}$

54 **(c)**

Given $v = k\sqrt{x}$ *or* $\frac{dx}{dt} = k\sqrt{x}$ or $x^{-\frac{1}{2}}dx = k\ dt$

Integrating both sides, we get

$\frac{x^{\frac{1}{2}}}{\frac{1}{2}} = kt + C$; assuming $x(0) = 0$

Therefore, $C = 0$

$2\sqrt{x} = kt \Rightarrow x = \frac{k^2t^2}{4}$ or $v = \frac{k^2t}{2}$

Therefore, work done

ΔW =increase in KE

$= \frac{1}{2}mv^2 - \frac{1}{2}m(0)^2 = \frac{1}{2}m\left[\frac{k^2t}{2}\right]^2 = \frac{1}{8}mk^4t^2$

55 **(c)**

Since the pendulum started with no kinetic energy, conservation of energy implies that the potential energy, at $Q_{\max}$ must be equal to the or5iginal potential energy, i.e., the vertical position will be same. Therefore,

$L\cos\alpha = l + (L-l)\cos\theta$

$\Rightarrow \cos\theta = \frac{L\cos\alpha - 1}{L-l}$

$\Rightarrow \theta = \cos^{-1}\left[\frac{L\cos\alpha - 1}{L-l}\right]$

56 **(d)**

If the particle is released at the origin, it will try to go in the direction of force. Here dU/dx is positive and hence force is negative, as a result, it will move towards negative x-axis

When the particle is released at $x = 2 + \Delta$, it will reach the point of least possible potential energy (-15 J) where it will have maximum kinetic energy

$\frac{1}{2}mv_{\max}^2 = 25$

$v_{\max} = 5\ \text{ms}^{-1}$

The particle will now perform oscillatory motion with $x = 5$ as mean position

In c., $E_i = u_i + k_i = 15 + 6 = 21$ J

At $x = 10, U_f = 20$

$K_f = 1 \neq 0$

So the particle crosses $x = 10$

57 **(a)**

For the path AC,

$W_{AC} = Fs\cos(90-\theta) = mgs\sin\theta = mgh$ ($\because F = mg$)

For path, $AB, W_{AB} = Fa\cos 90° = 0$

For path BC, $W_{BC} = Fh\cos 0° = mgh$

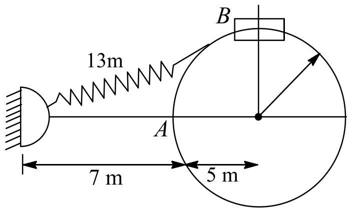
So that $W_{AB} + W_{BC} = mgh = W_{AC}$

i.e., $W_{ABC} = W_{BC}$

Note: *This shows that in a conservation field, w is also independent of the slope of inclined pla*

58 **(c)**

Initial extension will be equal to 6 m

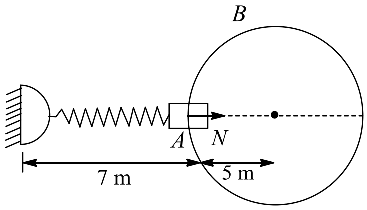


Initial energy $= \frac{1}{2}(200)(6)^2 = 3600$ J

Reaching A, we get $\frac{1}{2}mv^2 = 3600$ J

$mv^2 = 7200$ J

From FBD at A, we get $N = \frac{mv^2}{R} = \frac{7200}{5} = 1440$ N



59 **(b)**

Power used to pump the water $= \frac{mgh}{t} = \frac{100\times10\times10}{5}$

$= 200$ W

Power of engine4 $= 2000 \times \frac{100}{60} = 3.3$ kW

60 **(d)**

$R = u\sqrt{\frac{2h}{g}} \Rightarrow 20 = V_1\sqrt{\frac{2\times5}{10}}$ and $100 = V_2\sqrt{\frac{2\times5}{10}}$

$\Rightarrow V_1 = 20\ m/s, V_2 = 100\ m/s$

Applying momentum conservation just before and just after the collision $(0.01)(V) = (0.2)(20) + (0.01)(100)$

$V = 500\ m/s$

61 **(c)**

At equilibrium position, $x = \frac{mg}{k}$

$U_{\text{spring}} = \frac{1}{2}kx^2 = \frac{1}{2}k\left(\frac{mg}{k}\right)x$

$\frac{mgx}{2} = \frac{1}{2}$ (loss in GPE) $\Rightarrow G = 2S$

62 **(d)**

$N_A + mg\cos 60° = \frac{mv_A^2}{R}$

$N_A = \frac{mv_A^2}{R} - mg\cos 60°$

$= 6\ mg - 0.5\ mg = 5.5\ mg$

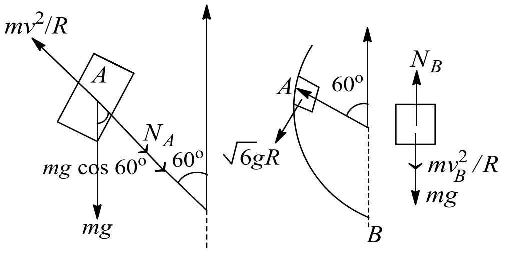
$\frac{1}{2}mv_A^2 + mgR(1+\cos 60°) = \frac{1}{2}mv_B^2$

$v_A^2 + 2gR\left(1+\frac{1}{2}\right) = v_B^2$

$6gR + 3gR = v_B^2$

$v_B^2 + 9\,gR \;\Rightarrow\; v_B = \sqrt{9gR}$

$N_B = mg + \frac{mv_B^2}{R} = 10mg$



63 **(b)**

In case of elastic collision ,coefficient of restitution e=1

or

Relative speed of approach =relative speed of separation.

∴ Option (b)is correct.

64 **(a)**

$m = 1\,kg \;\Rightarrow L = \frac{10}{3}$ m

$\frac{T_{\max}}{T_{\min}} = 4$

and $V_L = \sqrt{V_H^2 + 4g\,L}$

tension at highest point, $T_{\min} = \frac{mv_H^2}{L} - mg$

tension at lowest point,

$T_{\max} = \frac{mv_L^2}{L} + mg = \frac{m(v_H^2 + 4gL)}{L} + mg$

Now Eq. (i) can be written as

$m\left[\frac{v_H^2 + 4gL}{L} + g\right] = 4 \times m\left(\frac{v_H^2}{L} - g\right)$

$\Rightarrow v_H = \sqrt{3gL} = 10\ \text{ms}^{-1}$

65 **(c)**

Displacement of the box relative to the frame of Earth will be$\vec{s} + \vec{s}_0$. Hence, required work done $W = \vec{F}.(\vec{s} + \vec{s}_0)$

Note: work done in the frame of train will be $\vec{F}.\vec{s}$. this shows that work depends on the frame of reference. With change in frame of reference, force does not change while displacement may change

66 **(a)**

First case: $\frac{1}{2}mv^2 = Fs$ (i)

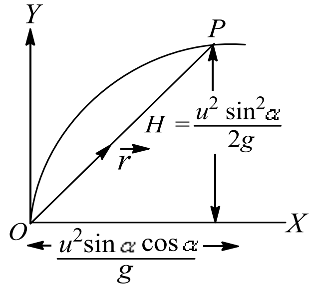
$\frac{1}{2}\left(m + \frac{m}{2}\right)v^2 = Fs'$ (ii)

Dividing Eq. (ii) by Eq. (i), we get $\frac{s'}{s} = \frac{3}{2}$ or $s' = 1.5\,s$

67 **(d)**

$\vec{r} = \frac{u^2 \sin\alpha\cos\alpha}{g}\hat{\imath} + \frac{u^2\sin^2\alpha}{2g}\hat{\jmath}$

$F = -mg\hat{\jmath}, W = \vec{F}.\vec{r} = -\frac{mu^2\sin^2\alpha}{2}$



Alternative method: Velocity at highest point $= u\cos\alpha$

$W_{mg} = \Delta KE = \frac{1}{2}m(u\cos\alpha)^2 - \frac{1}{2}mu^2$

$= -\frac{mu^2\sin^2\alpha}{2}$

68 **(a)**

Loss in PE = Work done against friction

$\Rightarrow mgh = \mu\, mg\, s \;\Rightarrow\; \mu = h/s$

69 **(c)**

As the particle moves only the action of conservation force, its mechanical energy must be conserved. So $\Delta T + \Delta U = 0$ (T stands for kinetic energy)

or $\Delta T = -\Delta U = U_i - U_f$

$= \alpha(3^2 + 3^2) - \alpha(1^2 + 1^2) = 16\,\alpha$

70 **(b)**

In case of non-conservation forces, the work done is dissipated as heat, sound, etc i.e., it does not increase the potential energy. But in case of conservative forces, work done is responsible for increasing or decreasing the potential energy

71 **(c)**

Work done against friction must equal to the initial kinetic energy

$\frac{1}{2}mv^2 = \int_1^\infty \mu mg\,dx \;\Rightarrow\; \frac{v^2}{2} = Ag\int_1^\infty \frac{1}{x^2}\,dx$

$\frac{v^2}{2} = Ag\left[-\frac{1}{x}\right]_1^\infty$

$v^2 = 2gA \;\Rightarrow\; v = \sqrt{2gA}$

72 **(a)**

$mgh = \frac{1}{2}mv^2 + 2mgR$

$gh = \frac{v^2}{2} + 2gR$

Required velocity at the top, $v = \sqrt{gR}$

$gh = \frac{gR}{2} + 2gR \;\Rightarrow h = \frac{5}{2}R$

73 **(a)**

According to the work-energy theorem,

$$\frac{1}{2}mv_0^2 = mg\alpha\int_0^x x\ dx + \frac{1}{2}kx^2$$

Solving we get, $x = v_0\sqrt{\frac{m}{k+\alpha mg}}$

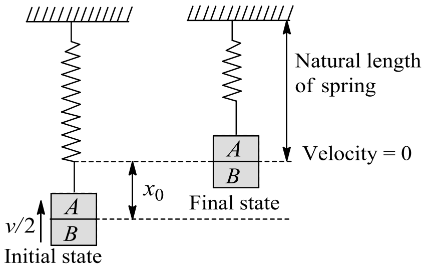
74 **(b)**

Since $k_1 > k_2$

Therefore, P will develop greater restoring force than Q. So the applied force on P will be more than the applied force on Q. Extension is same in both the cases. So, more work will be done on P

75 **(b)**

The initial extension in spring is $x_0 = \frac{mg}{k}$



Just after collision of B with A, the speed of the combined mass is $v/2$

For the spring to just attain natural length, the combined mass must rise up by $x_0 = \frac{mg}{k}$ and come to rest

Applying conservation of energy between initial and final states,

$$\frac{1}{2}2m\left(\frac{v}{2}\right)^2 + \frac{1}{2}k\left(\frac{mg}{k}\right)^2 = 2\ mg\left(\frac{mg}{k}\right)$$

Solving, we get $v = \sqrt{\frac{6mg^2}{k}}$

76 **(c)**

Initial KE $= 0$

Initial PE $= 0$

When the rope is just pulled off the table,

Final KE$= \frac{1}{2}(\lambda l)v^2$

Final PE$=\ (\lambda l)g\frac{l}{2}$

Time taken, $t = \frac{l}{v}$

Average power $= \frac{\text{Net change in energy}}{\text{TIme}}$

$$= \frac{\frac{1}{2}\lambda lv^2 + \frac{\lambda lgl}{2}}{\frac{l}{v}} = \frac{1}{2}\lambda v^3 + \frac{\lambda lvg}{2}$$

77 **(a)**

When four coaches (m each) are attached with an

$P = K\ 6\ mgv$ (i)

(Constant power, K being proportionality constant)

Since resistive force is proportional to weight,

If 12 coaches are attached

$P + K\ 14\ mg\ v_1$ (ii)

So by Eqs. (i) and (ii), $6\ mgv = 14\ mgv_1$

$$v_1 = \frac{6}{14}\times v$$

$$\frac{6}{14}\times 20 = \frac{6\times 10}{7} = \frac{60}{7}$$

$v_1 = 8.5\ \text{ms}^{-1}$

Similarly, for six coaches

$K\ 6\ mgv = k\ 8\ mgv_2$

$$v_2 = \frac{6}{8}\times 20 = \frac{3}{4}\times 20 = \frac{3}{4}\times 20 = 15\ \text{ms}^{-1}$$

78 **(a)**

KE of blocks at B =PE at A −PE at B

$$\frac{1}{2}mv^2 = mgh - mg2r = mg(h-2r)$$

$v^2 = 2g(h-2r)$ (i)

Also, $\frac{mv^2}{r} = x\ mg + mg$

or $v^2 = (x+1)rg$ (ii)

Equating Eqs. (i) and (ii), we get $2g(h-2r) = (x+1)\ gr$

or $2gh = (x+1)gr + 4gr = (x+5)gr$

$$h = \left(\frac{x+5}{2}\right)r$$

79 **(d)**

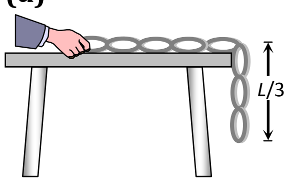
The z-c0omponeent of the force and the x-component of displacement are ineffective here

