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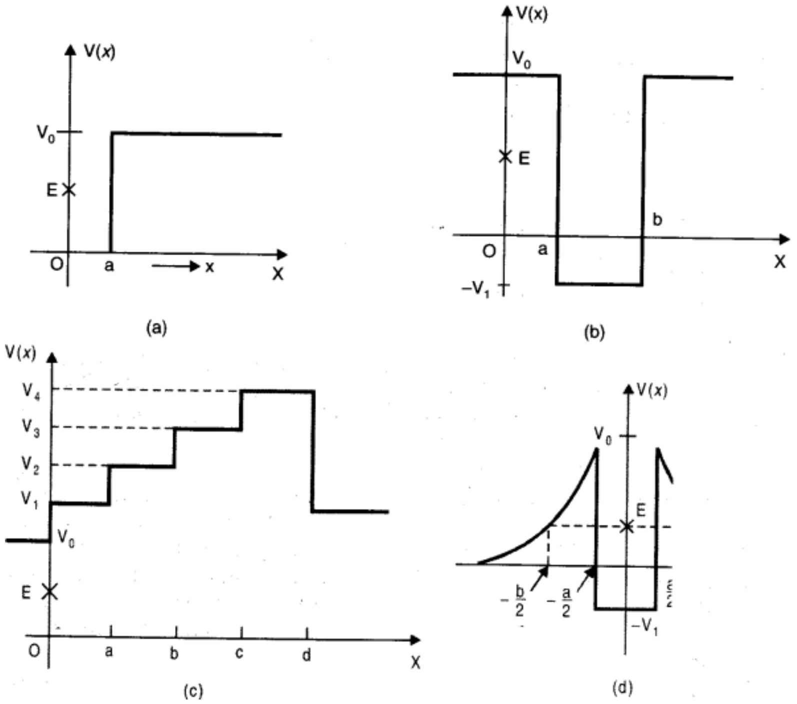
QUESTIONS FROM TEXTBOOK

Question 6. 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 it to rest.
Answer: Work done, W = T.S = Fs cos θ
(a) Work done 'positive', because force is acting in the direction of displacement i.e., θ = 0°.
(b) Work done is negative, because force is acting against the displacement i.e., θ = 180°.
(c) Work done is negative, because force of friction is acting against the displacement i.e., θ = 180°.
(d) Work done is positive, because body moves in the direction of applied force i.e., θ = 0°.
(e) Work done is negative, because the resistive force of air opposes the motion i.e., θ = 180°.

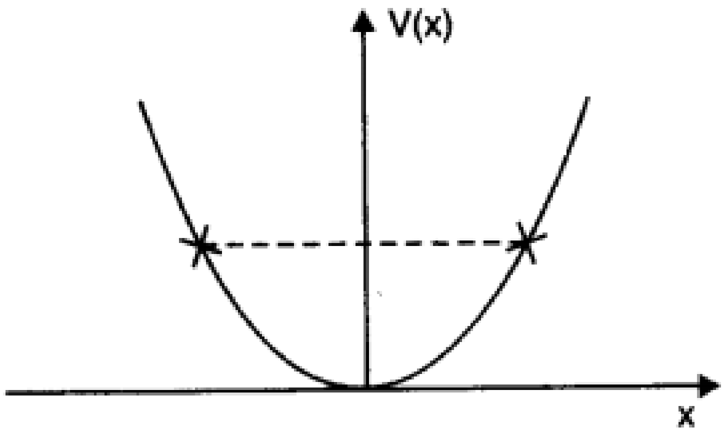
Question 6. 2. A body of mass 2 kg initially at rest moves under the action of an applied horizontal force of 7 N on a table with coefficient of kinetic friction = 0.1. Compute the
(a) Work done by the applied force in 10 s
(b) Work done by friction in 10 s
(c) Work done by the net force on the body in 10 s
(d) Change in kinetic energy of the body in 10 s and interpret your results.
Answer:
(a) We know that U_k = frictional force/normal reaction
frictional force = U_k x normal reaction
= 0.1 x 2 kg wt = 0.1 x 2 x 9.8 N = 1.96 N
net effective force = (7 - 1.96) N = 5.04 N
acceleration = 5.04/2 ms^{-2} = 2.52 ms^{-2}
distance, s=1/2x 2.52 x 10 x 10 = 126 m
work done by applied force = 7 x 126 J = 882 J
(b) Work done by friction = 1.96 x 126 = -246.96 J
(c) Work done by net force = 5.04 x 126 = 635.04 J
(d) Change in the kinetic energy of the body
= work done by the net force in 10 seconds = 635.04 J (This is in accordance with work-energy theorem).

