NCERT Exercise Questions

Work, Energy and Power

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.

Ans.

Case	Work done	Reason
(a) work done by a man in lifting a bucket out of a well by means of a rope tied to the bucket.	Positive	• Force and displacement in same direction
(b) work done by gravitational force in the above case,	Negative	• Force i .e weight (vertically downward) • Displacement (vertically upward)
(c) work done by friction on a body sliding down an inclined plane,	Negative	• Direction of frictional force is opposite of the direction of motion
(d) work done by an applied force on a body moving on a rough horizontal plane with uniform velocity,	Positive	• Force and displacement in same direction
(e) work done by the resistive force of air on a vibrating pendulum in bringing it to rest.	Negative	• Direction of resistive force is opposite of the direction of motion

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.

Ans. $Given: \; m = 2kg \qquad u = 0ms^{-1}$

$F = 7N \qquad \mu = 0.1$

$t = 10s$

$Sol^n: \; F = ma'$

$7 = 2a'$

$\boxed{a' = 3.5ms^{-2}}$

$f = \mu mg = 0.1 \times 2 \times 9.8$

$\boxed{f = -1.96N}$

$Also, \quad f = ma''$

$-1.96 = 2a''$

$\boxed{a'' = -0.98ms^{-2}}$

$Total\, acc.\; a = a' + a''$

$= 3.5 - 0.98$

$\boxed{a = 2.52ms^{-2}}$

$$s = ut + \frac{1}{2}at^2$$

$$= 0 \times 10 + \frac{1}{2} \times 2.52 \times 10^2$$

$\boxed{s = 126m}$

$(a) W = Fs = 7 \times 126 = 882J$

$(b) W = fs = -1.96 \times 126 = -247J$

$(c)\; Net\; force\, F' = F + f = 7 - 1.96 = 5.04N$

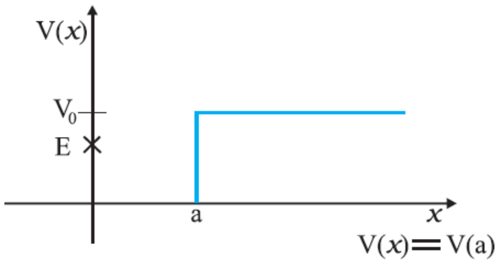
$W = F's = 5.02 \times 126 = 635J$

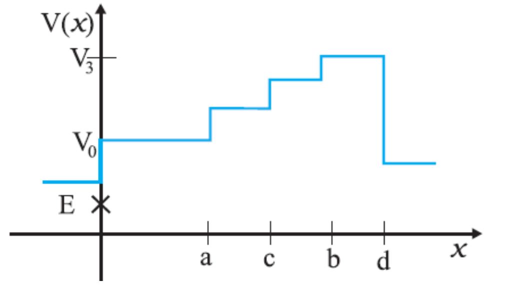
$(d)\; v = u + at = 0 + 2.52 \times 10 = 25.2ms^{-1}$

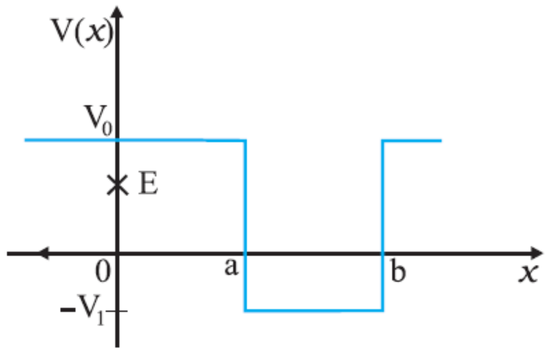
$$Change\, in\, K.E = \frac{1}{2}mv^2 - \frac{1}{2}mu^2 = \frac{1}{2} \times 2 \times (25.2)^2 - \frac{1}{2} \times 2 \times 0^2 = 635J$$

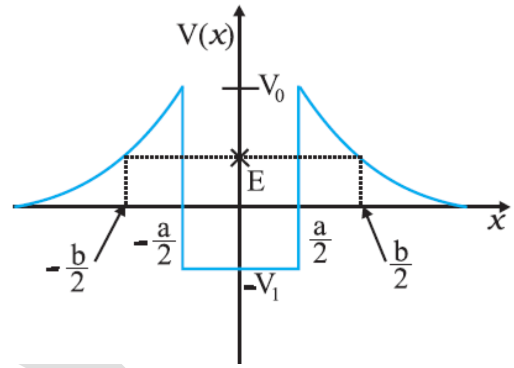
3. Given in Fig. 6.11 are examples of some potential energy functions in one dimension. The total energy of the particle is indicated by a cross on the ordinate axis. In each case, specify the regions, if any, in which the particle cannot be found for the given energy.

