WORK POWER ENERGY

Contents

Syllabus

Kinetic and potential energy ; Work and power ;

Conservation of linear momentum and mechanical energy.

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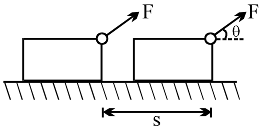
WORK POWER ENERGY

Work (W) :

The **work W** done by a constant force F when its point of application undergoes a displacement s is defined as

$W = F.s = Fs\cos\theta$



where θ is the angle between F and s.Work is a scalar quantity and its SI units is N-m or joule (J).

Note: Only the component ($F\cos\theta$) of the force F which is along the displacement contributes to the work done.

If $F = F_x\hat{i} + F_y\hat{j} + F_z\hat{k}$ and $s = \Delta x\hat{i} + \Delta y\hat{j} + \Delta z\hat{k}$

then $W = \vec{F}\cdot\vec{s} = F_x\Delta x + F_y\Delta y + F_z\Delta z$

1. Work done by a Variable Force :

When the magnitude and direction of a force varies with position, The work done by such a force for an infinitesimal displacement ds is given by

$dW = \vec{F}\cdot d\vec{s}$

In terms of rectangular components,

$$W_{AB} = \int_{X_A}^{X_B} F_x dx + \int_{Y_A}^{Y_B} F_y dy + \int_{Z_A}^{Z_B} F_z dz$$

2. Work Done by a Spring Force :

The work done by the spring force for a displacement from x_i to x_f is given by

$$W_s = -\frac{1}{2}k\left(x_f^2 - x_i^2\right)$$

3. Work Energy theorem :

Work done on a body can produce a change in its kinetic energy. Work is required to produce motion and it is also required to destroy motion.

$W = \Delta K = K_f - K_i$

4. Conservative Force :

The force which does work in complete independence of the path followed the body is called a conservative force. The gravitational force, spring force and electrostatic force are the examples of conservative forces.

5. Non-Conservative Force :

The work done by a non-conservative force not only depends on the initial and final positions but also on the path followed. The common examples of such forces are : frictional force and drag force of fluids.

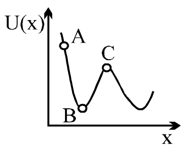
6. Potential Energy :

The potential energy is defined only for conservative forces.

$$U_B - U_A = -\int_A^B F_c . ds$$

7. Conservative force :

$$F_c = -\frac{dU}{dx}$$



At equilibrium, $\frac{dU}{dx} = 0$

The point B is the position of stable equilibrium, because $\frac{d^2U}{dx^2} > 0$

The point C is the position of unstable equilibrium, because $\frac{d^2U}{dx^2} < 0$

EXERCISE # 1

PART - I : OBJECTIVE QUESTIONS

* ***Marked Questions are having more than one correct option.***

SECTION (A) : WORK DONE BY CONSTANT FORCE

A-1.* No work is done by a force on an object if
(A) the force is always perpendicular to its velocity
(B) the force is always perpendicular to its acceleration
(C) the object is stationary but the point of application of the force moves on the object
(D) the object moves in such a way that the point of application of the force remains fixed

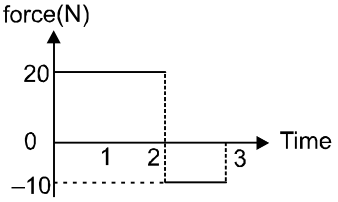
A-2. A bucket tied to a string is lowered at a constant acceleration of g/4. If the mass of the bucket is M and is lowered by a distance d, the work done by the string will be (assume the string to be massless)
(A) 1/4 Mg d (B) –3/4 Mgd (C) – 4/3Mgd (D) 4/3 Mgd

A-3. A body which is constrained to move along Y-direction is acted upon by a force $\vec{F} = (-2\hat{i} + 15\hat{j} + 6\hat{k})N$.
The work done by this force in displacing the body by 10m along Y-axis is-
(A) 190 J (B) 160 J (C) 150 J (D) 20 J

A-4. Work done by static friction on an object:
(A) may be positive (B) must be negative
(C) must be zero (D) none of these

SECTION (B) : WORK DONE BY A VARIABLE FORCE

B-1. Starting at rest, a 5 kg object is acted upon by only one force as indicated in figure. Find the total work done by the force.



(A) 180 J (B) 60 J (C) 150 J (D) 90 J

B-2. Force acting on a particle moving in a straight line varies with the velocity of the particle as F = $\frac{K}{v}$. Here, K is a constant. The work done by this force in time t is :
(A) $\frac{K}{v^2}.t$ (B) 2 Kt (C) Kt (D) $\frac{2Kt}{v^2}$

B-3. A force **F** = (3x $\hat{i}$ + 4 $\hat{j}$) Newton (where x is in metres) acts on a particle which moves from a position (2m, 3m) to (3m, 0m). Then the work done is
(A) 7.5J (B) –12J (C) –4.5 J (D) +4.5 J

B-4. A body is acted upon by a force which is inversely proportional to the distance covered. The work done will be proportional to:

(A) s (B) s^2 (C) $\sqrt{s}$ (D) None of these

B-5.* 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

SECTION (C) : WORK ENERGY THEORAM

C-1. The kinetic energy of a particle continuously increases with time

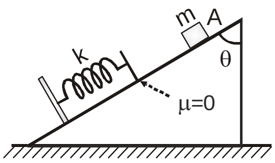
(A) the resultant force on the particle must be parallel to the velocity at all instants

(B) the resultant force on the particle must be at an angle less than 90° all the time

(C) its height above the ground level must continuously decrease

(D) the magnitude of its linear momentum is increasing continuously

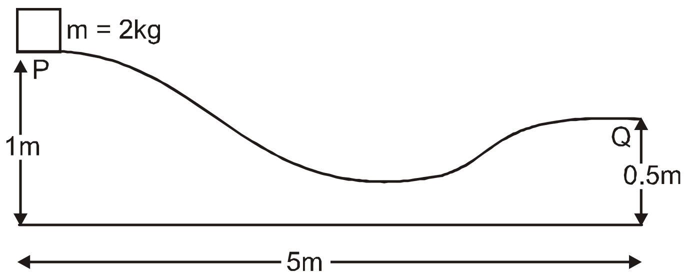
C-2. A block of mass 'm' is released from rest at point A. The compression in spring, when the speed of block is maximum :



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

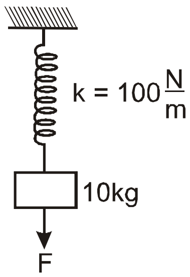
(C) $\frac{mg\cos\theta}{k}$ (D) $\frac{mg}{k}$

C-3. Find the horizontal velocity of the particle when it reach the point Q. Assume the block to be frictionless. Take g = 9.8 m/s^2.



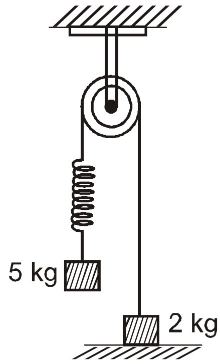
(A) 4 m/s (B) 5 m/s (C) $\sqrt{g}$ m/s (D) 3.6 m/s

C-4. A vertical spring of force constant 100 N/m is attached with a hanging mass of 10 kg. Now an external force is applied on the mass so that the spring is stretched by additional 2m. The work done by the force F is : (g = 10 m/s^2)



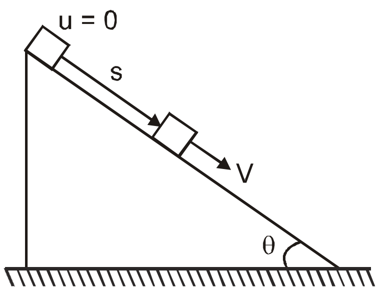
(A) 200 J (B) 400 J (C) 450 J (D) 600 J

C-5. System shown in figure is released from rest. Pulley and spring is massless and friction is absent every-where. The speed of 5 kg block when 2 kg block leaves contact with ground is : (Take force constant of spring k = 40 N/m and g = 10 m/s^2)



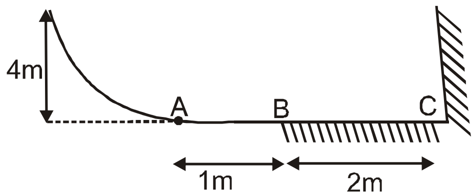
(A) $\sqrt{2}$ m/s (B) $2\sqrt{2}$ m/s (C) 2 m/s (D) $4\sqrt{2}$ m/s

C-6. A block is released from the top of a smooth inclined plane of inclination θ as shown in figure. Let *v* be the speed of the particle after travelling a distance s down the plane. Then which of the following will remain constant?