$dW = F_y dy = 3xy.dy$ $(\because z = 0)$

$= 6x^4dx$ $(\because y = x^2)$

Integrating between $x = 0$ and $x = 2$ gives the result

80 **(d)**



$W = \frac{MgL}{2n^2} = \frac{MgL}{2(3)^2} = \frac{MgL}{18}$ [$n = 3$ Given]

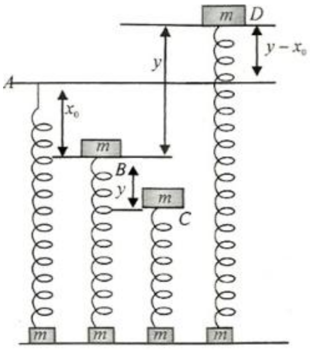
81 **(b)**

'A' is the position of the spring when it is in its normal uncompressed lengthy. The upper disc compresses the spring by x_0 when spring is in equilibrium. So$kx_0 = mg$. Hence, 'B' is the equilibrium position of the spring. Let it be further compressed by y and released. After releasing it can be proved that the spring will go up to the position 'D' so that BC=BD. Extension in the spring at this position= $y - x_0$

Now for lifting up of the lower disc:

$k(y - x_0) = mg \;\Rightarrow\; y = \frac{mg}{k} + x_0$

$\Rightarrow\; y = x_0 + x_0 = 2x_0$



82 **(d)**

Froe equilibrium, potential energy has to be minimum, maximum or constant

83 **(a)**

Since the speed of the particle increase, it kinetic energy also increases$\left(\frac{1}{2}mv^2\right)$. So, work is being done on the particle. However, since centripetal force is normal to the direction of displacement, no work is done by the centripetal force

84 **(c)**

By the conservation of momentum in the absence of external force total momentum of the system (ball + earth) remains constant

85 **(c)**

Work done by pseudo-force = change in PE

$ma_0R = mgR$

$a_0 = \text{g}$

86 **(c)**

$f = kt$

$m\int_0^v dv = k\int_0^t tdt$

$mv = kt^2$

$v = \frac{k}{m}\,t^2$

$\text{KE} = \frac{1}{2}mv^2 = \frac{1}{2}m\frac{k^2}{m^2}t^4 = \left(\frac{k^2}{2m}\right)t^4$

$\text{KE} \propto t^4$

87 **(b)**

Work done by the spring is— change in its internal energy

$W = -\frac{1}{2}kx^2$, since $kx = mg$

$= \frac{-mgx}{2} = -\frac{2\times 10\times 0.01}{2} - 0.1\text{ J}$

88 **(b)**

When a bicycle accelerates, it is in pure rolling motion during which the point of contact between the tyres and the ground is at instantaneous rest. Consequently, $\int \vec{F}.\vec{d}\,s = 0$ $[\because\; d\vec{s} = 0]$

89 **(c)**

If A moves down the incline by 1 m, B shall move up by $\frac{1}{2}$ m. If the speed of B is v, then the speed of A will be $2v$

From conservation of energy,

Gain in KE = loss in PE

$\frac{1}{2}m_A(2v)^2 + \frac{1}{2}m_Bv^2 = m_A\text{g}\times\frac{3}{5} - m_B\text{g}\times\frac{1}{2}$

Solving, we get

$v = \frac{1}{2}\sqrt{\frac{\text{g}}{3}}$

90 **(c)**

$K = \frac{1}{2}mv^2 = \frac{1}{2}mv_0^2 + \frac{1}{2}m\text{g}^2t^2 - mv_0\sin\theta\,\text{g}t$

$U = mv_0\sin\theta\,\text{g}t - \frac{1}{2}m\text{g}^2t^2$

If $K = U \;\Rightarrow \text{g}^2t^2 - 2v_0\text{g}t\sin\theta = \frac{v_0^2}{2} = 0$

Discriminant is negative for $\theta = 30°$

Therefore, the two curves do not touch

91 **(c)**

When block C is released from rest, it sides down on A, pushing it against the wall (because of a component of normal force between A and C), as on left of A a wall is there, it does not move. The kinetic energy of block C incrases and it becomes mgh when it is just going to pass on B

When block C comes in contact with B, sue to horizontal component of normal force between C and B, B starts moving towards right and kinetic energy of C gets converted into kinetic energy of B and potential energy of C, so block C is not able to reach the topmost point of B. Then block C starts sliding down B, but velocity of B will still be increasing and becomes maximum when C reaches its bottom-most point and is moving left

92 **(a)**

Total work done is equal to the energy stored in the spring

93 **(b)**

Tension in the string

$T = M(g - a) = Mg\left(g - \frac{g}{2}\right) = \frac{Mg}{2}$

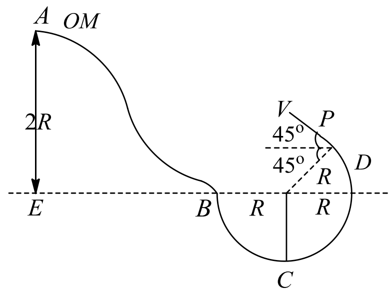
W = Force × Displacement $= -M\left(\frac{g}{2}\right)h$

Negative sing is because tension is in the upward direction and displacement is in the downward direction

94 **(a)**

Applying conservation of energy, we get

$2mgR - mg\frac{R}{\sqrt{2}} = \frac{1}{2}mu^2 \Rightarrow u = \sqrt{4gR - \sqrt{2}\,gR}$



$H_{\max} = R + \frac{R}{\sqrt{2}} + \frac{u^2 \sin^2 45°}{2g}$

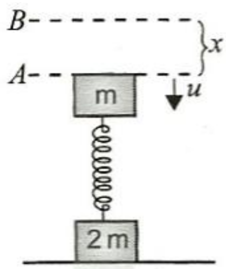
$= R + \frac{R}{\sqrt{2}} + \frac{4gR - \sqrt{2}\,gR}{2g \times 2}$

$= 2R + \frac{R}{\sqrt{2}} - \frac{R}{2\sqrt{2}}R\left[2 + \frac{1}{2\sqrt{2}}\right]$

95 **(b)**

$u = \sqrt{2gh}$

To lift the block B, the elongation x must be $2mg/k$



Applying work-energy theorem between A and B, we get

$0 - \frac{1}{2}mu^2 = -\frac{1}{2}mgx - \frac{1}{2}kx^2$

$\Rightarrow \frac{1}{2}mu^2 = mg\frac{2mg}{k} + \frac{1}{2}k\frac{4m^2g^2}{k}$

$\therefore u^2 = \frac{8mg^2}{k} = 2gh \Rightarrow h = \frac{4mg}{k}$

96 **(c)**

When a weightlifter lifts a weight by height h (say), then work done by the lifting force F

$W_1 = RFs\cos 0° = +Fh$

But work done in holding it up is zero because the displacement is zero

97 **(a)**

Work done in lifting water and drum is

$60 \times 10 \times 20$ J = 12000 J

Total mass of ropes = 40×0.5 kg = 20 kg

Work done in the case of ropes is

$20 \times 10 \times 10 = 2000$ J

Total work done= 14000 J

98 **(a)**

In the explosion of a bomb or inelastic collision between two bodies as force is internal, momentum is conserved while KE changes. Hence, the KE of a system can be changed without changing its momentum. Similarly, the reverse is also true, e.g., if a force acts perpendicular to motion, work done will be zero and so KE will remain constant. However, the force will change the direction of motion and so the momentum. Further, body may have energy (i.e., potential energy without having momentum)

99 **(c)**

Conservation of energy fives

$\frac{1}{2}mv^2 = mgR\sin\theta \Rightarrow \frac{mv^2}{R} = 2mg\sin\theta = F_C$

Now, $N - mg\sin\theta = F_C \Rightarrow N = 3\,mg\sin\theta$

$\therefore \frac{F_C}{N} = \frac{2}{3}$

100 **(d)**

Because both the teams balance each other, displacement is zero. Therefore, work done is also zero

101 **(a)**

Work done, $W = mgh + \mu ghL$

Which is a constant

102 **(a)**

From work-energy theorem, for upward motion

$\frac{1}{2}m(16)^2 = mgh + W$ (work done by air resistance) for downward motion

$\frac{1}{2}m(8)^2 = mgh - W \Rightarrow \frac{1}{2}[(16)^2 + (8)^2] = 2gh$

or $h = 8$ m

103 **(a)**

If h be the height of the ball above the floor and H the height from which the ball is dropped, then

$E = \frac{1}{2}mv^2$ =loss in PE or KE= $mg(H - h)$ or

$KE = -mgh + mgH$, which is of the form

$y = -ma + c$

104 **(d)**

$Power = Fv \propto v$

$\Rightarrow mv\frac{dv}{dt} = kv$, where k = constnat

$\Rightarrow m\frac{dv}{dt} = k \Rightarrow mv\frac{dv}{dx} = k$

$\Rightarrow vdv = \frac{k}{m}\,dx$

Integrating both sides, we get $\frac{v^2}{2} = \frac{k}{m}x$

Hence, displacement is proportional to square of instantaneous velocity

105 **(a)**

Applying the work-energy theorem, we get

$\frac{1}{2}mv^2 - 0 = F \times R + mg \times R$

$\frac{1}{2} \times \frac{1}{2} \times v^2 = 5 \times 5 + \frac{1}{2} \times 10 \times 5 = 50$

$v = \sqrt{200} = 14.14\ \text{ms}^{-1}$

106 **(a)**

$\frac{1}{2}kx^2 = mgh \;\Rightarrow\; x = \sqrt{\frac{2mgh}{k}}$

107 **(c)**

Velocity at lowest position $= \sqrt{2gl(1-\cos 60°)} = \sqrt{gl}$

$T = mg = \frac{mV^2}{l} = mg + \frac{m}{l}gl = 2mg$

$\therefore\; T = \mu 4\,mg \;\Rightarrow \mu = \frac{1}{2}$

108 **(b)**

The position of equilibrium corresponds to $F(x) = 0$

Since $F(x) = \frac{-dU(x)}{dx}$

So $F(x) = -\frac{d}{dx} = \left(\frac{a}{x^4} - \frac{b}{x^2}\right)$ or $F(x) = \frac{4a}{x^5} - \frac{2b}{x^3}$

For equilibrium, $F(x) = 0$, therefore

$\frac{4a}{x^5} - \frac{2b}{x^3} = 0 \;\Rightarrow x = \pm\sqrt{\frac{2a}{b}}$

$\frac{d^2U(x)}{dx^2} = -\frac{20a}{x^6} + \frac{8b}{x^4}$

Putting $x = \pm\sqrt{\frac{2a}{6}}$ gives $\frac{d^2U(x)}{dx^2}$ is negative

So U is maximum, hence it is position of unstable equilibrium

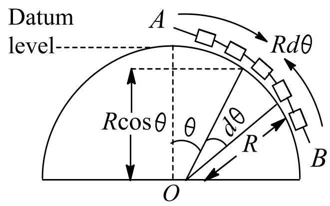
109 **(d)**

$x = x_1$ and $x = x_3$ are not equilibrium positions because $du/dx \neq 0$ at these points

$x = x_2$ is unstable equilibrium position, as U is maximum at this point

110 **(d)**

The mass of elemental length of chain subtending angle $d\theta$ at the centre $= \frac{m}{l}(Rd\theta)$



$\therefore$ Its PE $= \frac{m}{l}(Rd\theta)g[-(R - R\cos\theta)]$

The negative sign implies that the elemental length is below the datum level. Therefore,

$dU = \frac{-mgR^2}{l}(1-\cos\theta)d\theta$

Therefore, total PE of the chain

$U = \int_0^{\frac{1}{R}} -\frac{mgR^2}{l}(1-\cos\theta)d\theta$

$\Rightarrow\; -\frac{mgR^2}{l}[\theta - \sin\theta]_0^{\frac{1}{R}} = -\frac{mgR^2}{l}\left[\frac{l}{R} - \sin\frac{l}{R}\right]$

111 **(d)**

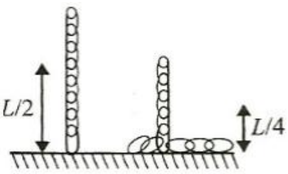
Here PE= Work done

$mgH = \mu_{\text{kinetic}}\,mgS$ or $S = \frac{H}{\mu_{\text{kinetic}}}$

The particle covers the length l or not or covers it repeatedly is determined by the above relation

112 **(c)**

The work done by the man is negative of the magnitude of decrease in potential energy of the chain



$\Delta U = mg\frac{l}{2} - \frac{m}{2}g\frac{l}{4} = 3\,mg\frac{l}{8}$

$W = -\frac{3mgl}{8}$

113 **(a)**

Area under $P - x$ graph

$= \int Pdx = \int\left(m\frac{dv}{dt}\right)v\,dx = \int_1^v mv^2\;dV$

$= \left[\frac{mv^3}{3}\right]_1^v = \frac{10}{7\times 3}\;(v^3 - 1)$

From the graph, area $= \frac{1}{2}(2+4)\times 10 = 30$

$= \frac{10}{7\times 3}(v^3 - 1) = 30$

$\therefore\; v = 4\ \text{ms}^{-1}$

Alternative method:

From graph

$P = 0.2\,x + 2$

$mv\;\frac{dv}{dx}v = 0.2\,x + 2$

$mv^2dv = (0.2x + 2)dx$

Now integrating both sides, we get

$$\int_1^v mv^2\ dv = \int_0^{10} (0.2x+2)\ dx$$

$v = 4\ \text{ms}^{-1}$

114 **(b)**

Power $P = \dfrac{\text{Work}}{\text{Time}}$

Work done by both will be same

Hence, $\frac{P_1}{P_2} = \frac{t_2}{t_1} = \frac{20}{15} = \frac{4}{3}$

115 **(d)**

$E_k = \dfrac{1}{2mv^2} = kt \ \Rightarrow$ Power $P = \left(\dfrac{dE_x}{dt}\right) = k$

In this case, $P + Fv$

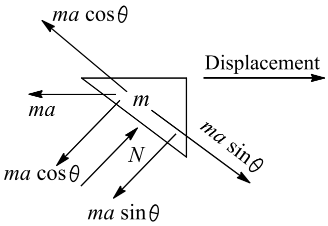
Hence, $F = \frac{P}{v} = \frac{K}{\sqrt{\frac{2Kt}{m}}} = \frac{K'}{\sqrt{t}}$

Where K' is another constant

116 **(a)**

ma is pseudo-force

We find that $mg \sin\theta$ is equal to$ma\cos\theta$. So block remains stationary w.r.t. cage and there is no need of friction

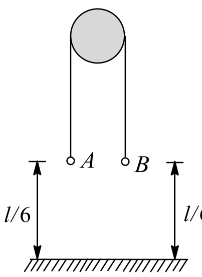


Statement (i) is correct because angle between N and displacement is positive, Friction force acting on the block is zero, hence no work will be done by friction, so **Statement (ii)** is incorrect

117 **(a)**

Final figure is shown below. It can be obtained as follows

We can assume that a part of length 1/6 is cut from the lower portion of side B, and part below A



Mass of this part= $\frac{m}{6}$

This part rises by $= \frac{l}{6}$

Work done=Increase in PE= $\frac{m}{6\ell}g\frac{\ell}{6} = \frac{mg\ell}{36}$

118 **(c)**

Work done $= \mu\, mg\, S = 04 \times 40 \times 10 \times 20$ J = 3200 J

119 **(b)**

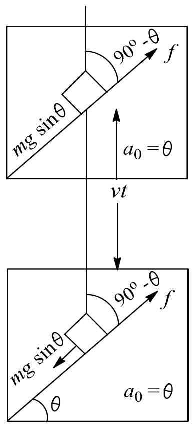
Effective length becomes double during sudden release

120 **(b)**

Since the lift's speed is constant, in the absence of acceleration, there will be no pseudo-force (referring to the lift as the frame of reference) or additional reaction/thrust due to inclined plane (referring to ground as the reference frame) on the particle

Therefore, friction= $mg\sin\theta$ acting along the plane. Distance moved by the particle (or lift) in time $t = vt$ Work done in time

$t = (mg\sin\theta)vt(\cos 90 - \theta) = mg\sin^2\theta\ vt$



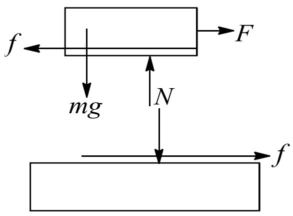
121 **(c)**

From the data, it is clear that mechanical energy is decreased

122 **(b)**

Maximum frictional force between the slab and the block

$f_{\max} = \mu N = \mu\, mg = \frac{1}{4} \times 4 \times 10 = 10$ N



Evidently, $f < f_{\max}$

So, the two bodies will move together as a single unit. If a be their combined acceleration, then

$$a = \frac{F}{m+M} = \frac{6}{4+5} = \frac{2}{3}\ \text{ms}^{-2}$$

Therefore, frictional force acting can be obtained as

$$f = Ma = \frac{2}{3} \times 5\ \text{N} = \frac{10}{3}\ \text{N}$$

Using $s = \frac{1}{2}at^2$

$s(2) = \frac{1}{2} \times \frac{2}{3}(2)^2 = \frac{4}{3}$ and $s(3) = \frac{1}{2} \times \frac{2}{3}(3)^2 = 3$

Therefore, work done by friction $= f[s(3) - s(2)]$

$= \frac{10}{3}\left[3 - \frac{4}{3}\right]$

$= \frac{50}{9} = 5.55$ J

123 **(d)**

By the work-energy theorem, $\frac{1}{2}mu^2 = \mu mgS + \frac{1}{2}kS^2$

i.e., $S^2 + \frac{2\mu mgS}{k} - \frac{mu^2}{k} = 0$

$\Rightarrow S = \frac{\frac{-2\mu mg}{k} + \sqrt{\frac{4\mu^2m^2g^2}{k^2} + \frac{4mu^2}{k}}}{2}$

$= \frac{-\mu mg + \sqrt{\mu^2m^2g^2 + mu^2k}}{k}$

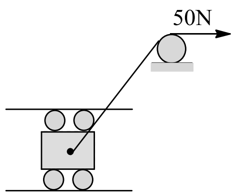
124 **(b)**

$P = Tv$ (numerically)

$= 4500 \times 2 = 9000$ W $= 6$ kW

125 **(b)**

Consider the rope and the block as a system. From work-energy theorem, $\Delta K = W_{\text{net}}$



Here only two forces do non-zero work on the system: one is the spring force and the other is the constant force of 50 N acting on the cable4. Let v be the speed of the block when it reaches B, then

$\frac{mv^2}{2} - 0 = -\left[\frac{k\times5^2}{2} - \frac{k\times1^2}{2}\right] +$ work done by 50 N force

Horizontal displacement of the rope over pulley as the block moves from A to B is $x = \sqrt{4^2 + 3^2} - 3 = 2$ m;

This is same as displacement of point of application of 50 N force

So, $\frac{mv^2}{2} = -\left[\frac{5\times5^2}{2} - \frac{5\times1^2}{2}\right] + 50 \times 2$

$= \frac{20 \times v^2}{2} = 40$

$\Rightarrow\ v = 2\ \text{ms}^{-1}$

126 **(b)**

Gravitational field is a conservative force field. In a conservative force field work done is path independent.

$\therefore \quad W_1 = W_2 = W_3$

127 **(a)**

From the conservation of energy

KE + PE $= E$ or KE $= E - \frac{1}{2}kx^2$

KE at $x = -\sqrt{\frac{2E}{k}}$ is $E - \frac{1}{2}k\left(\frac{2E}{k}\right) = 0$

The speed of particle at $x = -\sqrt{\frac{2E}{k}}$ is zero

128 **(d)**

Average power $< P = \frac{<W>}{t} = \frac{-mu^2\sin^2\alpha}{2\left(\frac{u\sin\alpha}{g}\right)}$

$= \frac{-mg\,u\sin\alpha}{2}$

[Since time taken to go from O to $P = \frac{u\sin\alpha}{g}$]

129 **(d)**

$f(x) = -\frac{dU}{dx}(x)$ or $U(x) = -\int F(x)\ dx$

Here $F(x) = -kx$, where k is a positive constant

130 **(d)**

$u = 10\ \text{ms}^{-1}, v = 20\ \text{ms}^{-1}$

Work done = Increase in kinetic energy

$= \frac{1}{2} \times 500[20^2 - 10^2] = \frac{500 \times 30 \times 10}{2}$

Power$= \frac{500\times30\times20}{2\times60} = 1250$ W

131 **(c)**

$f = \frac{3}{10}mg$

$W = -fs$

$= -\frac{3}{10}mgS$

$= -\frac{3}{10} \times 200 \times 10$ J $= -600$ J

132 **(d)**

Work done by friction force is equal to negative of the work done by the coolies

133 **(d)**

Statement I: Work done by gravity is same for motion from A to J and B to M fro equal mass. So KE will be equal

Statement II: Acceleration $= g\sin\theta$

$\sin\theta_A > \sin\theta_B \quad \Rightarrow \frac{h}{l} > \frac{h}{2l}$

Statement III: $W_g + W_{\text{ext}} = 0$ (Because the block moves slowly)

$W_{\text{ext}} = -W_g$

From B to O: W_g is positive, so $W_{\text{ext}} < 0$

134 **(c)**

Minimum stopping distance $= s$

Work done against the friction $= W = \mu mgs$

Initial momentum gained by both toy carts will be same

Because same force acts for same time

Initial kinetic energy of the toy cart $= \left(\frac{p^2}{2m}\right)$

Therefore, $\frac{\mu mgsp^2}{2m}$ or $s = \left(\frac{p^2}{2\mu gm^2}\right)$

For the two toy carts, momentum is numerically the same. Further μ and g are the same for the toy carts. So

$$\frac{s_1}{s_2} = \left(\frac{m_2}{m_1}\right)^2$$

135 **(a)**

$$F = \frac{k}{r^2}$$

$$U = -\int \vec{F}.d\vec{r} - \int \vec{F}.d\vec{r}\cos\pi$$

$$\int F\,dr = \frac{k}{r^2 dr} = -\frac{k}{r}l$$

V_2 =radial velocity $= \frac{dr}{dt}$

Hence, KE due to this velocity $= \frac{1}{2}\left(\frac{dr}{dt}\right)^2 m$

V_1 = tangential velocity and $mV_1 r = L$

$$\therefore\ V_1 = \frac{L}{mr}$$

KE due to tangential velocity $= \frac{1}{2}\,mV_1^2 = \frac{1}{2}m\frac{L^2}{m^2r^2}$

$$= \frac{1}{2}\frac{L^2}{mr^2}$$

Total energy $= KE_{\text{total}} + \text{PE}$

$$= \frac{1}{2}m\left(\frac{dr}{dt}\right)^2 + \frac{1}{2}\frac{L^2}{mr^2} - \frac{k}{r}$$

Note: *Work done by friction is independent of c horizontal span of inclined plane*

136 **(a)**

Work done by braking force=change in KE

$$-Fs = 0 - KE_i \ \Rightarrow s = \frac{KE_i}{F}$$

KE_i and F are same for both, Hence, s is also same for both

137 **(c)**

While moving from (0,0) to $(a, 0)$

Along positive x-axis, $y = 0\ \therefore \vec{F} = -kx\hat{j}$

$i.e.$, force is in negative y- direction while displacement is in positive x-direction

$\therefore W_1 = 0$

Because force is perpendicular to displacement

Then particle moves from $(a, 0)$ to $(a.a)$ along a line parallel to y-axis $(x = +a)$ during this

$\vec{F} = -k(y\hat{i} + a\hat{j})$

The first component of force, $-ky\hat{i}$ will not contribute any work because this component is along negative x-direction $(-\hat{i})$ while displacement is in positive y-direction $(a, 0)$ to (a, a). The second component of force $i.e.\ -ka\hat{j}$ will perform negative work

$\therefore W_2 = (-ka\hat{j})(a\hat{j}) = (-ka)(a) = -ka^2$

So net work done on the particle $W = W_1 + W_2$

$= 0 + (-ka^2) = -ka^2$

138 **(c)**

Stopping distance $= \frac{\text{kinetic energy}}{\text{retarding force}} \Rightarrow s = \frac{1}{2}\frac{mu^2}{F}$

If lorry and car both possess same kinetic energy and retarding force is also equal then both come to rest in the same distance

139 **(b)**

$$E' = \frac{1}{2}m[20^2 - 10^2] = \frac{1}{2}m \times 30 \times 10$$

$$E = \frac{1}{2}m \times 10 \times 10$$

$$\frac{E''}{E} = \frac{\frac{1}{2}m \times 30 \times 10}{\frac{1}{2}m \times 10 \times 10} = 3 \text{ or } E' = 3E$$

140 **(a)**

At any time,

$\vec{v} = [u\cos\theta]\hat{\imath} + [(u\cos\theta - gt)\hat{\jmath}]$

$P = \vec{F}.\vec{v} = (-mg\hat{\jmath}).[u\cos\theta\,\hat{\imath} + (u\sin\theta - gt)\hat{\jmath}]$

$= mg^2t - mg\,u\sin\theta$

Hence, power varies linearly with time

141 **(b)**

$dU = -\vec{F}.ds = -\vec{F}.(dx\hat{\imath} + dy\hat{\jmath})$

Also by reverse method using $F_x = -\frac{\partial U}{\partial X}$ and $F_y = -\frac{\partial U}{\partial Y}$, only option (b) satisfies the criteria

142 **(b)**

$W_{\text{gravity}} = \Delta U_{\text{spring}}$

$$mg\sin\theta\,(d + 0.25) = \frac{1}{2}k(0.25)^2$$

Which gives $d = 37.5$ cm

143 **(c)**

From energy conservation,

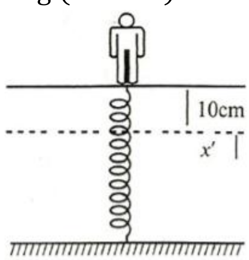
$$\frac{1}{2}kx^2 = \frac{1}{2}(4k)y^2$$

$$\frac{y}{x} = \frac{1}{2}$$

144 **(d)**

Initially, $60\text{ g} = kx = k(2.5)$ (i)

