Work, Energy & Power

Very Short Answer Type Questions

1. A rough inclined plane is placed on a cart moving with a constant velocity u on horizontal ground. A block of mass M rests on the incline. Is any work done by force of friction between the block and incline? Is there then a dissipation of energy?
2. Why is electrical power required at all when the elevator is descending? Why should there be a limit on the number of passengers in this case?
3. A body is being raised to a height h from the surface of earth. What is the sign of work done by
   (a) applied force
   (b) gravitational force?
4. Calculate the work done by a car against gravity in moving along a straight horizontal road. The mass of the car is 400 kg and the distance moved is 2m.
5. A body falls towards earth in air. Will its total mechanical energy be conserved during the fall? Justify.
6. A body is moved along a closed loop. Is the work done in moving the body necessarily zero? If not, state the condition under which work done over a closed path is always zero.
7. In an elastic collision of two billiard balls, which of the following quantities remain conserved during the short time of collision of the balls (i.e., when they are in contact).
   (a) Kinetic energy.
   (b) Total linear momentum?
   Give reason for your answer in each case.
8. Calculate the power of a crane in watts, which lifts a mass of 100 kg to a height of 10 m in 20s.
9. The average work done by a human heart while it beats once is 0.5J. Calculate the power used by heart if it beats 72 times in a minute.
10. Give example of a situation in which an applied force does not result in a change in kinetic energy.
11. Two bodies of unequal mass are moving in the same direction with equal kinetic energy. The two bodies are brought to rest by applying retarding force of same magnitude. How

would the distance moved by them before coming to rest compare?

12. A bob of mass m suspended by a light string of length L is whirled into a vertical circle as shown in Fig. 6.11. What will be the trajectory of the particle if the string is cut at

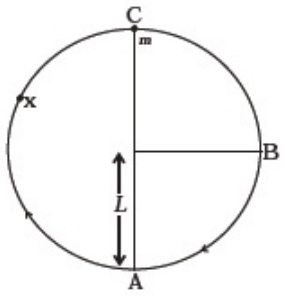

Fig. 6.11

- (a) Point B?
- (b) Point C?
- (c) Point X?

Short Answer Type Questions

1. A graph of potential energy V (x) verses x is shown in Fig. 6.12. A particle of energy E_0 is executing motion in it. Draw graph of velocity and kinetic energy versus x for one complete cycle AFA.

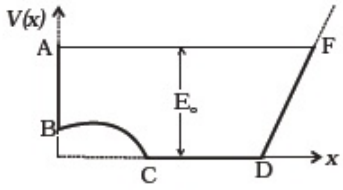

Fig. 6.12

2. A ball of mass m, moving with a speed $2v_0$, collides inelastically (e > 0) with an identical ball at rest. Show that

(a) For head-on collision, both the balls move forward.

(b) For a general collision, the angle between the two velocities of scattered balls is less than 90°.

3. Consider a one-dimensional motion of a particle with total energy E. There are four regions A, B, C and D in which the relation between potential energy V, kinetic energy (K) and total energy E is as given below:

   Region A : V > E

   Region B : V < E

   Region C : K > E

   Region D : V > K

   State with reason in each case whether a particle can be found in the given region or not.

4. The bob A of a pendulum released from horizontal to the vertical hits another bob B of the same mass at rest on a table as shown in Fig. 6.13.

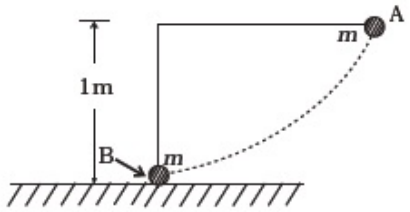

Fig. 6.13

   If the length of the pendulum is 1m, calculate

   (a) the height to which bob A will rise after collision.

   (b) the speed with which bob B starts moving. Neglect the size of the bobs and assume the collision to be elastic.

5. A raindrop of mass 1.00 g falling from a height of 1km hits the ground with a speed of 50 m s^{-1}. Calculate

   (a) the loss of P.E. of the drop.

   (b) the gain in K.E. of the drop.