(A) $v^2 + 2gs \sin\theta$ (B) $v^2 - 2gs \sin\theta$ (C) $v - \sqrt{2gs}\sin\theta$ (D) $v + \sqrt{2gs}\sin\theta$

C-7. A block of mass m = 0.1 kg is released from a height of 4 m on a curved smooth surface. On the horizontal surface, path AB is smooth and path BC offers coefficient of friction μ = 0.1. If the impact of block with the vertical wall at C be perfectly elastic, the total distance covered by the block on the horizontal surface before coming to rest will be : (take g = 10 m/s^2)



(A) 29 m (B) 49 m (C) 59 m (D) 109 m

SECTION (D) : POWER

D-1. A pump is required to lift 800 kg of water per minute from a 10 m deep well and eject it with a speed of 20 m/s. The required power in watts of the pump will be :

(A) 240000 (B) 4000 (C) 5000 (D) none of these

D-2. An engine pumps up 1000 kg of coal from a mine 100 m deep in 0.5 sec. The pump is running with diesel and efficiency of diesel engine is 25%. Then its power consumption will be ($g = 10 m/sec^2$):

(A) 200 kW (B) 8000 kW (C) 1000 kW (D) 500 kW

D-3. 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 the above

D-4. A self propelled vehicle of mass m whose engine delivers constant power P has an acceleration $a = P/mv$ (assume that there is no friction). In order to increase its velocity from v_1 to v_2 the distance it has to travel will be:

(A) $\frac{3P}{m}(v_2^2 - v_1^2)$ (B) $\frac{m}{3P}(v_2^3 - v_1^3)$ (C) $\frac{m}{3P}(v_2^2 - v_1^2)$ (D) $\frac{m}{3P}(v_2 - v_1)$

D-5. A man cycles up a hill rising 1 metre vertically for every 50 metre along the slope at the rate of 3.6 km/hour. If the weight of the man and cycle is 120 kg, the power of the man is ($g = 10 m/s^2$)

(A) 6 watt (B) 12 watt (C) 24 watt (D) 48 watt

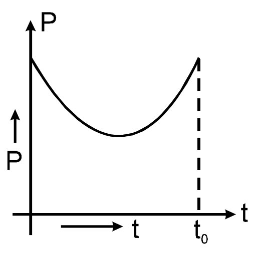
D-6. Find the speed V reached by a car of mass 'm' that is driven with constant power P and X is the distance travelled from rest -

(A) $\left(\frac{3XP}{m}\right)^{\frac{1}{3}}$ (B) $\left(\frac{2XP}{m}\right)^{\frac{1}{2}}$ (C) $\left(\frac{XP}{m}\right)^{\frac{1}{3}}$ (D) $\left(\frac{2XP}{3m}\right)^{\frac{1}{4}}$

D-7. A block of mass m is moving with a constant acceleration a on a frictional plane. If the coefficient of friction between the block and 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) $m(a+\mu g)at$

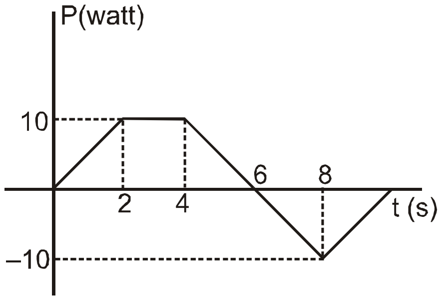
D-8. Power versus time graph for a given force is given below. Work done by the force upto time $t(\leq t_0)$.



(A) First decreases then increases (B) First increases then decreases

(C) Always increases (D) Always decreases

D-9. Power of a force acting on a block varies with time t as shown in figure. Then angle between force acting on the block and its velocity is :



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

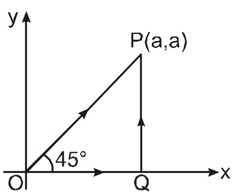
SECTION (E) : CONSERVATIVE & NONCONSERVATIVE FORCES AND EQUILIBRIUM

E-1.* Which of the following is/are conservative force(s) ?

(A) $\vec{F} = 2r^3\hat{r}$ (B) $\vec{F} = -\frac{5}{r}\hat{r}$ (C) $\vec{F} = \frac{3(x\hat{i}+y\hat{j})}{(x^2+y^2)^{3/2}}$ (D) $\vec{F} = \frac{3(y\hat{i}+x\hat{j})}{(x^2+y^2)^{3/2}}$

E-2.* One of the forces acting on a particle is conservative then which of the following statement(s) are true about this conservative force
(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) Then that particular force must be constant.
(D) Its work depends on the end points of the motion, not on the path between.

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



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

E-4. A moving particle is acted upon by several forces F_1, F_2, F_3,..... etc. One of the force is chosen, say F_2, then which of the following statement about F_2 will be true.

(A) Work done by F_2 will be negative if speed of the particle decreases.

(B) Work done by F_2 will be positive if speed of the particle increases

(C) Work done by F_2 will be equal to the work done by other forces if speed of the particle does not change

(D) If F_2 is a conservative force, then work done by all other forces will be equal to change in potential energy due to force F_2 when speed remains constant.

SECTION (F) : POTENTIAL ENERGY AND MECHANICAL ENERGY CONSERVATION

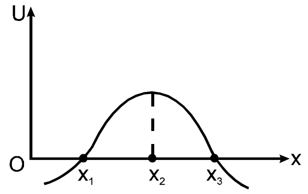
F-1. Potential energy function describing the interaction between two atoms of a diatomic molecule is

$$U(r) = \frac{a}{r^{12}} - \frac{b}{r^6}$$

Force acting between them will be zero when the distance between them would be

(A) $\left(\frac{2a}{b}\right)^{1/6}$ (B) $\left(\frac{b}{2a}\right)^{1/6}$ (C) $\left(\frac{a}{b}\right)^{1/6}$ (D) $\left(\frac{b}{a}\right)^{1/6}$

F-2. In the figure shown the potential energy U of a particle is plotted against its position 'x' from origin. Then which of the following statement is correct. A particle at:



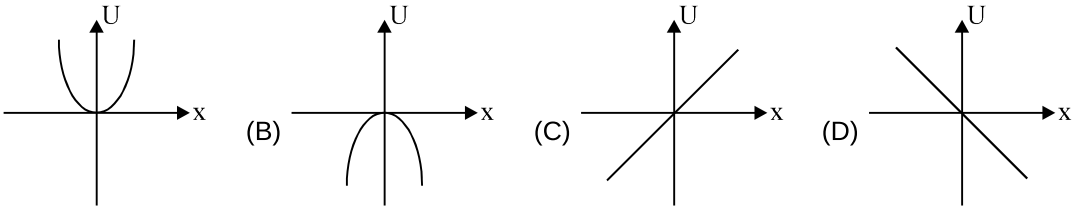
(A) x_1 is in stable equilibrium (B) x_2 is in stable equilibrium
(C) x_3 is in stable equilibrium (D) none of these

F-3. 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 drops the chain when half of the chain is in vertical position. Then work done by the man in this process is :

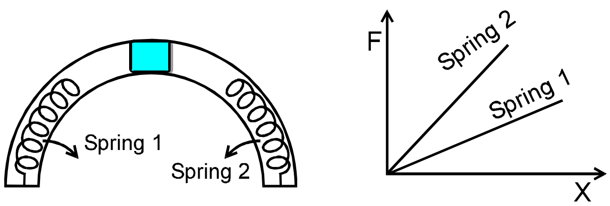
(A) $-mg\frac{\ell}{2}$ (B) $-\frac{mg\ell}{4}$ (C) $-\frac{3mg\ell}{8}$ (D) $-\frac{mg\ell}{8}$

F-4. A particle is acted by a force F = kx, where k is a +ve constant. Its potential energy at x = 0 is zero. Which curve correctly represents the variation of potential energy of the block with respect to x?