Let x' be the maximum compression when the person jumps on the balance, then $\frac{1}{2}kx'^2 = 60\text{g}\,(x' + 10)$



$$\Rightarrow \frac{1}{2}\left[\frac{60\text{ g}}{2.5}\right]x'^2 = 60\text{ g}(x' + 10) \Rightarrow x'^2 = 5x'^2 + 50$$

$$\Rightarrow\ x'^2 = 5x' - 50 = 0$$

Solving for x', we get $x' = 10$ cm

If m kg is the reading, then

$mg = k(10)$ (ii)

From Eqs. (i) and (ii), we get $m = 240$ kg (ii)

145 **(b)**

$$F_x = -\frac{\partial U}{\partial X} = \sin(x+y) = \frac{1}{\sqrt{2}}$$

$$F_y = -\frac{\partial U}{\partial Y} = \sin(x+y) = \frac{1}{\sqrt{2}}$$

$$\vec{F} = \frac{1}{\sqrt{2}}[\hat{\imath} + \hat{\jmath}]$$

146 **(b)**

From work-energy theorem, net work done by all forces (internal and external)=change in kinetic energy

$\Rightarrow$ Work done by gravity + work done by air drag

$= \frac{1}{2} \times 70(20^2 - 0^2)$

$\Rightarrow$ Work done by air drag= $14000 - 35000 = -21000$ J

147 **(c)**

$$\int F dt = \Delta \rho$$

$$\Rightarrow \frac{1}{2} \times 4 \times 3 - \frac{1}{2} \times 1.5 \times 2 = p_f - 0 \Rightarrow p_f$$

$$= 6 - 1.5 = \frac{9}{2}$$

$$K.E. = \frac{p^2}{2m} = \frac{81}{4 \times 2 \times 2}; K.E. = 5.06\,J$$

148 **(a)**

$$W = \int_{x_1}^{x_2} F_x\,dx + \int_{y_1}^{y_2} F_y\,dy + \int_{z_1}^{z_2} F_z\,dz$$

$$= \int_1^3 2x\,dx + \int_2^6 2dy + \int_3^1 3z^2\,dz = -10 \text{ J}$$

149 **(b)**

Given $a_n = kt^2$

or $\frac{v^2}{r} = kt^2$ or $v^2 = krt^2$

$\therefore$ Average power delivered $= \frac{\text{Total work done}}{\text{Total time elapsed}}$

$= \frac{\text{Increase in KE}}{\text{Total time elapsed}}$

or $< P >= \frac{\frac{1}{2}m(v^2 - 0^2)}{t_0} = \frac{m}{2}\frac{krt_0^2}{t_0} = \frac{mkrt_0^2}{2}$

Alternative: $v = \sqrt{krt} \Rightarrow a_t = \sqrt{kr}$

$P = F_t v = ma_1 v = m\,krt$

$$< P >= \frac{\int_0^{t_0} Pdt}{t_0} = \frac{1}{2}mkrt_0^2$$

150 **(a)**

$$a = \frac{\text{Net pulling force}}{\text{Total mass}}$$

$$= \frac{0.72g - 0.36g}{0.72 + 0.36} = \frac{g}{3}$$

$$s = \frac{1}{2}at^2 = \frac{1}{2}\left(\frac{g}{3}\right)(1)^2 = \frac{g}{6}$$

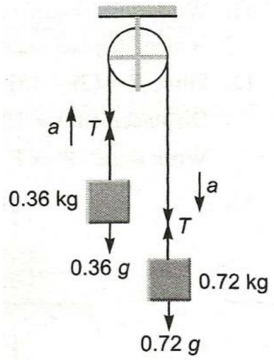
$T - 0.36g = 0.36a = 0.36\frac{g}{3}$

$\therefore T = 0.48g$

Now, $w_T = TS\,\cos 0°(on\ 0.36\ kg\ mass)$

$= (0.48\,g)\left(\frac{g}{6}\right)(1) = 0.08(g^2)$

$= 0.08(10)^2 = 8$J



151 **(c)**

From work-energy theorem,

$\Delta\text{KE} = W_{\text{net}}$ or $K_f K_i = \int P\,dt$

or $\frac{1}{2}mv^2 - 0 = \int_0^2 \left(\frac{3}{2}t^2\right)dt$ or $v^2 = \left[\frac{t^3}{2}\right]_0^2$

or $v = 2\text{ ms}^{-1}$

152 **(c)**

$P = Fv = m\frac{dv}{dt}v$ or $v\frac{dv}{dt} = \frac{P}{m}$

or $v\frac{dv}{dx}\frac{dx}{dt} = \frac{P}{m}$ or $v^2\frac{dv}{dx} = \frac{P}{m}$

or $v^2\,dv = \frac{P}{m}dx$

On integration, we get $\frac{v^3}{3} = \frac{Px}{m}$ or $v = \left(\frac{3xP}{m}\right)^{\frac{1}{3}}$

153 **(a)**

From work-energy theorem,

$$W = \Delta\text{KE} = K_f - K_i = \frac{1}{2}m(v_f^2 - v_i^2)$$

$$= \frac{1}{2} \times 2[(-20)^2 - (10)^2] = 300 \text{ J}$$

154 **(b)**

Let x be the extension in the string when 2 kg block leaves the contact with ground. Then tension in the spring should be equal to weight of 2 kg block:

$Kx = 2$g or $x = \frac{2g}{K} = \frac{2 \times 10}{40} = \frac{1}{2}$m

Now from conservation of mechanical energy,

$$mgx = \frac{1}{2}Kx^2 + \frac{1}{2}mv^2$$

or $v = \sqrt{2gx - \frac{Kx^2}{m}} = \sqrt{2 \times 10 \times \frac{1}{2} - \frac{40}{4\times5}} =$
$2\sqrt{2}\ \text{ms}^{-1}$

155 **(d)**

Given $\vec{F} = (xy^2)\hat{\imath} + (x^2y)\hat{\jmath}$

$$W = \int F_x\,dx + \int F_y\,dy = \int xy^2\,dx + \int x^2y\,dy$$

$$= \frac{1}{2}\int d(x^2y^2) = \left[\frac{x^2y^2}{2}\right]_{(0,0)}^{(4,0)} = 0$$

156 **(a)**

Work done by man, $mgL = mg(L-s) + mgs$ where $mg(L-s)$ is the increase in potential energy of the man and mgs is the increase in potential energy of the balloon because the4 balloon would have been lifted up but for the climbing of the man. So

$$\frac{\text{Increase in PE og man}}{\text{Increase in PE of balloon}} = \frac{mg(L-s)}{mgs} = \frac{L-s}{s}$$

157 **(d)**

The initial potential energy of the object is mgh, which has been used up for work against the force of friction. In returning the body to its initial position, the force performs the same work against friction. In addition, it imparts top the object the initial potential energy. As a result, the total work will be $2mgh$

158 **(b,c)**

If the man starts walking with velocity v (relative to the car) along the rails, the car recoils. Let the velocity with which the car recoils be V

Then, resultant velocity of the man will be equal to $(v - V)$

Since the car moves without friction, there is no external horizontal force on the system of man and car. Hence, applying conservation of momentum, we get

$$MV = m(v - V) \text{ or } V = \frac{mv}{m+M}$$

Work done by the man is used to provide kinetic energy to the car and to the man himself

Hence work done by him

$$W = \frac{1}{2}m(v-V)^2 + \frac{1}{2}mV^2 = \frac{1}{2}\left(\frac{mM}{m+M}\right)v^2$$

But $[m\,M/m + M]$ is less than m and M both, therefore W is less than $\frac{1}{2}mv^2$. Hence, option **a.** is wrong and **b.** is correct

If the man moves normal to the rails, then the car will not move. Hence in that case, man moves along with velocity v. Hence, work by him is used to provide kinetic energy to his own body which is equal to $\frac{1}{2}mv^2$. Hence, option **c.** is correct. Since option **b.** is correct, option **d.** is wrong

159 **(a,b)**

The change in momentum for each time internal t_0 is $\Delta p = Ft_0$ which is constant

But the change in kinetic energy in each time internal t_0 is different

First t_0 interval : $\Delta K_1 = \frac{\Delta p^2}{2m} = \frac{F^2t_0^2}{2m}$

Second t_0 interval: $\Delta K_2 = \frac{(\Delta p)^2 - (\Delta p)^2}{2m} = \frac{3F^2t60^2}{2m}$

The change in kinetic energy is $\Delta K = Fx_0$ =constnat

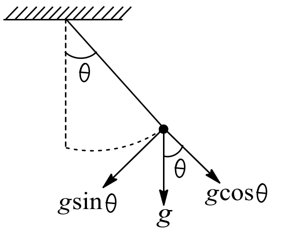
First x_0 displacement : $\Delta p_1 = \sqrt{2m\,\Delta K_1} = \sqrt{2m(Fx_0)}$

Second x_0 displacement

$\Delta p_2 = \sqrt{2m(2Fx_0)} - \sqrt{2m(Fx_0)} = 0.414\sqrt{2m(Fx_0)}$

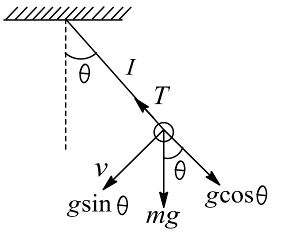
160 **(b,c)**

Since the body is moving in a circular path, it needs centripetal force (Mv^2/l)



$\therefore T - mg\cos\theta = MV^2/l$

Also the tangential acceleration acting on the mass is $g\sin\theta$



161 **(b)**

The force constant of a spring is inversely proportional to the length of the spring be L and spring constant be K (given)

Therefore, $K \times L = \frac{2L}{3} \times K' \Rightarrow K' = \frac{3}{2}K$

162 **(a,b,c)**

According to the work-energy theorem for a non-conservative system, we have $W_c + W_{nc} = \Delta K$

Also, we know that the work done by a conservation force equals the decrease in potential energy, so $W_c = -\Delta U$

$W_{nc} - \Delta U = \Delta K$

163 **(b)**

Friction decreases due to lubrication, which increases efficiency. Mechanical advantage depends upon geometrical construction of machine

164 **(b,d)**

The statement given in option (b) is a very standard concept related to the work-energy theorem. Work-energy theorem can be applied to any system

Work-energy theorem can be applied to non-inertial frames of reference also, provides the work done by inertial forces is also considered on right-hand side of the work-energy theorem

165 **(b,d)**

b. Think in terms of positive work

d. Since the kinetic energy is increasing, momentum would also increase

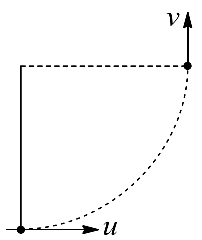
166 **(d)**

From energy conservation,

$v^2 = u^2 - 2gL$ (i)

Now, since the two velocity vectors shown in figure are mutually perpendicular, the magnitude of change of velocity will be given by

$|\Delta\vec{v}| = \sqrt{u^2 + v^2}$



Substituting the value of v^2 from Eq. (i),

$|\Delta\vec{v}| = \sqrt{u^2 + u^2 - 2gL} = \sqrt{2(u^2 - gL)}$

167 **(a,b,c,d)**

Work done by a force of friction can be positive, negative as well as zero, depending upon whether the force acts in the direction of displacement, opposite to the direction of displacement or force does not displace the body. So, all the options are correct

168 **(c)**

$p = \sqrt{2Km} \Rightarrow p \propto \sqrt{m}$

$\frac{m_1}{m_2} = \frac{1}{4} \therefore \frac{p_1}{p_2} = \frac{1}{2}$

169 **(a,c,d)**

Option (a) is correct because at 3, force is opposite to displacement. At (b), u is minimum

Option (b) is incorrect because at 2, there is net force and hence no equilibrium

Option (c) is correct because at 1, 3 and (b) force is zero

At (b), $\frac{du}{dx} = -F = 0$

Option (d) is correct. Positive work is done after position 1, hence KE will increase, So KE is least at 1

170 **(a,c)**

Since, force on the vehicle is constant, it will move with a constant acceleration

Let this acceleration be a

Then at time t, its velocity will be equal to $v = at$

Hence, at time t, the kinetic energy,

$KE = \frac{1}{2}mv^2 = \frac{1}{2}ma^2t^2$

It means, graph between E and t will be a parabola of increasing slope. Hence, option c. is correct

The power associated with the force is equal to

$P = Fv = Fat$

Hence, the graph between power and time will be a straight line passing through the origin. Hence, option **a.** is also correct

171 **(c,d)**

Since it is inelastic collision, energy will be lost, therefore, energy is not same. Hence option (b) is incorrect. The linear momentum of ball will not be before and after the collision as there is an impulsive force on the ball by ground

Hence, (a) is incorrect

For the system ball and earth, the impulsive forces become internal, hence linear momentum of system will be conserved

Hence, option (c) is correct

Option (d) is correct because the total energy of the system is definitely conserved even if some energy is in form of heat or sound etc.