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.





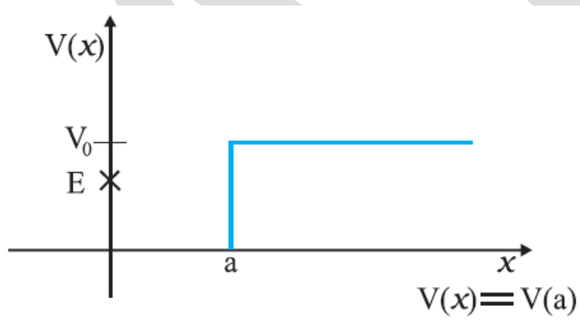
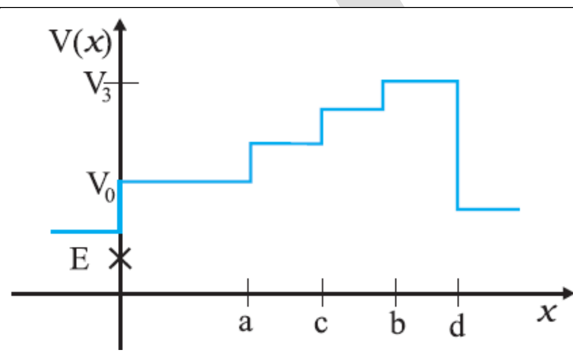


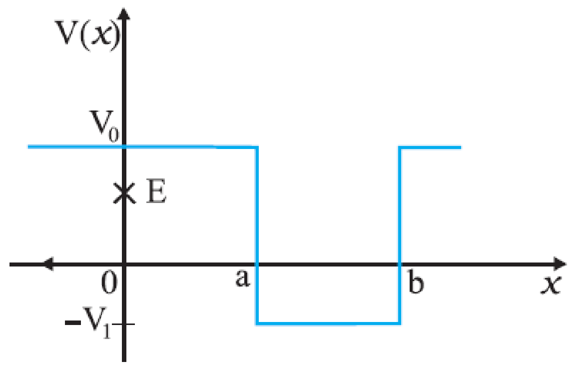
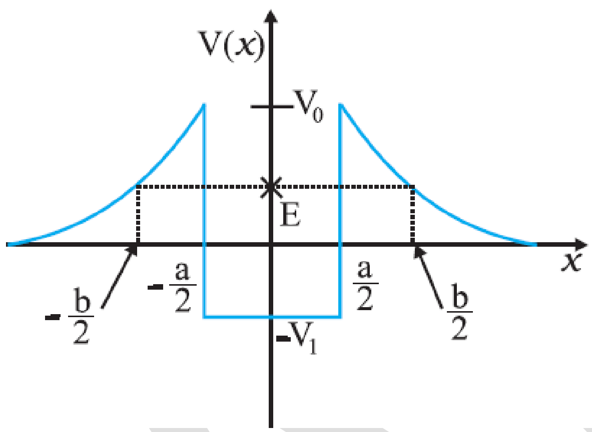


Ans. E=K.E+P.E

K.E=E-P.E

Kinetic energy of a body is a positive quantity. It cannot be negative. Therefore, the particle will not exist in a region where K.E. becomes negative.

Case	**Regions**	**Reason**
	x > a	• P.E (V_0) > total energy (E) for $x > a$. • K.E = -ve • So, the particle will not exist is this region. • Minimum total energy of the particle = 0
	All regions	• P.E ($V0$) > total energy (E) in all regions. • Hence, the particle will not exist in this region.