(A) (B) (C) (D)

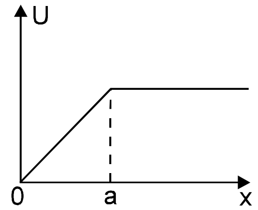


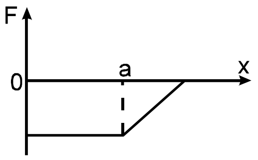
F-5. In the figure, a block rests on the top of a smooth fixed hemispherical tube of radius R in which it can just fit. Two springs are connected to the base as shown. The block is given a small jerk so that it can slide on the hemisphere. The F-X (F is magnitude of force and X is compression) graph for the springs is given below. Which of the following may be possible :

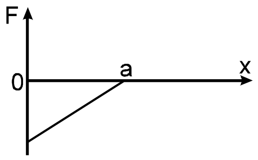


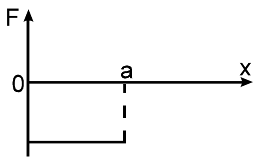
(A) The block will compress both springs by same amount.
(B) The block will compress the springs during its to and fro motion about its original position by different amounts.
(C) The block will perform to and fro motion along the hemispherical surface about the original position.
(D) The block can never come to the original position.

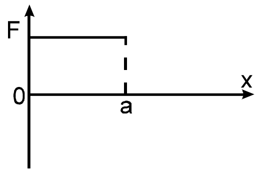
F-6. The potential energy of a particle varies according to the graph shown. Force acting on it varies according to which of the following graphs



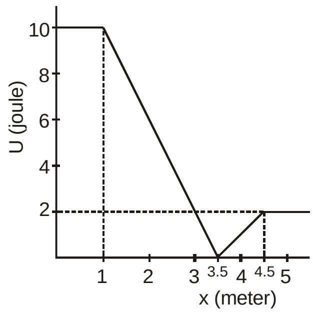
(A) 

(B) 

(C) 

(D) 

F-7. A body with mass 2 kg moves in one direction in the presence of a force which is described by the potential energy graph. If the body is released from rest at x = 2m, then its speed when it crosses x = 5 m is :



(A) zero

(B) 1 ms^{-1}

(C) 2 ms^{-1}

(D) 3 ms^{-1}

F-8. An object is attached to a vertical spring and is allowed to fall under the gravity. What is the distance traversed by the object before being stopped ?

(A) mg/k (B) 2mg/k (C) mg/2k (D) none of these.

F-9.* The potential energy (in joules) of a particle of mass 1kg moving in a plane is given by V = 3x + 4y, the position coordinates of the point being x and y, measured in metres. If the particle is at rest at (6, 4) ; then

(A) its acceleration is of magnitude $5m/s^2$

(B) its speed when it crosses the y–axis is 10m/s

(C) it crosses the y-axis (x = 0) at y = –4

(D) it moves in a striaght line passing through the origin (0, 0)

F-10. The potential energy of a particle of mass m free to move along x-axis is given by $U = \frac{1}{2}kx^2$ for x < 0 and U = 0 for x ≥ 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 $x = -\sqrt{\frac{2E}{k}}$ is

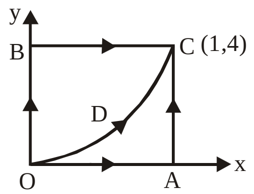
(A) zero (B) $\sqrt{\frac{2E}{m}}$ (C) $\sqrt{\frac{E}{m}}$ (D) $\sqrt{\frac{E}{2m}}$

PART - II : MISLLANEOUS QUESTIONS

COMPREHENSION TYPE

COMPREHENSIONS # 1 :

A particle is moved along the different paths OAC, OBC and ODC as shown in the figure. Path ODC is a parabola, y = 4x². The work done by a force $F = xy\hat{i} + x^2y\hat{j}$ on the particle along



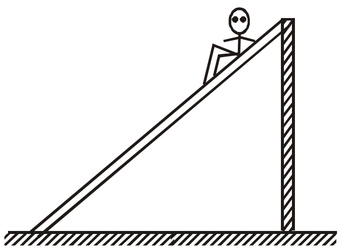
1. The path OAC is
(A) 8 J (B) 2 J (C) 19/3 J (D) zero

2. The path OBC is
(A) 8 J (B) 2 J (C) 19/3 J (D) zero

3. The path ODC is
(A) 8 J (B) 2 J (C) 19/3 J (D) zero

COMPREHENSIONS # 2 :

In a children's park, there is a slide which has a total length of 10 m and a height of 8.0m as shown in figure. A vertical ladder is provided to reach the top. A body weighing 200 N climbs up the ladder to the top of the slide and slides down the ground. The average friction offered by the slide is three tenth of his weight.



4. The work done by the ladder on the boy as he goes up is
(A) 600 J (B) 1600 J (C) zero (D) 800 J

5. The work done by the slide on the boy as he comes down is
(A) 1600 J (B) –600 J (C) zero (D) 500 J

6. The work done by forces inside the body of the boy is : (during downward motion of the boy on the slide)
(A) zero (B) –600 J (C) 800 J (D) 1600 J

COMPREHENSIONS # 3 :

A single conservative force $f(x)$ acts on a m = 1 kg particle moving along the x-axis. The potential energy $U_{(x)}$ is given by : $U_{(x)} = 20 + (x - 2)^2$
where x is in metres. At x = 5 m, a particle has kinetic energy of 20 J

7. The total mechanical energy of the system is:

(A) zero (B) 20 J (C) 29 J (D) 49 J

8. The minimum potential energy of the particle is :

(A) zero (B) 20 J (C) 29 J (D) 49 J

9. The maximum speed of the particle is:

(A) 1 m/s (B) 29 m/s (C) $\sqrt{29}$ m/s (D) $\sqrt{58}$ m/s

10. The minimum speed of the particle is:

(A) 1 m/s (B) $\sqrt{40}$ m/s (C) $\sqrt{58}$ m/s (D) zero

11. The maximum value of potetial energy is :

(A) zero (B) 20 J (C) 29 J (D) 49 J

12. The least value of x (position of particle is) will be:

(A) zero (B) – 2 (C) $-\sqrt{29}+2$ (D) $\sqrt{29}+2$

13. The largest value of x will be :

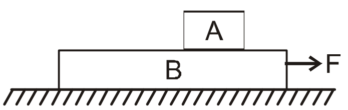
(A) zero (B) – 2 (C) $-\sqrt{29}+2$ (D) $\sqrt{29}+2$

14. The position of equilibrium and its nature is:

(A) x = 2, unstable (B) x = 2, stable (C) x = 2, neutral (D) no equilibrium position exists

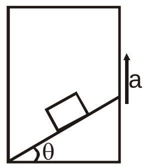
MATCH THE COLUMN

15. A block A of mass m kg lies on block B of mass m kg. B in turn lies on smooth horizontal plane. The coefficient of friction between A and B is μ. Both the blocks are initially at rest. A horizontal force F is applied to lower block B at t = 0 such that there is relative motion between A and B. In the duration from t = 0 second till the lower block B undergoes a displacement of magnitude L, match the statements in column-I with results in column-II.



Column-I	**Column-II**
(A) Work done by friction force on block A is	(p) positive
(B) Work done by friction force on block B is	(q) negative
(C) Work done by friction on block A plus work done by friction on block B is	(r) less than μ mgL in magnitude
(D) Work done by force F on block B is	(s) equal to μ mgL in magnitude

16. A block of mass m is stationary with respect to a rough wedge as shown in figure. Starting from rest in time t, (m = 1kg, θ = 30°, a = 2m/s^2, t = 4s) work done on block:



Column-I	**Column-II**
(A) by gravity	(p) 144 J
(B) by normal reaction	(q) 32 J
(C) by friction	(r) 56 J
(D) by all the forces	(s) 48 J
	(t) none of these

EXERCISE # 2

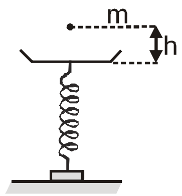
PART - I : MIXED OBJECTIVE

SINGLE CORRECT ANSWER TYPE

1. Kinetic energy of a particle moving in a straight line varies with time t as K = 4t^2. The force acting on the particle -

(A) is constant
(B) is increasing
(C) is decreasing
(D) first increase and then decrease

2. A ball of mass m is dropped from a height h on a platform fixed at the top of a vertical spring. The platform is displaced by a distance x. The spring constant is

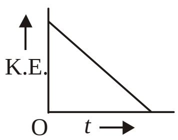


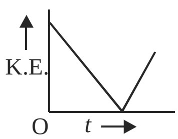
(A) $\frac{2mg}{x}$ (B) $\frac{2mgh}{x^2}$ (C) $\frac{2mg(h+x)}{x^2}$ (D) $\frac{2mg(h+x)}{h^2}$

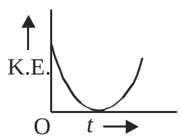
3. When the momentum of a body increases by 100%, its KE increases by :

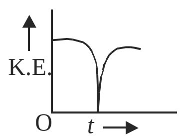
(A) 400% (B) 100% (C) 300% (D) none of these

4. A ball is projected vertically upwards with an initial velocity. Which of the following graphs best represents the K.E. of the ball as a function of time from the instant of projection till it reaches the point of projection ?