Thus, option (c) and (d) are correct

172 **(b,d)**

When $m_1 > m_2$ and m_2 at rest, after collision the ball of mass m_2 moves with double the velocity of u_1. So option (b) is incorrect

When collision is oblique and m_2 at rest with $m_1 = m_2$, after collision the ball moves in perpendicular direction. So option (d) is also incorrect

173 **(b,d)**

Initially, there will be collision between C and A which is elastic. So by conservation of momentum, we have

$mv = mv_A + mv_C$

$v = v_A + v_C$ (i)

And as in elastic collision, KE after collision is same as before collision; hence

$\frac{1}{2}mv^2 = \frac{1}{2}mv_A^2 + \frac{1}{2}mv_C^2$

i.e., $v^2 = v_A^2 + v_C^2$

Subtracting Eq. (ii) from the square Eq. (i), we have

$2v_Av_C = 0$

So, either $v_A = 0$ or $v_C = 0$

$v_A = 0$ corresponds to no interaction between A and C, so the only physically possible solution is $v_C = 0$, which in the light of Eq. (i) gives $v_A = v_0$, i.e., after collision C stops and A starts moving with velocity v_0. Now A will move and compress the spring which in turn accelerates B and retards A and finally both A and B will move with same velocity (say$V$). In this situation, compression of the spring will be maximum

As external force is zero, momentum of the system ($A + B +$ spring) is conserved, i.e.,

$mv = (m + m)V \Rightarrow V = \frac{v}{2}$

So, KE of the AB system at maximum compression

$\frac{1}{2} \times 2m \times \left(\frac{v}{2}\right)^2 = \frac{1}{4}mv^2$

By conservation of mechanical energy,

$\frac{1}{2}mv^2 = \frac{1}{2}(m + m)V^2 + \frac{1}{2}kx_0^2$

Or $mv^2 - 2m\left(\frac{v_0}{2}\right)^2 = kx^2$

i.e., $k = \frac{mv^2}{2x_0^2}$ or $x_0 = v\sqrt{\frac{m}{2k}}$

174 **(a,d)**

Initial momentum of the system is zero in all three directions

$\sum \vec{P}_x = 0, \sum \vec{P}_y = 0$ and $\sum \vec{P}_z = 0$. So, by the law of conservation of linear momentum after collision is must be zero. According to option (a) and (d) it is not possible

175 **(b,c)**

Let the mass of the block hanging from the spring be m. Then initial elongation of the spring will be equal to mg/k. When the force F is applied to pull the block down, the work done by F and further loss of gravitational potential energy of the block is used to increase strain energy of this spring

$(F\delta + mg\delta) = \left[\frac{1}{2}k\left(\frac{mg}{k} + \delta\right)^2 - \frac{m^2g^2}{2k}\right]$ (i)

From Eq. (i) $\delta = 2F/k$

Hence, option b. is correct

Since a constant force is applied on the block to pull it down, during this process, work done by force, $W = F\delta$. Hence, option c. is also correct

Increase in energy of the spring is equal to

$\left[\frac{1}{2}k\left(\frac{mg}{k} + \delta\right)^2 - \frac{m^2g^2}{2k}\right]$

From this equation, increase in energy is not equal to $\frac{1}{2}k\delta^2$

Hence, option **d.** is wrong

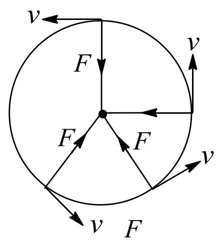
176 **(a,b,c,d)**

$W = Fs\cos\theta$. As $\cos\theta$ can be $\pm$ and zero,

Therefore, W may be positive, negative or zero

177 **(c,d)**

The given case is of in uniform circular motion, in which speed or kinetic energy remains constant. Directions of velocity and acceleration keep on changing although their magnitudes remain constant



178 **(b)**

The centripetal acceleration, $a_c = k^2rt^2$

$\Rightarrow \frac{v^2}{r} = k^2rt^2 \Rightarrow \frac{1}{2}mv^2 = \frac{m}{2}k^2r^2t^2$

$\Rightarrow \text{KE} = \frac{m}{2}k^2r^2t^2 \Rightarrow \frac{d}{dt}(\text{KE}) = mk^2r^2t$

$\Rightarrow \text{Power} = mk^2r^2t$

Alternative method:

Since $v = krt$ and tangential acceleration

$a_t = \frac{dv}{dt} = kr$

Tangential force $= mkr$

Instantaneous power $P = F \times v = mkr \times krt = mk^2r^2t$

179 **(a,c)**

If the body slips over a rough surface such that normal reaction of the surface has to balance only the normal component of weight of the body, then the energy lost against friction depends only upon the horizontal component of displacement and is equal toμmgx. It does not depend upon the shape of the surface

If the vertical component of displacement of the body is equal to y, increase in its gravitational potential energy will be equal to mgy

Hence, total work done by the force will be equal to $\mu mgx + mgy$

Hence, options **a.** and **c.** are correct

180 **(a,c)**

Energy will be conserved whether Y is fixed or free to move because no dissipating force is present. But momentum will be conserved only if Y is free to move, because then external force will be zero

181 **(c,d)**

For an isolated system (a system which has no interaction with surrounding, i.e., $F_{\text{ext}} = 0$), in the absence of any dissipative effect, both mechanical energy and total energy are conserved but not the kinetic energy and potential energy. So options **c.** and **d.** are correct

182 **(a,b,c)**

When force is perpendicular to motion, $\theta = 90$

$W = Fs\cos\theta = Fs\cos 90° = 0$

$\text{KE} = \frac{1}{2}mv^2$ = constant, as v is constant

183 **(a,b,c)**

In case of an explosion of a bomb, all the energies except total energy change. So options **a.**, **b.** and **c.** are correct

184 **(c)**

$P = \text{constant} = k$

$m\dfrac{dv}{dt}v = k$

$vdv = \dfrac{k}{m}dt \Rightarrow v \propto \sqrt{t}$

$\dfrac{ds}{dt} \propto \sqrt{t} \Rightarrow ds \propto \sqrt{t}dt$

$s \propto t^{3/2}$

185 **(a,b,c,d)**

Since potential energy of the particle is equal to, ϕ, x-component of the force acting on the particle is equal to

$F_x = -\dfrac{d\phi}{dx}$

And y-component of the force on the particle is equal to

$F_y = -\dfrac{d\phi}{dy}$

Hence, force acting on the particle is $\vec{F} = -(3\hat{\imath} + 4\hat{\jmath})\text{N}$

It means, force acting on the particle is constant. Hence, the particle moves with constant acceleration. So option a. is correct;

Acceleration of the particle, $\vec{a} = \frac{\vec{F}}{m_2} = -(3\hat{\imath} + 4\hat{\jmath})\text{ms}^{-2}$

Its magnitude is $a = \sqrt{3^2 + 4^2} = 5\text{ ms}^{-2}$

Since, the particle was initially at rest at (6, 4), position of the particle at time t is given by

$x = 6 + \dfrac{1}{2}a_x t^2 = (6 - \dfrac{3}{2}t^2)\text{m}$

and $y = 4 + \frac{1}{2}a_y t^2 = (4 - 2t^2)\text{m}$

when the particle crosses the x-axis, $y = 0$

$t_1 = \sqrt{2}\text{ s}$

Displacement of the particle during this time,

$s_1 = \dfrac{1}{2}at^2 = 5\text{m}$

Hence, work done by the force, up to this instant

$Fs_1 = 5 \times 5\text{ J} = 25\text{ J}$

Hence, option **b.** is also correct

The particle crosses y-axis when $x = 0$

Hence, $6 - \frac{3}{2}t_2^2 = 0$ or $t_2 = 2\text{ s}$

Speed of the particle at this instant will be

$v = at_2 = 5 \times 2 = 10\text{ ms}^{-1}$

Hence, option c. is also correct

At $t = 4$ s, $x = 6 - \frac{3}{2}(4)^2 = -18$ m

and $y = 4 - 2(4)^2 = -28$ m

Hence, option **d.** is also correct

186 **(a,b)**

When work done by force of gravity is negative, then

$W = -mgh$

i.e., KE decreases while PE increases. So options **a.** and **b.** are correct

187 **(a,b,d,e)**

Initially, the spring has an elongation, $\Delta L = mg/k$, where m is the mass of hanging block and k is the force contact of the spring. It means, initially spring has some strain energy

When the boy pushes the block upwards, the potential energy of the block increases and work is done by the boy during lifting of the block but spring becomes strain free. It means, initially, strain energy stored in spring is lost. Hence, the work done by the boy will be equal to increase in gravitational potential energy of the block minus loss in strain energy stored in the spring. Hence, only c. is correct, i.e., all other options **a., b., d.** and **e.** are not correct

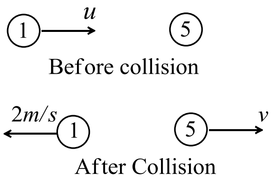
188 **(b,d)**

When work done on a particle is positive, velocity increases. Therefore, momentum increases and KE increases

189 **(a,b,c)**

In options **a.** and **c.**, no work is done because the force of gravity in option **a.** and the centripetal force in option **c.** are perpendicular to the direction of displacement. In option **b.**, no net force acts on the raindrop since it is falling with a uniform velocity, hence no work is done. In **d.**, the mass has to do work against gravity. Hence, the correct answers are **a.**, **b.** and **c.**

190 **(a,c)**



Since collision is elastic, so $e = 1$

Velocity of approach = Velocity of separation

So, $u = v + 2$ ...(i)

By momentum conservation

$1 \times u = 5v - 1 \times 2$

$u = 5v - 2 \Rightarrow v + 2 = 5v - 2$

So, $v = 1\ m/s$ and $u = 3\ m/s$

Momentum of system $= 1 \times 3 = 3\ kgm/s$

Momentum of 5 kg after collision $= 5 \times 1 = 5\ kgm/s$

So, kinetic energy of centre of mass

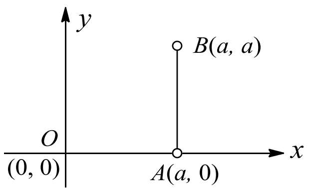
$$= \frac{1}{2}(m_1 + m_2)\left(\frac{m_1 u}{m_1 + m_2}\right)^2$$

$$= \frac{1}{2}(1+5)\left(\frac{1 \times 3}{6}\right)^2 = 0.75\ J$$

Total kinetic energy $= \frac{1}{2} \times 1 \times 3^2 = 4.5\ J$

191 **(d)**

$$w = \int f_x\, dx + \int f_y\, dy = -k\int y dx - k\int x dy$$



From 0 to A, $dy = 0, y = 0$

So $W_{OA} = 0$

From A to B: $dx = 0, x = a$

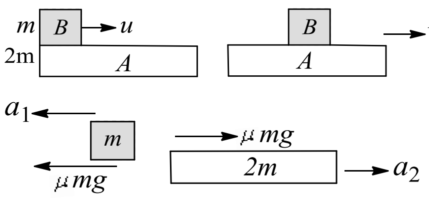
$$W_{AB} = -ka\int_0^a dy = -ka^2$$

Hence total work done

$W_T = W_{OA} + W_{AB} = 0 - ka^2 = -ka^2$

192 **(b,d)**

v is the final common velocity



$$a_1 = \frac{\mu mg}{m} = \mu g, a_2 = \frac{\mu mg}{2m} = \frac{\mu g}{2}$$

Acceleration of B relative to A:

$$a_1 + a_2 = \mu g + \frac{\mu g}{2}$$

$= \frac{3}{2}\mu g$ towards left

Work done against friction:

$$W_1 = K_i - K_f = \frac{1}{2}mu^2 - \frac{1}{2}3mv^2 = \frac{mu^2}{3}$$

Final KE $= \frac{1}{2}3mv^2 = \frac{m\mu^2}{6}$

Hence, **c.** is not correct

Option (d) is correct, because momentum is always conserved as there is no external force

193 **(c)**

Number of particle striking the blades/time ∝ velocity of wind

KE of particle ∝ (velocity of wind)^2

∴ Power output

∝ (Number of particles stricking /time) × (KE of particle) ∝ V^3

Alternative method:

$$F = v\left(\frac{dm}{dt}\right) = v\frac{d}{dt}(\rho \times \text{volume})$$

$$v\rho\frac{d}{dt}(\text{volume}) = v\rho \times (Av) = A\rho v^2$$

Power =force ×Velocity

$= A\rho v^2 \times v = A\rho v^3 \Rightarrow P \propto v^3$

194 **(b,c)**

Consider a system of two point particles which are free to move on a smooth horizontal surface, then the work done by electrical forces acting on the two particles is non-zero. But it is not necessarily true always. For a rigid body, there is no relative displacement of particles, hence, internal forces do not any work

195 **(a,b,d)**

$E_A = mgh_A + K_A$

$E_B = K_B; E_C = mgh_C + K_C$

Using conservation of energy

$E_A = E_B = E_C$; $K_B > K_C$

If $h_A > h_C$; $k_C > k_A$ and if $h_A < h_C$; $k_C < k_A$

196 **(a,b,c,d)**

$$\Delta KE = \frac{1}{2}mv^2 = \frac{1}{2} \times 1 \times 2^2 = 2\text{ J}$$

$W_{\text{conc}} = -\Delta U = -5\ J \Rightarrow \Delta U = 5$ J

$W_{\text{ext}} = \Delta U + \Delta KE = 5 + 2 = 7$ J

197 **(a,b,c,d)**

At any time $t, v = \sqrt{u^2 + g^2t^2 - 2ugt\sin\theta}$

$$E = \frac{1}{2}mv^2 = \frac{1}{2}m(u^2 + g^2t^2 - 2ugt\sin\theta)$$

Hence, $E - T$ graph is parabolic $E = \frac{p^2}{2m}$

Hence, $E - p^2$ graph is straight line through origin

$E = \frac{1}{2}mu^2 - mgy$

Putting $y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$ we get

$E = \frac{1}{2}mu^2 - mg\,x\tan\theta + \frac{mg^2x^2}{2u^2\cos^2\theta}$

Hence $E - t$ graph is a straight line and $E - x$ graph is parabolic

and $E - x$ graph is parabolic

198 **(b,d)**

$\frac{1}{2}mv^2 = a(t)$

or $v \propto t^{1/2}$

$a = \frac{dv}{dt} \propto t^{-1/2}$ or $F \propto \frac{1}{\sqrt{t}} \propto \frac{1}{v}$