Question 6.3. Given figures 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 some physical contexts for which these potential energy shapes are relevant.



Answer: We know that total energy E = K.E. + P.E. or K.E. = E - P.E. and kinetic energy can never be negative.The object can not exist in the region, where its K.E. would become negative.
(a) In the region between x = 0 and x = a, potential energy is zero. So, kinetic energy is positive. In the region x > a, the potential energy has a value greater than E. So, kinetic energy will be negative in this region. Thus the particle cannot be present in the region x > a.
The minimum total energy that the particle can have in this case is zero.
(b) Here P.E. > E, the total energy of the object and as such the kinetic energy of the object would be negative. Thus object cannot be present in any region of the graph.
(c) Here x = 0 to x = a and x > b, the P.E. is more than E, so K.E. is negative. The particle can not exist in these portions.
(d) The object can not exist in the region between x = -b/2 to x =- a/2 and x = -a/2 to x = -b/2 .Because in this region P.E. > E.

Question 6.4.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 Nm^{-1} , the graph of V (x) versus x is shown in Fig. Show that a particle of total energy 1 J moving under this potential must 'turn back' when it reaches x = ± 2 m.

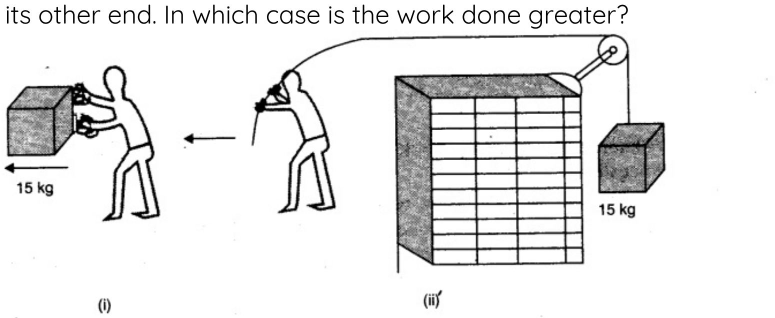


Answer: Here, force constant k = 0.5 Nm^{-1} and total energy of particle E = 1J. The particle can go up to a maximum distance x_m, where its total energy is transformed into elastic potential energy.

$$\frac{1}{2}kx_m^2 = E$$

$$\Rightarrow \qquad x_m = \sqrt{\frac{2E}{K}} = \sqrt{\frac{2\times1}{0.5}} = \sqrt{4} = \pm 2\text{m}.$$

Question 6. 5. Answer the following:
(a) The casing of a rocket in flight bums 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 atomosphere loses its energy gradually due to dissipation against atmospheric resistance, however small. Why then does its speed increase progressively as it comes closer and closer to the earth?
(d) In Fig.(i), the man walks 2 m carrying a mass of 15 kg on his hands. In Fig. (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?



Answer:
(a) Heat energy required for burning of casing of rocket comes from the rocket itself. As a result of work done against friction the kinetic energy of rocket continuously decreases - and this work against friction reappears as heat energy.
(b) This is because gravitational force is a conservative force. Work done by the gravitational ' force of the sun over a closed path in every complete orbit of the comet is zero.
(c) As an artificial satellite gradually loses its energy due to dissipation against atmospheric resistance, its potential decreases rapidly. As a result, kinetic energy of satellite slightly increases i.e., its speed increases progressively.
(d) In Fig. (i), force is applied on the mass, by the man in vertically upward direction but distance is moved along the horizontal.
$\theta = 90°$. $W = F_s \cos 90° =$ zero
In Fig. (ii), force is applied along the horizontal and the distance moved is also along the horizontal. Therefore, $\theta = 0°$.
$W = F_s \cos \theta = mg \times s \cos 0°$
$W = 15 \times 9.8 \times 2 \times 1 = 294$ joule.
Thus, work done in (ii) case is greater.