(A)


(B)


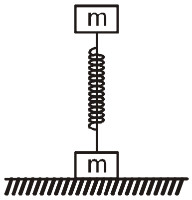
(C)


(D)


5. An elastic spring of unstretched length L and force constant k is stretched by a small length x. It is further stretched by a small length y. The work done in the second stretching is

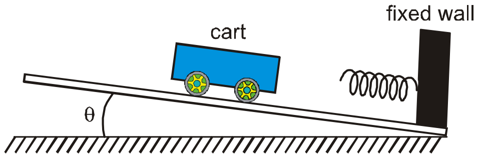
(A) $\frac{1}{2}ky^2$ (B) $\frac{1}{2}k(x^2+y^2)$ (C) $\frac{1}{2}k(x+y)^2$ (D) $\frac{1}{2}ky(2x+y)$

6. A system consists of two identical cubes, each of mass m,linked together by a compressed weightless spring of force constant k. The cubes are also connected by a thread which is burnt at a certain moment. The minimum value of initial compression x_0 of the spring for which lower cube bounce up after the thread is burnt is:



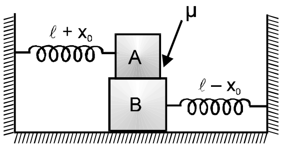
(A) $\frac{2mg}{k}$ (B) $\frac{3mg}{k}$ (C) $\frac{3mg}{2k}$ (D) $\frac{6mg}{k}$

7. The cart starting from rest moves down the incline. When the cart maximally compresses the spring (that is compression in the spring is maximum) at the bottom of the track, the cart's



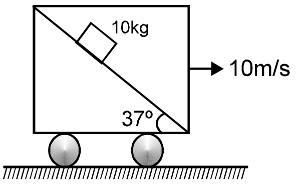
(A) velocity and acceleration are zero.
(B) velocity is nonzero but its acceleration is zero.
(C) acceleration is nonzero, but its velocity is zero.
(D) velocity and acceleration are both nonzero.

8. For the system shown in figure two spring are identical and have spring constant K. Friction coefficient between the blocks is μ. The mass of each block is 'm'. By the time the two springs come in their natural length (ℓ), which of the following statement is correct. (Ground may be rough or smooth)



(A) Work done by friction on block A is positive
(B) Work done by friction on block B is positive
(C) Work done by friction on system A + B is positive
(D) None of these

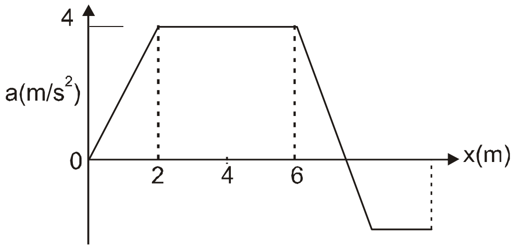
9. A block of mass 10 kg is released on a fixed wedge inside a cart which is moved with constant velocity 10 m/s towards right. Take initial velocity of block with respect to cart zero. Then work done by normal reaction (with respect to ground)on block in two second will be: (g = 10 m/s^2).



(A) zero (B) 960 J (C) 1200 J (D) none of these

10. The minimum work done to accelerate a truck on a horizontal road from rest to speed v
(A) is less than that required to accelerate it from v to 2v.
(B) is equal than that required to accelerate it from v to 2v.
(C) is more than that required to accelerate it from v to 2v.
(D) may be any one of the above since it depends on the force acting on the truck and the distance over which it acts.

11. Graph shows the acceleration of a 3 kg particle as an applied force moves it from rest along x axis. The total work done by the force on the particle by the time the particle reaches x = 6 m, is equal to

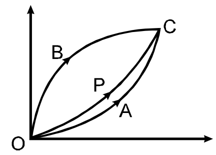


(A) 20 J (B) 30 J (C) 40 J (D) 60 J

12. Under the action of a force a 2kg mass moves such that its position x as a function of time is given by $x = \frac{t^3}{3}$ where x is in metres and t in seconds. The work done by the force in first two seconds is
(A) 1600 joules (B) 160 joules (C) 16 joules (D) 1.6 joules

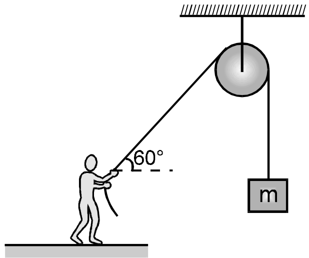
13. A man who is running has half the kinetic energy of a boy of half of his mass. The man speeds up by 1 ms^{-1} and then has same kinetic energy as the boy. The original speed of the man was
(A) $\sqrt{2}$ ms^{-1} (B) $(\sqrt{2}-1)$ ms^{-1} (C) 2 ms^{-1} (D) $\sqrt{2}+1$ ms^{-1}

14. A particle is constrained to move from initial point 'O' to final point 'C' along three different smooth horizontal tracks namely OBC, OPC & OAC. If the particle moves under the influence of an external force F such that the initial and the final speeds are same, then:



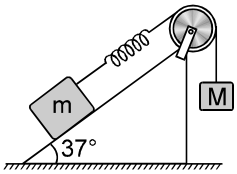
(A) force F is conservative
(B) force F cannot be conservative
(C) there exists no closed path along which line integral of force F is zero
(D) there necessarily exists a path along which line integral of force F is zero.

15. A man is supplying a constant power of 500 J/s to a massless string by pulling it at a constant speed of 10 m/s as shown. It is known that kinetic energy of the block is increasing at a rate of 100 J/s. Then the mass of the block is :



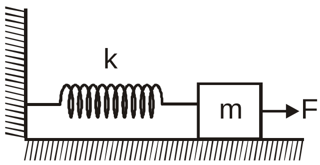
(A) 5 kg (B) 3 kg (C) 10 kg (D) 4 kg

16. A block of mass m is attached with a massless spring of force constant k. The block is placed over a fixed rough inclined surface for which the coefficient of friction is $\mu = \frac{3}{4}$. The block of mass m is initially at rest. The block of mass M is released from rest with spring in unstretched state. The minimum value of M required to move the block up the plane is (neglect mass of string and pulley and friction in pulley.)