199 **(a,c,d)**

Work done by friction can be negative, zero or positive. Hence, b. is incorrect. All others are correct

200 **(a,b,d)**

When the plank is shifted, the cord elongates and becomes inclined with vertical. Therefore, a tension is developed in the cord and that tension has two components, a vertical component and a horizontal component: Horizontal component tries to slide the block leftwards, relative to the plank. But friction F_2 prevents that slipping. Hence, the block moves to the right with the plank Since the block does not slip over the plank, no energy is lost against frictionF_2. Hence, work done by the force F is used to overcome loss aginst friction F_1 and to elongate the cord. Therefore, option **a.** is correct

The cord elongates due to displacement of the block and the block gets displaced due to friction F_2 acting on it. Hence, the friction F_2 is responsible for the elongation of the cord. Therefore, strain energy stored in the cord is equal to work done by the friction on the block or work done against friction acting on the upper surface of the plank. Hence, the total work done by F is equal to energy lost against friction F_1 plus work done against friction acting on upper surface of the plank. Therefore, option b. is correct. Hence, it is obvious that option **c.** is wrong Since, strain energy stored in the cord is equal to work done by friction acting on the block, option **d.** becomes same as option **b.** Hence, it is also correct

201 **(a,b,d)**

i.According to the law of conservation of momentum,

$$\vec{p}_B + \vec{p}_G = 0 \;\; or \;\; \vec{p}_G = -\vec{p}_B$$

$ii.\, \vec{m}v + \vec{M}V = 0\; i.e., \vec{V} = \frac{m}{M}\vec{v}$ i.e., if the bullet moves forward, gun recoils or kicks backward, and the heavier the gun, the lesser the recoil

iii.As $K = \frac{p^2}{2m}$, so $\frac{K_G}{K_B} = \frac{m}{M}$

i.e., $K_G < K_B$

iv.As $\vec{F}_G = -\vec{F}_B$ or $M\vec{a}_G = -m\vec{a}_B$

i.e., $|\vec{a}_B| > |\vec{a}_G|$

So options **a.**, **b.** and **d.** are constant

202 **(b,c,d)**

Single force on a particle may change the magnitude and or direction of velocity, so momentum changes necessarily but kinetic energy may or may not change

From work-energy theorem,

$\Delta K = W_{\text{ext}} + W_{\text{int}} + W_{\text{conservative}} + W_{NC}$

Kinetic energy can be increased due to work done by internal forces also

203 **(a,b)**

Internal forces are often non-conservative, so they can change kinetic energy or mechanical energy. If $F_{\text{ext}} = 0$, momentum is always conserved whether internal forces are present or not; similarly, energy of the system is also conserved always. So options **a.** and **b.** are correct

204 **(a,d)**

$W = Fs\cos\theta$

1. If $\theta = \frac{\pi}{2}$, $\cos\theta = 0$, so $W = 0$
2. Force can never be perpendicular to its acceleration
3. For work to be done, point of application of force must move

205 **(a,c)**

Since, $W = \int \vec{F}.\overrightarrow{dr}$

Clearly for forces a. and b., the integration does not require any formation of the path taken

For c. $W_C = \int \frac{3(x\hat{\imath}+y\hat{\jmath})}{(x^2+y^2)^{\frac{3}{2}}}.(dx\hat{\imath} + dy\hat{\jmath}) = 3\int \frac{x\,dx+y\,dy}{(x^2+y^2)^{\frac{3}{2}}}$

Taking $x^2 + y^2 = t$, we gte $2x\,dx + 2y\,dy = dt$

$x\,dx = y\,dy = \frac{dt}{2}$

$W_c = 3\int \frac{dt/2}{t^{3/2}} = \frac{3}{2}\int \frac{dt}{t^{3/2}}$

Which will be independent of path after solving

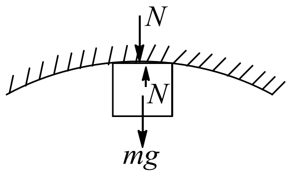
Hence, **a.,b.**, and **c.** are conservative forces

But **d.** requires some more information on path to solve it. Hence, it is non-conservative

206 **(a)**

Since the body presses the surface with a force N, according to Newton's third law the surface presses the body with a force N. The other force acting on the body is its weight mg

For circular motion to take place, a centripetal force is required which is provided by $mg + N$



$\therefore mg + N = \frac{mv^2}{r}$

If the surface is smooth, then on applying conservation of mechanical energy, the velocity of the body is always same at the topmost point. Hence, N and r have inverse relationship. From the figure it is clear that r is minimum for first figure, therefore, N will be maximum

207 **(b,c,d)**

1. False, it is repulsion here
2. True, since minimum potential energy means maximum kinetic energy
3. True, since slope gives force and it is zero here
4. True, since a well >> KT, would mean molecules staying together

208 **(a,d)**

It is the definition of a conservation force. Increase in KE will be due to work done by other forces also

209 **(c,d)**

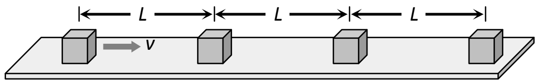
When two blocks connected by a spring move towards each other, the law of conservation of momentum leads to the following results:

$i. \overrightarrow{p_2} = -\vec{p}_2$, i.e., at any instant two blocks will have equal and opposite momenta

$ii. \vec{v}_2 = -\left(\frac{m_1}{m_2}\right)\vec{v}_1$, i.e., two blocks move in opposite directions with lighter block moving faster

iii.It is quite clear that forces acting on them will be equal and opposite. Acceleration may ne different if masses are different. So options **c.** and **d.** are correct

210 **(b,d)**



Since collision is perfectly inelastic so all the blocks will stick together one by one and move in a form of combined mass

Time required to cover a distance 'L' by first block $= \frac{L}{v}$

Now first and second block will stick together and move with $v/2$ velocity (by applying conservation of momentum) and combined system will take time $\frac{L}{v/2} = \frac{2L}{v}$ to reach up to block third

Now these three blocks will move with velocity $v/3$ and combined system will take $\frac{L}{v/3} = \frac{3L}{v}$ to reach upto the block fourth

So, total time $= \frac{L}{v} + \frac{2L}{v} + \frac{3L}{v} + \cdots \frac{(n-1)L}{v} = \frac{n(n-1)L}{2v}$

And velocity of combined system having n blocks as $\frac{v}{n}$

211 **(b,c,d)**

Except kinetic energy, rest of the energies can be negative (because $K \propto V^2$). So options b., c. and d. are correct

212 **(b)**

If two protons are brought near one another, work has to be done against electrostatic force because same charge repel each other. The work done is stored as potential energy in the system

214 **(e)**

When a body slides down on inclined plane, work done by friction is negative because it opposes the motion ($\theta = 180°$ between force and displacement)

If $\theta < 90°$ then $W =$ positive because $W = F.s.\cos\theta$

215 **(a)**

The work done on the spring against the restoring force is stored as potential energy in both conditions when it is compressed or stretched

216 **(d)**

Using conservation of mechanical energy and taking zero velocity at the bottom point is $2\sqrt{gR}$

217 **(c)**
The gravitational force on the comet due to the sun is a conservative force. Since the work done by a conservative force over a closed path is always zero (irrespective of the nature of path), the work done by the gravitational forces over every complete orbit of the comet is zero

218 **(d)**
Work done in the motion of a body over a closed loop is zero only when the body is moving under the action of conservative forces (like gravitational or electrostatic forces). $i.e.$ work done depends upon the nature of force

219 **(d)**
Centripetal force is always perpendicular to velocity, hence it does no work

If speed of the body changes, then additional tangential force comes into play and resultant force does not remain towards centre

220 **(c)**
According to conservation of mechanical energy as for conservation forces the sum of kinetic energy and potential energy remains constant and throughout the motion it is independent of time. This is the law of conservation of mechanical energy.

ie, KE+PE=total energy =constant.

221 **(a)**
When two moving bodies collide, their temperatures rise due to some part of KE is converted into heat energy of two colliding bodies.

223 **(a)**
$K = \frac{1}{2} mv^2 \therefore K \propto v^2$

If velocity is doubled then K.E. will be quadrupled

224 **(a)**
When a spring is compressed or stretched, work is to be done against restoring force. This work done is stored in the spring in from of potential energy

225 **(b)**
The potential energy of two identical molecules increases when the distance between them is increased

226 **(a)**
Einstein mass-energy equivalence relation is given by

$\mathrm{E} = \mathrm{mc}^2$

From the relation, it can be said that if energy is conserved, then mass is conserved or vice-versa. Also, per this equation, Whole of the energy can be converted into mass or can be converted wholly into energy.

227 **(c)**
For conservative forces the sum of kinetic and potential energies at any point remains constant throughout the motion. This is known as law of conservation of mechanical energy. According to this law,

Kinetic energy + Potential energy = constant

Or, $\Delta K + \Delta U = 0$ or, $\Delta K = -\Delta U$

228 **(d)**
Work done by non-conservative force depends upon the entire path, i.e., distance

229 **(e)**
When the force retards the motion, the work done is negative

Work done depends on the angle between force and displacement $W = Fs\cos\theta$

231 **(d)**
In an elastic collision both the momentum and kinetic energy remains conserved. But this rule is not for individual bodies, but for the system of bodies before and after the collision. While collision in which there occurs some loss of kinetic energy is called inelastic collision. Collision in daily life are generally inelastic. The collision is said to be perfectly inelastic, if two bodies stick to each other

232 **(d)**
At the highest point of vertical circle tension is zero, not velocity

233 **(c)**

When we supply current through the cell, chemical reactions takes place, so chemical energy of cell is converted into electrical energy

234 **(a)**
Work done and power developed is zero in uniform circular motion only

235 **(c)**
$\Delta KE = W_{\text{by net force}}$

This relation is valid for particle as well as system of particles

236 **(a)**
K.E. of one bullet $= k$ ∴ K.E. of n bullet $= nk$

According to law of conservation of energy, the kinetic energy of bullets be equal to the work done by machine gun per sec

237 **(d)**
$W = \vec{F}.\vec{S}$

As $\vec{S}$ depends on reference frame, W is not an invariant physical quantity

238 **(a)**
Work done and power developed is zero in uniform circular motion

$p = W/t$, hence reason is the correct explanation of assertion

239 **(c)**
Change in kinetic energy = work done by net force

This relationship is valid for particle as well as system of particles

240 **(c)**
Work done by internal force=change in kinetic energy

If $F_{\text{ext}} = 0, F_{n.C} = 0$

During motion of circular path work done by the centripetal force is zero

242 **(a)**
From Einstein equation $E = mc^2$

244 **(d)**
Since mass of car<mass of lorry. Retardation on car is more than lorry. And car will stop earlier; at lesser distance

245 **(a)**
Since the gaseous pressure and the displacement (of piston) are in the same direction. Therefore $\theta = 0°$

∴ Work done $= Fs\cos\theta = Fs =$ Positive

Thus during expansion work done by gas is positive

246 **(c)**
During a round trip, the body finally comes at its initial position, i.e., the displacement of body is equal to zero. Therefore, work done is equal to zero. So $W = \vec{F}.\vec{S} = 0$. Statement I is correct and statement II is wrong

247 **(c)**
$$W(mg) + W(\text{spring}) + W(\text{Man}) = 0 - \Delta U + E + W = 0$$

$\Delta U = E + W$

Work done by spring force is positive when a compressed spring is released or stretched spring is released

248 **(a)**
In a quick collision, time t is small. As $F \times t =$ constant, therefore, force involved is large, $i.e.$ collision is more violent in comparison to slow collision

250 **(d)**
The maximum extension is non-zero, whole the spring never undergoes compression. Hence, statement I is false

251 **(b)**
Both the statement 1 & statement 2 is true, statement 2 is not a correct explanation for statement 1. In fact the momentum is conserved both in elastic as well as in inelastic collision. But in elastic collision the total kinetic energy of the system is also conserved

252 **(a)**
If roads of the mountain were to go straight up, the slope θ would have been large, the frictional force $\mu mg\cos\theta$ would be small. Due to small friction, wheels of vehicle would slip. Also for

going up a large slope, a greater power shall be required

253 **(a)**
From the formula,

$$K = \frac{p^2}{2m} \Rightarrow p^2 \propto m$$

Thus, if kinetic energy is same for both bodies then momentum will be greater for heavy body.

Also if momentum is equal for both the bodies then kinetic energy will be higher for lighter body.