(c) Is the gain in K.E. equal to loss of P.E.? If not why.

Take g = 10 m s^{-2}

6. Two pendulums with identical bobs and lengths are suspended from a common support such that in rest position the two bobs are in contact (Fig. 6.14). One of the bobs is released after being displaced by 10° so that it collides elastically head-on with the other bob.

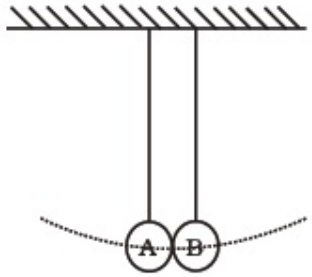

Fig. 6.14

7. Suppose the average mass of raindrops is 3.0 × 10^{-5} kg and their average terminal velocity 9ms^{-1}. Calculate the energy transferred by rain to each square metre of the surface at a place which receives 100 cm of rain in a year.
8. An engine is attached to a wagon through a shock absorber of length 1.5m. The system with a total mass of 50,000 kg is moving with a speed of 36 km h^{-1} when the brakes are applied to bring it to rest. In the process of the system being brought to rest, the spring of the shock absorber gets compressed by 1.0 m. If 90% of energy of the wagon is lost due to friction, calculate the spring constant.
9. An adult weighing 600N raises the centre of gravity of his body by 0.25 m while taking each step of 1 m length in jogging. If he jogs for 6 km, calculate the energy utilised by him in jogging assuming that there is no energy loss due to friction of ground and air. Assuming that the body of the adult is capable of converting 10% of energy intake in the form of food, calculate the energy equivalents of food that would be required to compensate energy utilised for jogging.
10. On complete combustion a litre of petrol gives off heat equivalent to 3×10^{7}J. In a test drive a car weighing 1200 kg. including the mass of driver, runs 15 km per litre while

moving with a uniform speed on a straight track. Assuming that friction offered by the road surface and air to be uniform, calculate the force of friction acting on the car during the test drive, if the efficiency of the car engine were 0.5.

Long Answer Type Questions

1. A block of mass 1 kg is pushed up a surface inclined to horizontal at an angle of 30° by a force of 10 N parallel to the inclined surface (Fig. 6.15).The coefficient of friction between block and the incline is 0.1. If the block is pushed up by 10 m along the incline, calulate

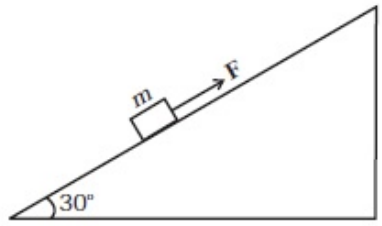

Fig. 6.15

   - (a) work done against gravity
   - (b) work done against force of friction
   - (c) increase in potential energy
   - (d) increase in kinetic energy
   - (e) work done by applied force.

2. A curved surface is shown in Fig. 6.16. The portion BCD is free of friction. There are three spherical balls of identical radii and masses. Balls are released from rest one by one from A which is at a slightly greater height than C.

Fig. 6.16

With the surface AB, ball 1 has large enough friction to cause rolling down without slipping; ball 2 has a small friction and ball 3 has a negligible friction.

- (a) For which balls is total mechanical energy conserved?
  (b) Which ball (s) can reach D?
  (c) For balls which do not reach D, which of the balls can reach back A?

3. A rocket accelerates straight up by ejecting gas downwards. In a small time interval Δt, it ejects a gas of mass Δm at a relative speed u. Calculate KE of the entire system at $t + \Delta t$ and t and show that the device that ejects gas does work = $(\frac{1}{2})\Delta mu^2$ in this time interval (neglect gravity).
4. Two identical steel cubes (masses 50g, side 1cm) collide head-on face to face with a speed of 10cm/s each. Find the maximum compression of each. Young's modulus for steel = Y= $2 \times 10^{11} N/m^2$.
5. A baloon filled with helium rises against gravity increasing its potential energy. The speed of the baloon also increases as it rises. How do you reconcile this with the law of conservation of mechanical energy? You can neglect viscous drag of air and assume that density of air is constant.