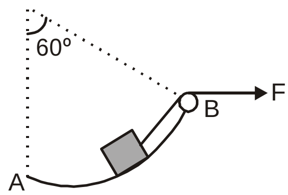
(A) $\frac{3}{5}$m (B) $\frac{4}{5}$m (C) $\frac{6}{5}$m (D) $\frac{3}{2}$m

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



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

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

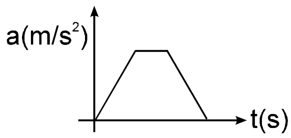


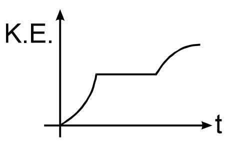
(A) $\sqrt{3}$ m/s (B) $10\sqrt{3}$ m/s (C) $100\sqrt{3}$ m/s (D) None of these

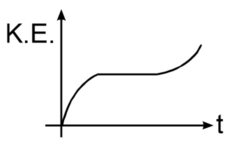
19. Two equal masses are attached to the two ends of a spring of spring constant k. The masses are pulled out symmetrically to stretch the spring by a length x over its natural length. The work done by the spring on each mass is :

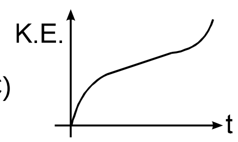
(A) $\frac{1}{2}kx^2$ (B) $-\frac{1}{2}kx^2$ (C) $\frac{1}{4}kx^2$ (D) $-\frac{1}{4}kx^2$

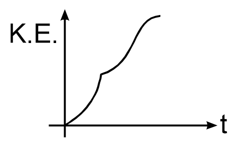
20. For a particle moving on a straight line the variation of acceleration with time is given by the graph as shown. Initially the particle was at rest. Then the corresponding kinetic energy of the particle versus time graph will be



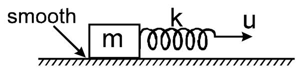
(A)


(B)


(C)


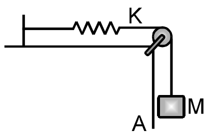
(D)


21. A block attached with a spring is kept on a smooth horizontal surface. Now the free end of the spring is pulled with a constant velocity u horizontally. Then the maximum energy stored in the spring and block system during subsequent motion is :



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

22. Block A in the figure is released from rest when the extension in the spring is x_0. (x_0 < Mg/k). The maximum downward displacement of the block is (there is no friction) :



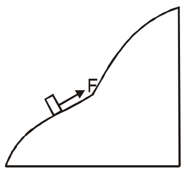
(A) $\frac{2Mg}{K} - 2x_0$ (B) $\frac{Mg}{2K} + x_0$ (C) $\frac{2Mg}{K} - x_0$ (D) $\frac{2Mg}{K} + x_0$

MULTIPLE CORRECT ANSWER(S) TYPE

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

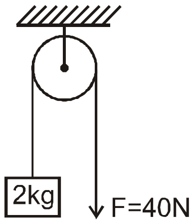
(A) the spring was initially compressed by a distance x and was finally in its natural length
(B) it was initially stretched by a distance x and finally was in its natural length
(C) it was initially in its natural length and finally in a compressed position
(D) it was initially in its natural length and finally in a stretched position

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



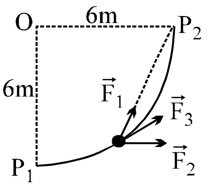
(A) Is independent of shape of trajectory
(B) Depends upon vertical component of displacement but independent of horizontal component
(C) Depends upon both the components of displacement
(D) Does not depend upon coefficient of friction

25. A block of mass 2 kg is hanging over a smooth and light pulley through a light string. The other end of the string is pulled by a constant force F = 40 N. The kinetic energy of the particle increase 40 J in a given interval of time. Then : (g = 10 m/s^2)



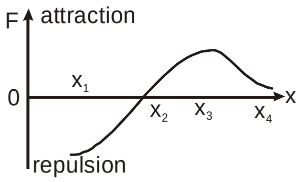
(A) tension in the string is 40 N
(B) displacement of the block in the given interval of time is 2 m
(C) work done by gravity is – 20 J
(D) work done by tension is 80 J

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



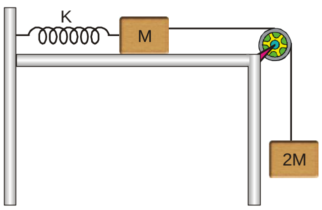
(A) work done by $\vec{F}_1$ is 120 J
(B) work done by $\vec{F}_2$ is 180 J
(C) work done by $\vec{F}_3$ is 45 pJ
(D) $\vec{F}_1$ is conservative in nature

27. The diagram given shows how the net interaction force (conservative) between two particles A and B is related to the distance between them varies from x_1 to x_4. Then:



(A) potential energy of the system increases from x_1 to x_2.
(B) potential energy of the system increases from x_2 to x_3.
(C) potential energy of the system increases from x_3 to x_4.
(D) KE. increases from x_1 to x_2 and decreases from x_2 to x_3.

28. Two blocks, of masses M and 2M, are connected to a light spring of spring constant K that has one end fixed, as shown in figure. The horizontal surface and the pulley are frictionless. The blocks are released from rest when the spring is non deformed. The string is light.



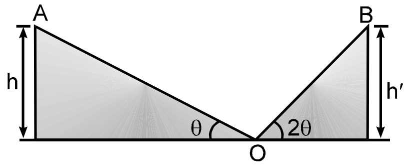
(A) Maximum extension in the spring is $\frac{4Mg}{K}$.

(B) Maximum kinetic energy of the system is $\frac{2M^2g^2}{K}$

(C) Maximum energy stored in the spring is four times that of maximum kinetic energy of the system.

(D) When kinetic energy of the system is maximum, energy stored in the spring is $\frac{4M^2g^2}{K}$

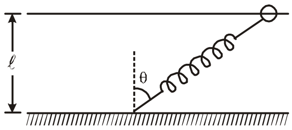
29. A body starts to slide from A, down the fixed smooth inclined plane AO having inclination θ with horizontal and then ascends another fixed smooth plane OB upto B. If impact at O is neglected: (h' = h)



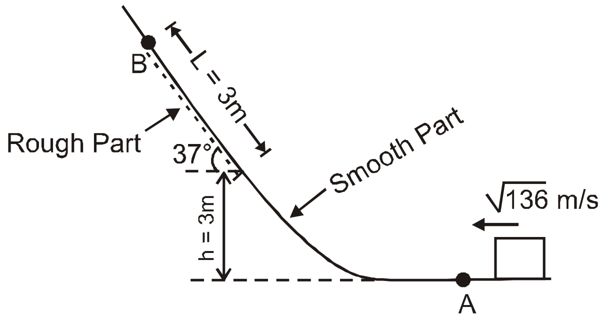
(A) $t_{AO} > t_{OB}$
(B) $t_{AO} < t_{OB}$
(C) $t_{AO} = t_{OB}$
(D) $h' = h$

PART - II : SUBJECTIVE QUESTIONS

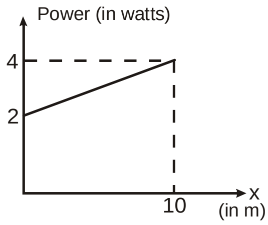
1. One end of a spring of natural length ℓ and spring constant k is fixed at the ground and the other is fitted with a smooth ring of mass m which is allowed to slide on a horizontal rod fixed at a height ℓ (figure). Initially, the spring makes an angle of θ with the vertical when the system is released from rest. If the speed of the ring when the spring becomes vertical is $(2\ell / 3)\sqrt{\frac{k}{m}}$ m/s then find the value of angle θ :



2. A small block slides along a path that is without friction until the block reaches the section L = 3m, which begins at height h = 3m on a flat incline of angle 37°, as shown. In that section, the coefficient of kinetic friction is 0.50. The block passes through point A with a speed of $\sqrt{136}$ m/s. Find the speed of the block as it passes through point B where the friction ends, in m/s. (Take g = 10 m/s^2)



3. A particle A of mass $\frac{10}{7}$ kg is moving in the positive direction of x. Its initial position is x = 0 & initial velocity is 1 m/s. The velocity of particle at x = 10 is v m/s. Find value of v ? : (use the graph given)



4. A ball is suspended from the top of a cart by a string of length 1 m. The cart and the ball are initially moving to the right at constant speed V, as shown in figure I. The cart comes to rest after colliding and sticking to a fixed bumper, as in figure II. The suspended ball swings through a maximum angle 60°. The initial speed

is $V = \sqrt{K+1}$ m/s. Find value of K. (take g = 10 m/s^2)

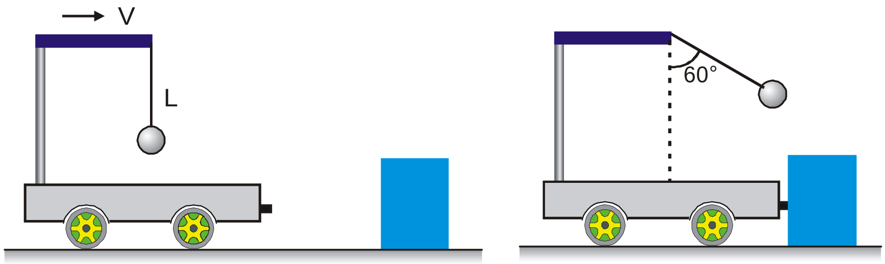
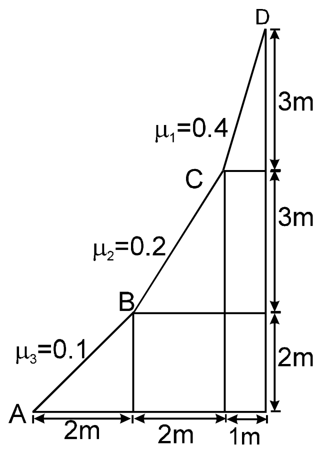