254 **(e)**
Rate of change of momentum is proportional to external forces acting on the system. The total momentum of whole system remain constant when no external force is acted upon it

255 **(d)**
$U = \frac{1}{2}K(\Delta x)^2$; Δx may be compression or elongation

256 **(c)**
When two bodies of same mass undergo an elastic collision, their velocities get interchanged after collision. Water and heavy water are hydrogenic materials containing protons having approximately the same mass as that of a neutron. When fast moving neutrons collide with protons, the neutrons come to rest and protons move with the velocity of that of neutrons

257 **(d)**
When two bodies have same momentum then lighter body masses more kinetic energy because $E = \frac{P^2}{2m}$

$\therefore E \propto \frac{1}{m}$ when $P =$ constant

258 **(e)**
Potential energy $U = \frac{1}{2}kx^2$ $i.e. U \propto x^2$

This is a equation of parabola, so graph between U and x is a parabola, not straight line

259 **(a)**
From, definition, work done in moving a body against a conservative force is independent of the path followed

260 **(a)**
$E = \frac{P^2}{2m}$. In firing momentum is conserved $\therefore E \propto \frac{1}{m}$

So $\frac{E_{\text{gun}}}{E_{\text{bullet}}} = \frac{m_{\text{bullet}}}{m_{\text{gun}}}$

261 **(c)**
The coefficient of friction between two surface is independent of angle of inclination of the surface

262 **(a)**
For speed to be minimum at c, the speed at B should be just zero

Hence, statement II is the correct explanation of statement I

263 **(d)**
Vehicle is stopped, but due to inertia bob will acquire the velocity v_0 w.r.t. vehicle

$h = l - l\cos 60° = \frac{l}{2} = 2.5$ m

$mgh = \frac{1}{2}mv_0^2$

$v_0 = \sqrt{2gh} = \sqrt{2 \times 10 \times 2.5} = 5\sqrt{2}$ ms^{-1}

Net force at the lowest point is

$\frac{mv_0^2}{l} = \frac{2 \times (5\sqrt{2})^2}{5} = 20$ N

Acceleration of the bob at the lowest point,

$\frac{v_0^2}{l} = \frac{(5\sqrt{2})^2}{5} = 10$ ms^{-2}

At point $B: T = mg\cos 60°$

Net force $= mg\sin 60° = 2 \times 10 \times \frac{\sqrt{3}}{2} = 10\sqrt{3}$ N

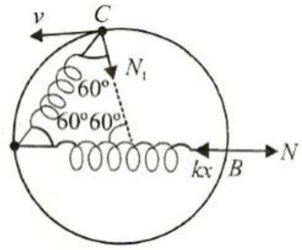
Acceleration $= g\sin 60° = 10 \times \frac{\sqrt{3}}{2} = 5\sqrt{3}$ ms^{-2}

264 **(b)**
As the force and direction of movement is in the same direction, so work done by lifting force is positive. Due to constant velocity total work must be zero. As gravity acts downwards, so work done by it is negative. Here we have only two forces, lifting force and gravity, which are operational. As the object is moving with constant velocity, net work done by these forces has to be zero

265 **(b)**
At position $B, x = 2R - R = R$

$N = kx = \frac{mg}{R}R = mg$

$\frac{1}{2}mv^2 = \frac{1}{2}kx^2$



$$v = \sqrt{\frac{k}{m}}R = \sqrt{gR}$$

$$N_1 = \frac{mv^2}{R} = m(\sqrt{gR})^2/R = mg$$

266 **(a)**

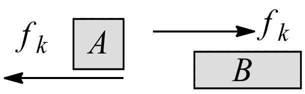
In OA, velocity increases, hence KE increases. So overall work done is positive. If a number of forces are acting on the body, then it is possible that some forces do positive work, some negative and some zero

In BC, velocity is constant, hence there is no change in KE. So net work done by all the forces is zero

267 **(b)**

Friction forces on A and B will be acting as shown in figure

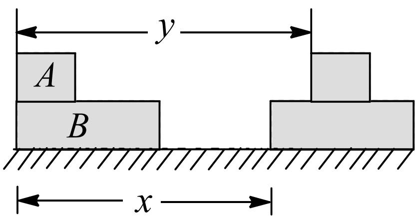
Both will be moving towards right after giving the impulse



i.Work done by friction on B should be positive

ii.Work done by friction on A should be negative

iii.Negative work done on A will be more than positive work on B by friction. This is because displacement of A will be more than that of B during any time



iv.In the frame of A, B will go towards left by a displacement of $y - x$. Hence

work will be negative.

268 **(a)**

For the particle to just complete the circle motion $v_B = \sqrt{5gR}$

For this, $mgh = \frac{1}{2}mv_B^2 \Rightarrow h = \frac{5}{2}R = 2.5\,R$

In this case, velocity at C will be $\sqrt{3gR}$

Force exerted by the particle on the track at point C is

$$\frac{m(\sqrt{3gR})^2}{R} = 3\,mg$$

And force exerted by the particle on the track at point A will be zero in this case

For the force at A to be more than its weight,

$$mg + N = \frac{mv_A^2}{R}$$

$$N = \frac{mv_A^2}{R} - mg > mg$$

$$v_A > \sqrt{2gR}$$

Applying conservation of energy between O and A, we get

$$mgh = mg2R + \frac{1}{2}mv_A^2$$

If $v_A > \sqrt{2gR}$, then $h > 3R$

269 **(c)**

$$\sqrt{5gr} = \sqrt{5 \times 10 \times 2} = 10\text{ ms}^{-1}$$

$$\sqrt{2gr} = \sqrt{2 \times 10 \times 2} = \sqrt{40}\text{ ms}^{-1}$$

1. $3.5\ ms^{-1}$ is less than $\sqrt{2gr}$. So the particle will stop before the string becomes horizontal

2. $8\ ms^{-1}$ lies $2gr$ and $\sqrt{5gr}$. The particle will cross the horizontal position but will not be able to reach the highest point

3. Tension is maximum at the lowest point. Hence,

$$15 = mg + \frac{mv_L^2}{r} \Rightarrow v_2 = \sqrt{40}\text{ ms}^{-1}$$

In this case particle will just be able to reach the horizontal level. Here both speed and tension become zero

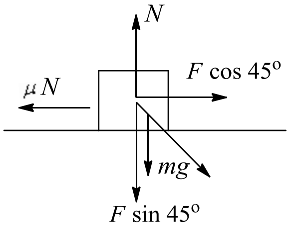
4. $30 = mg + \frac{mv_2^2}{r} \Rightarrow v_2 = 10\text{ ms}^{-1}$

Here particle will be able to reach the highest point. Tension will become zero at the highest point. Hence b. and d. are matching

270 **(a)**

$$F\cos 45° = \mu mg + \mu F\sin 45°$$

$$F = 75\sqrt{2}\,N$$



Surface is exerting friction and normal force, but Work is done by friction only$= -75\sqrt{2} \times \frac{1}{\sqrt{2}} \times 20$

Work done by gravity is zero as it is perpendicular to the direction of motion

Work done by man on the block in pushing it through 10 m is

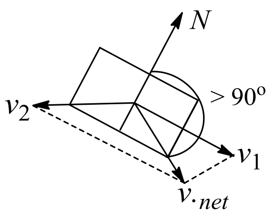
$w = 75\sqrt{2} \times \frac{1}{\sqrt{2}} \times 10 = 750$ J

As the block is moving with constant velocity, net force on the block must be zero

271 **(c)**

1. Angle between velocity of the block and normal reaction on the block is obtuse. Hence, work done by normal reaction on the block is negative

As the block falls by vertical distance h, from work-energy theorem



Work done by mg + work done by N = KE of the block

$$\because |\text{work done by } N| = \frac{1}{2}mv^2 - mgh < 0$$

$$\therefore \frac{1}{2}mv^2 < mgh$$

2. Work done by normal reaction on wedge is positive. Since loss in PE of the block=KE of wedge + KE of block, work done by normal reaction on the wedge = KE of the wedge therefore, work done by N on the wedge is less then mgh

3. Net work done by normal reaction on the block and wedge is zero

4. The net work done by all forces on the block is positive, because its kinetic energy has increased. Also KE of the block is less thanmgh. Hence, net work done on the block = final KE of the block $< mgh$

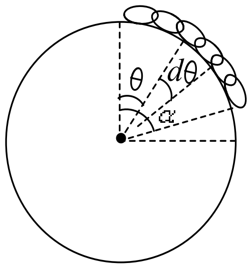
272 **(d)**

Gravitational PE w.r.t. the centre of sphere

$$= \int_0^{\frac{l}{R}} \frac{M}{l} gR^2 \cos\theta \, d\theta = \frac{M}{l} \, gR^2 \sin\left(\frac{l}{R}\right) t \quad \left(\alpha = \frac{l}{R}\right)$$

When the chain has been released and it has slid through angle θ, from mechanical energy theorem, we have

$u_i - u_f = k_f - k_i \Rightarrow u_i - u_f = k_f$



$$\frac{M}{l} gR^2 \sin\left(\frac{l}{R}\right) - \int_\theta^{\theta+Q\frac{l}{R}} \frac{M}{l} gR^2 \cos\theta \, d\theta = \frac{1}{2}mv^2$$

If v is the velocity at the moment when angle traversed is θ, then

$$KE = \frac{mR^2 g}{l}\left[\sin\left(\frac{l}{R}\right) + \sin\theta - \sin\left(\theta + \frac{l}{R}\right)\right]$$

From the expression of KE, v can be obtained and differentiated in order to obtain tangential acceleration which will be ($\theta = 0°$)

$$a_t = \frac{Rg}{l}\left[1 - \cos\left(\frac{l}{R}\right)\right] \quad \left[\text{use } v = \frac{Rd\theta}{dt}\right]$$

[Differentiate w.r.t. time where $\frac{d\theta}{dt} = \omega$]

Radial acceleration $= \frac{v^2}{R}$

Hence, we have

$$a_r = \frac{2Rg}{l}\left[\sin\left(\frac{l}{R}\right) + \sin\theta - \sin\left(\theta + \frac{l}{R}\right)\right]$$

273 **(c)**

From $\frac{t_A}{t_B} = \left(\frac{m_A}{m_B}\right)^{1/2}$

$$\frac{t_A}{5} = \left(\frac{1000}{2000}\right)^{1/2} = \frac{1}{\sqrt{2}}$$

$t_A = 5/\sqrt{2}$ s

274 **(b)**

From $\frac{dU}{dr} = \frac{B}{r^2} - \frac{2A}{r^3}$

$$\frac{d^2U}{dr^2} = -\frac{2B}{r^3} + \frac{6A}{r^4}$$

As $r \to r_0 = \frac{2A}{B}, \frac{d^2U}{dr^2} = -\frac{2B^4}{8A^3} + \frac{6AB^4}{16A^4} = \frac{B}{8A^3}$, which is positive

$\therefore U$ is minimum

Hence, the equilibrium is stable

275 **(c)**

As $F_{\text{ext}} = 0$, according to the law of conservation of momentum,

$\vec{P}_1 + \vec{P}_2$ =constnat

But initially both the blocks were at rest, so

$\vec{P}_1 + \vec{P}_2 = 0$ i.e., $\vec{P}_2 = -\vec{P}_1$

i.e., at any instant, the two blocks will have momentum equal in magnitude but opposite in direction (through they may have different values of momentum at different positions)

276 **(b)**

$v = u + at \Rightarrow 20 = 0 + a \times 4 \Rightarrow a = 5\text{ ms}^{-2}$

$F = ma = 2 \times 5 = 10\text{ N}$

Velocity at 2 s: $v_1 = at = 5 \times 2 = 10\text{ ms}^{-1}$

Power $= Fv_1 = 10 \times 10 = 100\text{ W}$

277 **(a)**

Force requires to keep the belt moving $= F$

$F = v\frac{dm}{dt} = 0.2 \times 2 = 0.4\text{ N}$

Extra power required : $P = Fv = 0.4 \times 2 = 0.08$ W

Rate of change of kinetic energy is

$\frac{1}{2}v^2\left(\frac{dm}{dt}\right) = \frac{1}{2}(0.2)^2 \times 2 = 0.04\text{ Js}^{-1}$

278 **(a)**

When the man climbs the ladder of length l, the balloon descends by height h. So net height gained by the man is $l - h$. Hence, gain in potential energy of the man is $mg(l - h)$

Work done by man : $W_1 = mgl$

Inclination in potential energy of balloon= work done by man – increase in potential energy of man, i.e.,

$mgl - mg(l - h) = mgh$

279 **(d)**

At $x = 5$ m, $U = 20 + (5-2)^2 = 29$ J, $K = 20$ J

Mechanical energy= $E = U + K = 29 + 20 = 49$ J

280 **(c)**

From work-energy theorem, kinetic energy of the block at

$x = x$ is $K = \int_0^x 4 - x^2\,dx = 4x - \frac{x^3}{3}$

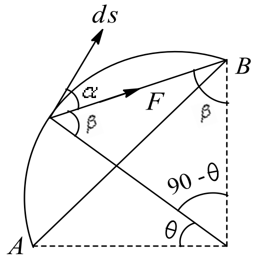
For K to be maximum, $\frac{dK}{dx} = 0$