Question 6. 6. Point out the correct alternative:
(a) When a conservative force does positive work on a body, the potential energy of the body increases/decreases/remains unaltered.
(b) Work done by a body against friction always results in a loss of its kinetic/potential energy.
(c) The rate of change of total momentum of a many particle system is proportional to the external force/sum of the internal forces of the system.
(d) In an inelastic collision of two bodies, the quantities which do not change after the collision are the total kinetic energy/total linear

momentum/total energy of the system of two bodies.
Answer:
(a) Potential energy of the body decreases, because the body in this case goes closer to the centre of the force.
(b) Kinetic energy, because friction does its work against motion.
(c) Internal forces can not change the total or net momentum of a system. Hence the rate of change of total momentum of many particle system is proportional to the external force on the system.
(d) In an inelastic collision of two bodies, the quantities which do not change after the collision are the total kinetic energy/total linear momentum/ total energy of the system of two bodies.

Question 6. 7. State if each of the following statements is true or false. Give reasons for your answer.
(a) In an elastic collision of two bodies, the momentum and energy of each body is conserved.
(b) Total energy of a system is always conserved, no matter what internal and external forces on the body are present.
(c) Work done in the motion of a body over a closed loop is zero for every force in nature.
(d) In an inelastic collision, the final kinetic energy is always less than the initial kinetic energy of the system.
Answer:
(a) False, the total momentum and total energy of the system are conserved.
(b) False, the external force on the system may increase or decrease the total energy of the system.
(c) False, the work done during the motion of a body over a closed loop is zero only when body is moving under the action of a conservative force (such as gravitational or electrostatic force). Friction is not a conservative force hence work done by force of friction (or work done on the body against friction) is not zero over a closed loop.
(d) True, usually in an inelastic collision the final kinetic energy is always less than the initial kinetic energy of the system.

Question 6. 8. Answer carefully, with reasons:
(a) In an elastic collision of two billiard balls, is the total kinetic energy conserved during the short time of collision of the balls (i.e., when they are in contact)?
(b) Is the total linear momentum conserved during the short time of an elastic collision of two balls?
(c) What are the answers to (a) and (b) for an inelastic collision?
(d) If the potential energy of two billiard balls depends only on the separation distance between their centres, is the collision elastic or inelastic? (Note, we are talking here of potential energy corresponding to the force during collision, not gravitational potential energy).
Answer:
(a) In this case total kinetic energy is not conserved because when the bodies are in contact dining elastic collision even, the kinetic energy is converted into potential energy.
(b) Yes, because total momentum conserves as per law of conservation of momentum.
(c) The answers remain unchanged.
(d) It is a case of elastic collision because in this case the forces will be of conservative nature.

Question 6. 9. A body is initially at rest. It undergoes one-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
Answer:
(ii) From $v = u + at$
$v = 0 + at = at$

As power, p = F x v

$\therefore$ p = (ma) x at = ma^2t

Since m and a are constants, therefore, p $\propto$ t.

Question 6. 10. A body is moving unidirectionally 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

Answer: (ii) p = force x velocity

$$[p] = [F]\,[v] = [MLT^{-2}]\,[LT^{-1}]$$

$$\Rightarrow \quad [p] = [ML^2T^{-3}]$$

$$\text{or} \quad L^2T^{-3} = \text{constant} \Rightarrow \frac{L^2}{T^2} = \text{constant}$$

$$\therefore \quad L^2 \propto T^3 \Rightarrow L \propto T^{3/2}.$$

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