Figure (1)

Figure (2)

5. A body of mass 1 kg is shifted from A to D on inclined planes by applying a force slowly such that the block is always is in contact with the plane surfaces. Neglecting the jerk experienced at points C and B, total work done by the applied force is 30K ? . Find K :



6. A particle is projected vertically upwards with a speed of 16 m/s, after some time, when it again passes through the point of projection, its speed is found to be 8 m/s. It is known that the work done by air resistance is same during upward and downward motion. Then the maximum height (in metre) attained by the particle is ? (Take g = 10 m/s^2) :

EXERCISE # 3

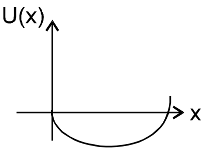
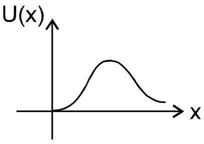
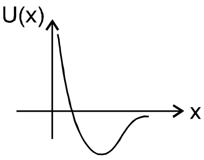
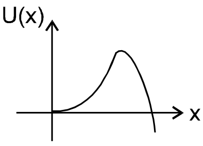
PART-I IIT-JEE (PREVIOUS YEARS PROBLEMS)

***Marked Questions are having more than one correct option.**

1. A wind-powered generator converts wind energy into electrical energy. Assume that the generator converts a fixed fraction of the wind energy intercepted by its blades into electrical energy. For wind speed v, the electrical power output will be proportional to- **[JEE (Scr.) 2000, 3/105]**

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

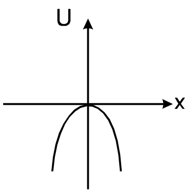
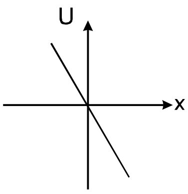
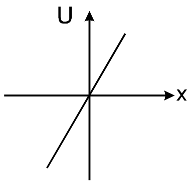
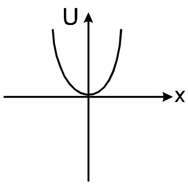
2. A particle, which is constrained to move along the x-axis, is subjected to a force in the same direction which varies with the distance x of the particle from the origin as $F(x) = -kx + ax^3$. Here k and a are positive constants. For $x \geq 0$, the functional form of the potential energy U(x) of the particle is : **[JEE(Scr) 2002, 3/105]**

(A) 
(B) 
(C) 
(D) 

3. An ideal spring with spring-constant k is hung from the ceiling and a block of mass M is attached to its lower end. The mass is released with the spring initially unstreched. Then the maximum extension in the spring is : **[JEE(Scr) 2002, 3/105]**

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

4. A particle moves under the influence of a force F = kx in one dimensions (k is a positive constant and x is the distance of the particle from the origin). Assume that the potential energy of the particle at the origin is zero, the schematic diagram of the potential energy U as a function of x is given by : **[JEE(Scr) 2004, 3/84]**

(A) 
(B) 
(C) 
(D) 

5. **STATEMENT - 1 :** **[JEE 2007' 3/184] [JEE 2007, 3/81] [Conducted by Bombay]**

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

Because

STATEMENT - 2

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

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

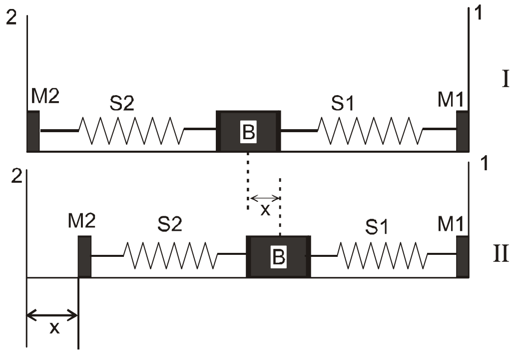
(B) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1

(C) Statement-1 is True, Statement-2 is False

(D) Statement-1 is False, Statement-2 is True.

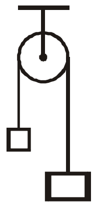
6. A block (B) is attached to two unstretched springs S1 and S2 with spring constants k and 4 k, respectively (see figure I). The other ends are attached to identical supports M1 and M2 not attached to the walls. The springs and supports have negligible mass. There is no friction anywhere. The block B is displaced towards wall 1 by a small distance x (figure 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 **[JEE 2008, 3/163] [conducted by IIT Roorkee]**

Figure :

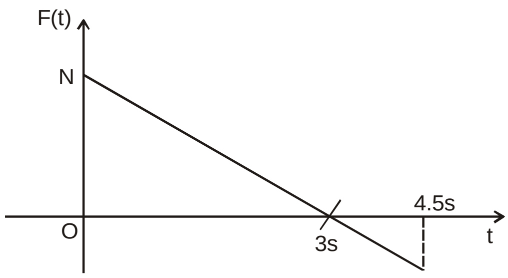


(A) 4 (B) 2 (C) $\frac{1}{2}$ (D) $\frac{1}{4}$

7. A light inextensible string that goes over a smooth fixed pulley as shown in the figure connects two blocks of masses 0.36 kg and 0.72 kg. Taking g = 10 m/s^2, find the work done (**in joules**) by the string on the block of mass 0.36 kg during the first second after the system is released from rest. **[JEE 2009, 4/160, –1]**

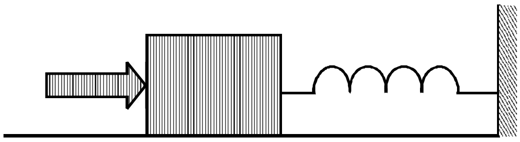


8. A block of mass 2 kg is free to move along the x-axis. It is at rest and from t = 0 onwards it is subjected to a time-dependent force F (t) in the x direction. The force F (t) varies with t as shown in the figure. The kinetic energy of the block after 4.5 seconds is : **[JEE' 2010, 8/163] conducted by IIT Madras]**



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

9. A block of mass 0.18 kg is attached to a spring of force-constant 2 N/m. The coefficient of friction between the block and the floor is 0.1. Initially the block is at rest and the spring is un-stretched. An impulse is given to the block as shown in the figure. The block slides a distance of 0.06 m and comes to rest for the first time. The initial velocity of the block in m/s is V = N/10. Then N is : **[JEE' 2011, 4/160] [conducted by IIT Kanpur]**



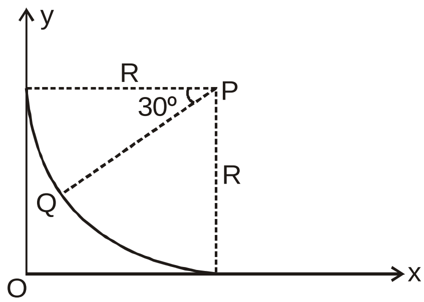
10. The work done on a particle of mass m by a force, $K\left[\dfrac{x}{(x^2+y^2)^{3/2}}\hat{i}+\dfrac{y}{(x^2+y^2)^{3/2}}\hat{j}\right]$ (K being a constant of appropriate dimensions), when the particle is taken from the point (a, 0) to the point (0, a) along a circular path of radius a about the origin in the x-y plane is : **[JEE Advanced (P-1) 2013]**

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

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

Paragraph for Questions 12 and 13

A small block of mass 1 kg is released from rest at the top of a rough track. The track is a circular are of radius 40 m. The block slides along the track without toppling and a frictional force acts on it in the direction opposite to the instantaneous velocity. The work done in overcoming the friction up to the point Q, as shown in the figure below, is 150 J.
(Take the acceleration due to gravity, $g = 10ms^{-2}$) **[JEE Advanced (P-2) 2013]**