Or $4 - x^2 = 0$ or $x = \pm 2$ m

At $x = +2$ m, $\frac{d^2K}{dx^2}$ is negative, i.e., kinetic energy K is maximum and

$K_{\text{max}} = 4 \times 2 - \frac{(2)^3}{3} \cong 5.33$ J

281 **(b)**



$ds = Rd\theta$

$90 - \theta + 2\beta = 180°$

$\Rightarrow \beta = \frac{90+\theta}{2}, \alpha = 90 - \beta = 90 - \left(\frac{90+\theta}{2}\right)$

$= \frac{90-\theta}{2}$

$dW = F\,ds\cos\alpha$

or $W = \int_0^{90°} FR\cos\frac{90-\theta}{2}\,d\theta = F(\sqrt{2}R)$

282 **(b)**

Loss in PE of spring + loss in PE of m_2 = gain in KE of $(m_1 + m_2)$ +work done against friction

$\Rightarrow \frac{1}{2}kx^2 + m_2gh = \frac{1}{2}(m_1+m_2)v^2 + \mu_k m_1 gh$

$\Rightarrow v = \sqrt{\frac{kx^2 + 2m_2gh - 2\mu_k m_1 gh}{m_1 + m_2}}$

283 **(d)**

At the lowest point: $T_L = mg\sin 37° + \frac{mv_L^2}{l}$

$\Rightarrow 274 = 3 \times 10 \times \frac{3}{5} + \frac{3v_L^3}{0.75} \Rightarrow v_L = 8\text{ ms}^{-1}$

284 **(d)**

Let the velocity at the top point is v_C. Then for projectile motion from C to A,

Range $= v_c\sqrt{\frac{2(\text{Height})}{g}} \Rightarrow 3R = v_c\sqrt{\frac{2 \times 2R}{g}}$

$\Rightarrow v_C = \frac{3}{2}\sqrt{Rg}$

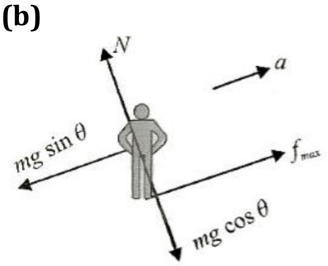
To find velocity at B, apply conservation of energy, i.e.,

$\frac{1}{2}mv_B^2 = mg\,2R + \frac{1}{2}mv_C^2 \Rightarrow V_B = \frac{5}{2}\sqrt{Rg}$

285 **(a,c,d)**

Work by friction will be zero if there is no slipping of the man's foot on incline. Work done by man will be equal to increase in his kinetic + potential energy

286 **(b)**



$$a = \frac{f_{\max} - mg\sin\theta}{m}$$
$$a = \frac{\mu mg\cos\theta - mg\sin\theta}{m} = \frac{g}{3}$$
$$AB = vt + \frac{1}{2}at^2$$
$$\frac{h}{\sin 30°} = \sqrt{\frac{gh}{6}}t + \frac{1}{2}\frac{g}{3}t^2$$
$$gt^2 + \sqrt{6gh}t - 12h = 0$$
Solving, we get $t = \sqrt{6\frac{h}{g}}$
$$v_f = v_i + at = \sqrt{\frac{gh}{6}} + \frac{g}{3}\sqrt{6\frac{h}{g}} = 3\sqrt{\frac{gh}{6}}$$
Distance moved by conveyor belt till the boy reched B:
$$s - v_i t = \sqrt{\frac{gh}{6}}\sqrt{\frac{6h}{g}} = h$$
w.r.t. conveyor belt, distance moved by the boy
$2h - h = h$
Work done by gravity w.r.t. conveyor
$$W_{\text{mg}} = -mgh\sin 30° = -\frac{mgh}{2}$$
From the frame of belt : $v_i = 0, v_f = at = 2\sqrt{\frac{gh}{6}}$
$$W_{\text{boy}} = \Delta KE + \Delta PE$$
$$= \frac{1}{2}m\left(v_f^2 - v_i^2\right) + mg\frac{h}{2}$$
$$= \frac{1}{2}m\left[4\frac{gh}{6}\right] + \frac{mgh}{2} = \frac{5mgh}{6}$$
From the frame of ground:
$$W_{\text{boy}} + W_f + W_{\text{mg}} = \Delta\text{KE}$$
$$W_f = \frac{2}{3}mgh + mgh - \frac{5}{6}mgh$$
$$\Rightarrow W_f = \frac{5}{6}mgh$$
$Note: Work\ done\ by\ friction\ or\ work\ done\ by\ be$

287 **(a)**

i.During accelerated motion, negative work is done against friction and there is also change in kinetic energy. Hence, net work needed is positive

ii.During uniform motion, work is done against friction only and that is positive

iii.During retarted motion, the load has to be stopped in exactly 50 m. If only friction is considered, then the load stops in 12.5 m which is less than where it has to stop. Hence, the camel has to apply some force so that the load stops in 50 m (>12.5 m). therefore, the work done in this case is also positive

288 **(c)**

Applying work-energy theorem on the block for any compression x,
$$W_{\text{ext}} + W_{\text{g}} + W_{\text{spring}} = \Delta\text{KE}$$
$$Fx = 0 - \frac{1}{2}Kx^2 = \frac{1}{2}mv^2$$
KE versus x graph is an inverted parabola

289 **(d)**

Let t be time taken by the ball from B to C
$$R = \frac{1}{2}gt^2$$
$$t = \sqrt{\frac{2R}{g}}$$
$$2R = v\sqrt{\frac{2R}{g}}$$
$$v = \sqrt{2gR}$$
Applying energy conservation at point A and B,
$$1/2mv_0^2 = \frac{1}{2}mv^2 + mg2R$$
$$\Rightarrow v_0 = \sqrt{6gR}$$

290 **(a)**

Stable equilibrium corresponds to minimum potential energy

291 **(a)**

The concept used in solving these questions is that kinetic energy can never be negative. It would always be non-negative
Total mechanical energy $= KE + U$
Here if $E = 25$ J, then $K = 25 - U$
For K to be non-negative, $U < 25$ J, which is the case for $-\infty < x < -5$ and $5 < x < \infty$

292 **(c)**

For path OMA:

Path OM: $\vec{F} = y^2\hat{\imath}, dx = 0$

$$W_{OM} = \int_0^6 \vec{F}.\overrightarrow{dx} = 0$$

Path MA: $\vec{F} = (36\hat{\imath} + x\hat{\jmath})$N

$$W_{MA} = \int_{x_1}^{x_2} F_x\,dx + \int_{y_1}^{y_2} F_y\,dy, dy = 0$$

$= 36 \times 6 + 0 = 216$ J

$W_{OMA} = 216$ J

For path OLA:

Path OL: $\vec{F} = \hat{\jmath}, dy = 0$

$W_{OL} = 0$

Path LA: $\vec{F} = (y^2\hat{\imath} + 6\hat{\jmath})N$

$$W_{LA} = \int_{x_1}^{x_2} F_x\,dx + \int_{y_1}^{y_2} F_y\,dy$$

$= 0 + 6 \times (y_2 - y_1) = 6 \times 6 = 36$ J

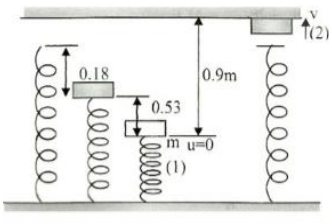
$\therefore W_{OMA} \neq W_{OLA}$

Hence, force is not conservative

293 **(a)**

$mg = K(0.18)$

$\Rightarrow K = mg/0.18$



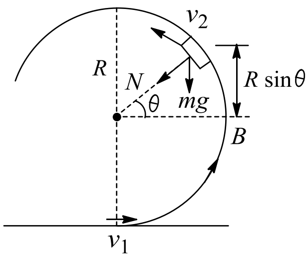
$$\frac{1}{2}k(0.18 + 0.53)^2 = mg(0.9) + \frac{1}{2}mv^2$$

$$\frac{mg}{0.18}(0.71)^2 = 2mg(0.9) + mv^2$$

$$\Rightarrow v = \sqrt{\frac{g(0.71)^2}{0.18} - 2g(0.9)} = 3.14\text{ ms}^{-1}$$

294 **(c)**

$$v_1 = \frac{2}{\sqrt{5}}\sqrt{5gR} = 2\sqrt{gR}$$



Now,

$v_2^2 = v_1^2 - 2g(R + R\sin\theta)$

$= 2gR - 2gR\sin\theta$

$$N + mg\sin\theta = \frac{mv_2^2}{R}$$

Put $N = 0$

$\Rightarrow mg\sin\theta = m2g\,(1 - \sin\theta)$

$$\Rightarrow \sin\theta = \frac{2}{3} \Rightarrow \theta = \sin^{-1}\left(\frac{2}{3}\right)$$

295 **(a)**

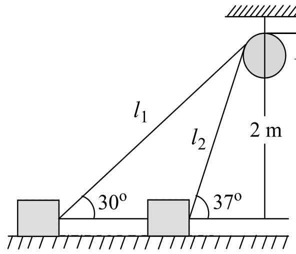
During compression, displacement $= x$,

Hence, work done by gravity $= Mgx$

296 **(b)**

$$l_1 = \frac{2}{\sin 30°} = 4\text{ m}, l_2 = \frac{2}{\sin 37°} = \frac{10}{3}\text{ m}$$

Displacement of point P: $l_1 - l_2 = 4 - \frac{10}{3} = \frac{2}{3}$ m



Work done, $W = F(l_1 - l_2) = 50 \times \frac{2}{3} = \frac{100}{3}$ J

297 **(b)**

Velocity of block at point 'B' before striking

$v = \sqrt{60}\,m/s$

After collision with point 'B' velocity along the plane

$= v\cos 30° = \sqrt{45}\,m/s$

Velocity $\perp$ to plane $= v\sin 30° = \sqrt{60} \times \frac{1}{2} = \sqrt{15}\,m/s$

As the collision is totally inelastic therefore perpendicular component of velocity will become zero

So, block will possess velocity along the plane

$\therefore v = \sqrt{45}\,m/s$

298 **(4)**

As the centre of gravity of rope co0mes up by $h/2$ and that of bucket by h, required work would be

$W = \sqrt{\eta gr} + Mgh = 4000$ J $= 4$ kJ

299 **(6)**

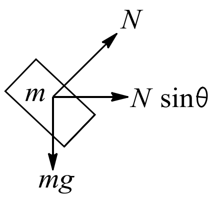
$N = mg + mv^2/r = 120[10 + 20^2/10]$

$= 6000$ N $= 6$ kN

300 **(5)**

If block does not slip then, $a = g\tan\theta$

$\Rightarrow 10 = 10\tan\theta \Rightarrow \theta = 45°$



$$N\sin\theta = ma \Rightarrow N \times \frac{1}{\sqrt{2}} = 0.1 \times 10 \Rightarrow N = \sqrt{2}\,N$$

$$S = \frac{1}{2} \times at^2 = \frac{1}{2} \times 10(1)^2 = 5\text{ m}$$

$W_N = NS\cos\theta = \sqrt{2} \times 5 \times 1/\sqrt{2} = 5J$

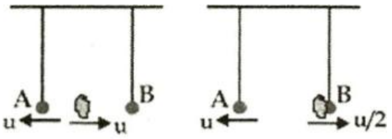
Alternatively: $W_N = \frac{1}{2}mv^2 = \frac{1}{2}(0.1)(at)^2 = 5$ J

301 **(8)**

For completing the full circle:

$\frac{u}{2} = \sqrt{5gL} \Rightarrow u = 4 \text{ ms}^{-1}$

Relative velocity $= 2u = 8 \text{ ms}^{-1}$



302 **(2)**

Maximum elongation is given by

$x_{\max} = \frac{2[F_1m_2 + F_2m_1]}{K(m_1 + m_2)}$

Here $F_1 = F_2; m_1 = m$ and $m_2 = M$

Put the values and solve to get $x_{\max} = 2F/K$

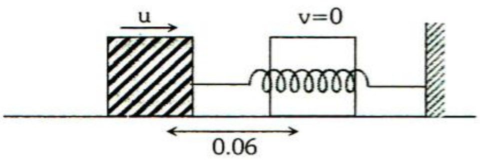
303 **(4)**

Speed of block will be maximum when

$mg\cos\theta = kx \Rightarrow x = \frac{mg\cos\theta}{K}$

Where x is compression. So $n = 4$

304 **(4)**



$\mu = 0.1$

$\frac{1}{2}mu^2 = \mu mg \times 0.06 + \frac{1}{2}kx^2$

$\frac{1}{2} \times 0.18\, u^2 = 0.1 \times 0.18 \times 10 \times 0.06 + \frac{1}{2} \times 2 \times (0.06)^2$

$0.4 = \frac{N}{10}$

$N = 4$

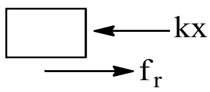
305 **(7)**

$5.6 = \frac{1}{2}k(0.3)^2$

$W = \frac{1}{2}k[(0.3 + 0.15)^2 - 0.3^2]$

Solve to get: $W = 7$ J

306 **(7)**



Let compression in the spring be x

$fl \geq kx \Rightarrow (1/2) \times 0.14 \times 10 > 10x$

$\Rightarrow x \leq 0.07 \text{ m} = 7\text{cm}$