12. The magnitude of the normal reaction that acts on the block at the point Q is: **[JEE Advanced (P-2) 2013]**

(A) 7.5 N (B) 8.6 N (C) 11.5 N (D) 22.5 N

13. The speed of the block when it reaches the point Q is : **[JEE Advanced (P-2) 2013]**

(A) 5 ms^{-1} (B) 10 ms^{-1} (C) $10\sqrt{3}$ ms^{-1} (D) 20 ms^{-1}

PART-II AIEEE (PREVIOUS YEARS PROBLEMS)

*** Marked Questions are having more than one correct option.***

1. If a body loses half of its velocity on penetrating 3 cm in a wooden block, then how much will it penetrate more before coming to rest? **[AIEEE 2002, 4/300]**
(1) 1 cm (2) 2 cm (3) 3 cm (4) 4 cm

2. A spring of force constant 800 N/m has an extension of 5cm. The work done in extending it from 5cm to 15cm is : **[AIEEE 2002, 4/300]**
(1) 16 J (2) 8 J (3) 32 J (4) 24 J

3. A spring of spring constant 5×10^3 N/m is stretched initially by 5 cm from the unstretched position. Then the work required to stretch it further by another 5 cm is : **[AIEEE 2003, 4/300]**
(1) 12.50 N-m (2) 18.75 N-m (3) 25.00 N-m (4) 6.25 N-m

4. 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 : **[AIEEE 2003, 4/300]**
(1) $t^{3/4}$ (2) $t^{3/2}$ (3) $t^{1/4}$ (4) $t^{1/2}$

5. A uniform chain of length 2 m is kept on a table such that a length of 60 cm hangs freely from the edge of the table. The total mass of the chain is 4 kg. What is the work done in pulling the entire chain on the table? **[AIEEE 2004, 4/300]**
(1) 7.2 J (2) 3.6 J (3) 120 J (4) 1200 J

6. A force $\vec{F} = (5\hat{i} + 3\hat{j} + 2\hat{k})$ N is applied over a particle which displaces it from origin to the point $\vec{r} = (2\hat{i} - \hat{j})$ m. The work done on the particle in joules is : **[AIEEE 2004, 4/300]**
(1) – 7 (2) + 7 (3) + 10 (4) + 13

7. A body of mass m accelerates uniformly from rest to v_1 in time t_1. The instantaneous power delivered to the body as a function of time t is : **[AIEEE 2004, 4/300]**
(1) $\frac{mv_1 t}{t_1}$ (2) $\frac{mv_1^2 t}{t_1^2}$ (3) $\frac{mv_1 t}{t_1}$ (4) $\frac{mv_1^2 t}{t_1}$

8. A body of mass m is accelerated uniformly from rest to a speed v in a time T. The instantaneous power delivered to the body as a function of time, is given by : **[AIEEE 2005, 4/300]**
(1) $\frac{mv^2}{T^2}.t$ (2) $\frac{mv^2}{T^2}.t^2$ (3) $\frac{1}{2}\frac{mv^2}{T^2}.t$ (4) $\frac{1}{2}\frac{mv^2}{T^2}.t^2$

9. A particle of mass 100 g is thrown vertically upwards with a speed of 5 m/s. the work done by the force of gravity during the time the particle goes up is **[AIEEE 2006, 1.5/180]**
(1) – 0.5 J (2) –1.25 J (3) +1.25 J (4) 0.5 J

10. A ball of mass 0.2 kg is thrown vertically upwards by applying a force by hand. If the hand moves 0.2 m which applying the force and the ball goes upto 2 m height further, find the magnitude of the force. Consider g = 10 m/s^2 : **[AIEEE 2006, 3/180]**
(1) 22 N (2) 4 N (3) 16 N (4) 20 N

11. A particle is projected at 60° to the horizontal with a kinetic energy K. The kinetic energy at the highest point is : **[AIEEE 2007, 3/120]**
(1) *K* (2) zero (3) *K*/4 (4) *K*/2

12. An athlete in the olympic games covers a distance of 100 m in 10 s. His kinetic energy can be estimated to be in the range **[AIEEE 2008, 3/105]**
(1) 2×10^5 J – 3×10^5 J (2) 20,000 J – 50,000 J
(3) 2,000 J – 5,000 J (4) 200 J – 500 J

13. If two springs S_1 and S_2 of force constants k_1 and k_2, respectively, are streched by the same force, it is found that more work is done on spring S_1 than on spring S_2. **[AIEEE 2012, 4/120]**
Statement 1 : If stretched by the same amount, work done on S_1, will be more than that on S_2.
Statement 2 : $k_1 < k_2$
(1) Statement 1 is false, Statement 2 is true.
(2) Statement 1 is true, Statement 2 is true; Statement 2 is a correct explanation for Statement 1.
(3) Statement 1 is true, Statement 2 is true; Statement 2 is not a correct explanation for Statement 1.
(4) Statement 1 is true, Statmenet 2 is false.

EXERCISE # 4

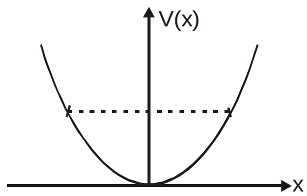
NCERT QUESTIONS

1. The sign of work done by a force on a body is important to understand. State carefully if the following quantities are positive or negative :
(A) work done by a man in lifting a bucket out of a well by means of a rope tied to the bucket.
(b) work done by gravitational force in the above case.
(c) work done by friction on a body sliding down an inclined plane.
(d) work done by an applied force on a body moving on a rough horizontal plane with uniform velocity,
(e) work done by the resistive force of air on a vibrating pendulum in bringing into rest.

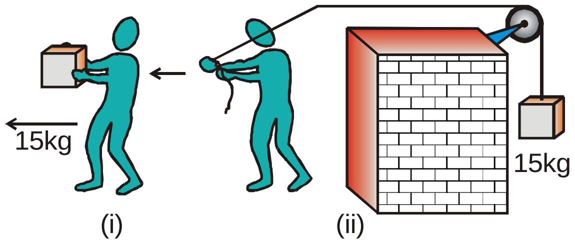
2. A body of mass 2 kg initially at rest moves under the action of an applied horizontal force of 7 N on a table with coefficient of kinetic friction - 0.1. Compute the
(a) work done by the applied force in 10 s,
(b) work done by friction in 10 s,
(c) work done by the net force on the body in 10 s
(d) change in kinetic energy of the body in 10 s,
and interpret your results.

3. Given in figure are examples of some potential energy functions in one dimension. The total energy of the particle is indicated by a cross on the ordinate axis. In each case, specify the regions, if any, in which the particle cannot be found for the given energy. Also, indicate the minimum total energy the particle must have in each case. Think of simple physical contexts for which these potential energy shapes are relevant.

4. The potential energy function for a particle executing linear simple harmonic motion is given by $V(x) = kx^2/2$, where k is the force constant of the oscillator. For $k = 0.5\ N\ m^{-1}$, the graphj of V(x) versus x is shown in figure. Show that a particle of total energy 1 J moving under this potential must 'turn back' when it reaches $x = \pm 2$ m.



5. Answer the following :
(a) The casing of a rocket in flight burns up due to friction. At whose expense is the heat energy required for burning obtained ? The rocket or the atmosphere ?
(b) Comets move around the sun in highly elliptical orbits. The gravitational force on the comet due to the sun is not normal to the comet's velocity in general. Yet the work done by the gravitational force over every complete orbit of the comet is zero. Why ?
(c) An artificial satellite orbiting the earth in very thin atmosphere loses its energy gradually due to dissipation against atmospheric resistance, however small. Why then as it comes closer and closer to the earth ?
(d) In figure the man walks 2 m carrying a mass of 15 kg on his hands. In figure (ii) he walks the same distance pulling the rope behind him. The rope goes over a pulley, and a mass of 15 kg hangs at its other end. In which case is the work done greater ?



6. A body is initially at rest. It undergoes on -dimensional motion with constant acceleration. The power delivered to it at time t is proportional to
(i) $t^{1/2}$ (ii) t (iii) $t^{3/2}$ (iv) t^2

7. A body is moving uni-directionally under the influence of a source of constant power. Its displacement in time t is proportional to :
(i) $t^{1?2}$ (ii) t (iii) $t^{3/2}$ (iv) t^2

8. A body constrained to move along the z-axis of a coordinate system is subject to a constant force F given by :

$$F = -\hat{i} + 2\hat{j} + 3\hat{k}\ N$$

where $\hat{i}, \hat{j}, \hat{k}$ are unit vectors along the x-, y- and z-axis of the system respectively. What is the work done by this force in moving the body a distance of 4 m along the z-axis ?

9. An electron and a proton are detected in a cosmic ray experiment, the first with kinetic energy 10 keV, and the second with 100 keV. Which is faster, the electron or the proton ? Obtain the ratio of their speeds. (Electron mass = 9.11×10^{-31} kg, proton mass = 1.67×10^{-27} kg, 1 eV = 1.60×10^{-19} J).

10. A rain drop of radius 2 mm falls from a height of 500 m above the ground. It falls with decreasing acceleration (due to viscous resistance of the air) until at half its original height, it attains its maximum (terminal) speed, and moves with uniform speed height, it attains its maximum (terminal) speed, and moves with uniform speed thereafter. What is the work done by the gravitational force on the drop in the first and second half of its journey ? What is the work done by the resistive force in the entire journey if its speed on reaching the ground is 10 m s^{-1} ?

11. A pump on the ground floor of a building can pump up water to fill a tank of volume 30 m^3 in 15 min. If the tank is 40 m above the ground, and the efficiency of the pump is 30%, how much electric power is consumed by the pump ?

12. The bob of a pendulum is released from a horizontal position A as shown in figure. If the length of the pendulum is 1.5 m, what is the speed with which the bob arrives at the lowermost point B, given that it dissipated 5% of its initial energy against air resistance ?

13. A trolley of mass 300 kg carrying a sandbag of 25 kg is moving uniformly with a speed of 27 km/h on a frictionless track. After a while, sand starts leaking out of a hole on the trolley's floor at the rate of 0.05 kg s^{-1}. What is the speed of the trolley after the entire sand bag is empty ?

14. A particle of mass 0.5 kg travels in a straight line with velocity $v = ax^{3/2}$ where a = 5 $m^{-1/2}$ s^{-1}. What is the work done by the net force during its displacement from x = 0 x = 2m ?

15. The blades of a windmill sweep out a circle of area A.
(a) If the wind flows at a velocity v perpendicular to the circle, what is the mass of the air passing through it in time t ?
(b) What is the kinetic energy of the air ?
(c) Assume that the windmill converts 25% of the wind's energy into electrical energy, and that A = 30 m^2, v = 36 km/h and the density of air is 1.2 kgm^{-2}. What is the electrical power produced ?

16. A person trying to loose weight (dieter) lifts a 10 kg mass 0.5 m, 1000 times. Assume that the potential energy lost each time she lowers the mass is dissipated. (a) How much work does she do against the gravitational force ? (b) Fat supplies 3.8×10^7 J of energy per kilogram which is converted to mechanical energy with a 20% efficiency rate. How much fat will the dieter use up ?

17. A large family uses 8 kW of power. (A) Direct solar energy is incident on the horizontal surface at an average rate of 200 W per square meter. If 20% of this energy can be converted to useful electrical energy, how large an area is needed to supply 8 kW ? (b) Compare this area to that of the roof of a typical house.

18. A bullet of mass 0.012 kg and horizontal speed 70 ms^{-1} strikes a block of wood of mass 0.4 kg and instantly comes to rest with respect to the block. The block is suspended from the ceiling by means of thin wires. Calculate the height to which the block rises. Also, estimate the amount of heat produced in the block.

19. Two inclined frictionless tracks, one gradual and he other steep meet at A from where two stones are allowed to slide down from rest, one on each track (Figure). Will the stones reach the bottom at the same time ? Will they reach there with the same speed ? Explain. Given $\theta_1 = 30°$, $\theta_2 = 60°$, and h = 10 m, what are the speeds and times taken by the two stones ?

ANSWERS

Exercise # 1

PART-I

A-1.*	(ACD)	**A-2.**	(B)	**A-3.**	(C)	**A-4.**	(A)	**B-1.**	(D)	**B-2.**	(C)	**B-3.**	(C)
B-4.	(D)	**B-5.***	(BD)	**C-1.**	(BD)	**C-2.**	(C)	**C-3.**	(C)	**C-4.**	(A)	**C-5.**	(B)
C-6.	(B)	**C-7.**	(C)	**D-1.**	(B)	**D-2.**	(B)	**D-3.**	(A)	**D-4.**	(B)	**D-5.**	(C)
D-6.	(A)	**D-7.**	(D)	**D-8.**	(C)	**D-9.**	(ACD)	**E-1.***	(ABC)	**E-2.***	(AD)	**E-3.**	(A)
E-4.	(D)	**F-1.**	(A)	**F-2.**	(D)	**F-3.**	(C)	**F-4.**	(B)	**F-5.**	(BC)	**F-6.**	(C)
F-7.	(C)	**F-8.**	(B)	**F-9.***	(ABC)	**F-10.**	(A)						

PART-II

1.	(A)	**2.**	(B)	**3.**	(C)	**4.**	(C)	**5.**	(B)	**6.**	(D)	**7.**	(D)
8.	(B)	**9.**	(D)	**10.**	(D)	**11.**	(D)	**12.**	(C)	**13.**	(D)	**14.**	(B)

15. (A) – p, r ; (B) – q, s ; (C) – q, r ; (D) – p

16. (A) – t ; (B) – p ; (C) – s ; (D) – q

Exercise # 2

PART-I

1.	(A)	**2.**	(C)	**3.**	(C)	**4.**	(C)	**5.**	(D)	**6.**	(B)	**7.**	(C)
8.	(D)	**9.**	(B)	**10.**	(A)	**11.**	(D)	**12.**	(C)	**13.**	(D)	**14.**	(D)
15.	(D)	**16.**	(A)	**17.**	(A)	**18.**	(B)	**19.**	(D)	**20.**	(D)	**21.**	(C)
22.	(A)	**23.**	(AB)	**24.**	(AC)	**25.**	(ABD)	**26.**	(BCD)	**27.**	(BCD)	**28.**	(ABC)
29.	(AD)												

PART-II

1.	$\theta = 53^o$	**2.**	4	**3.**	4	**4.**	9	**5.**	3	**6.**	8

Exercise # 3

PART-I

1.	(C)	**2.**	(D)	**3.**	(B)	**4.**	(A)	**5.**	(C)	**6.**	(C)	**7.**	8 J
8.	(C)	**9.**	4	**10.**	(D)	**11.**	5	**12.**	(A)	**13.**	(B)		

PART-II

1.	(1)	**2.**	(2)	**3.**	(2)	**4.**	(2)	**5.**	(2)	**6.**	(2)	**7.**	(2)
8.	(1)	**9.**	(2)	**10.**	(1)	**11.**	(3)	**12.**	(3)	**13.**	(1)		

Exercise # 4

1. (a) +ve (b) –ve (c) – ve (d) +ve (e) – ve

2. (a) 882 J (b) – 247 J; (c) 635 J (d) 535 J
Work done by thenet force on a body equals change in its kinetic energy.

3. (a) x > a ; 0 (c) x < a, x > b ; $-V_1$
(b) $-\infty < x < \infty$; V_1 (d) – b/2 < x < –a/2, a/2 < x < b/2; $-V_1$

5. (a) rocket ; (b) For a conservative force work done over a path is minus of change in potential energy. Over a complete orbit, there is not change in potential energy; (c) K.E. increases, but P.E. decreases, and the sum decreases due to dissipation against friction; (d) in the second case.

6. (b) t

7. (c) $t^{3/2}$

8. 12 J

9. The electron is faster, $v_e/v_p = 13.5$

10. 0.082 J in each half; – 0.163 J

11. 43.6 W

12. 5.3 m s^{-1}

13. 27 km h^{-1} (no change in speed)

14. 50 J

15. (a) $m = \rho Avt$ (b) $K = \rho A v^3 t/2$ (c) P = 4.5 kW h

16. (a) 49,000 J (b) 6.45 10^{-3} kg

17. (a) 200 m^2 (b) Comparable to the roof of a large house of dimension 14m × 14 m.

18. 21.2 cm, 28.5 J

19. No, the stone on the steep plane reaches the bottom earlier; yes, they reach with the same speed v [mgh = (1/2) mv^2]
$V_B = V_C = 14.1$ m s^{-1}, $t_B = 2\sqrt{2}$ s, $t_C = 2\sqrt{2}$ s