	$x > a$ $x < b$	• Condition regarding the positivity of K.E. is satisfied only in the region between $x > a$ and $x < b$. • Minimum P.E = $-V1$. K.E. = $E - (-V1) = E + V1$. So, for the positivity of the kinetic energy, the total energy of the particle must be greater than $-V1$. • So, the minimum total energy the particle must have is $-V1$.
	$-\frac{b}{2} < x < \frac{a}{2}$ $\frac{a}{2} < x < \frac{b}{2}$	• $V_0 > E$ for $-\frac{b}{2} < x < \frac{a}{2}$ and $\frac{a}{2} < x < \frac{b}{2}$. • *So*, the particle will not exist in these regions. • Minimum P.E = $-V1$. K.E. = $E - (-V1) = E + V1$. So, for the positivity of the kinetic energy, the total energy of the particle must be greater than $-V1$. • So, the minimum total energy the particle must have is $-V1$.

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 graph of $V(x)$ versus x is shown in Fig. 6.12. Show that a particle of total energy 1 J moving under this potential must 'turn back' when it reaches $x = \pm$ 2 m.

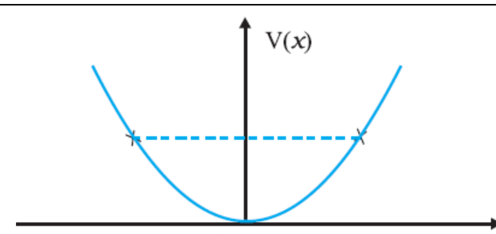


Fig. 6.12

Ans.
$$P.E\,(V) = \frac{1}{2}kx^2, \qquad E = 1J$$

$$Now,\ E = P.E + K.E$$

$$1 = \frac{1}{2}kx^2 + \frac{1}{2}mv^2$$

$$At\ 'turn\,back'\ velocity\ becomes\ zero\ so,\ K.E = 0$$

$$\therefore \quad 1 = \frac{1}{2}kx^2$$

$$2 = 0.5x^2$$

$$x^2 = 4$$

$$x = \pm 2m$$

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 does its speed increase progressively as it comes closer and closer to the earth?

(d) In Fig. 6.13(i) the man walks 2 m carrying a mass of 15 kg on his hands. In Fig. 6.13(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?

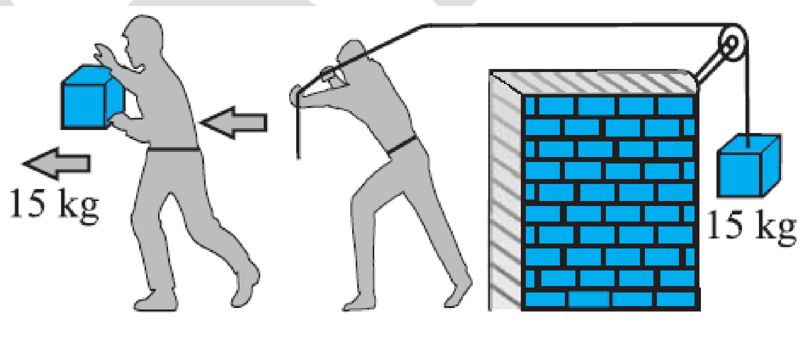


Fig. 6.13

Ans. (a) Due to the burning of the casing mass of the rocket is reduced and hence total energy is reduced.

According to law of conservation of energy

$$Total\ \ energy = kinetic\, energy + potential\, energy$$

$$E = \frac{1}{2}mv^2 + mgh$$

So, the heat energy required for the burning is obtained from the rocket.

(b) Because Gravitational force is a conservative force and the work done by a conservative force over a closed path is zero.

(c) When an artificial satellite, orbits closer to earth, its potential energy decreases (because of the reduction in the height). Since the total energy of the system remains constant, the reduction in P.E. results in an increase in K.E. Hence, the velocity of the satellite increases. However, due to atmospheric friction, the total energy of the satellite decreases by a small amount.

(d) Case I

$$W = Fs\cos\theta = 15\times 9.8\times 2\times \cos 90^o = 0$$

Case II

$$W = Fs\cos\theta = 15\times 9.8\times 2\times \cos 0^o = 294J$$

More work is done in Case II

6. Underline 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 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.

Ans. (a) When a conservative force does positive work on a body, the potential energy of the body decreases.

Reason: A conservative force does a positive work on a body when it displaces the body in the direction of force. As a result, the body advances toward the centre of force. It decreases the separation between the two, thereby decreasing the potential energy of the body.

(b) Work done by a body against friction always results in a loss of its kinetic energy.

Reason: The work done against the direction of friction reduces the velocity of a body. Hence, there is a loss of kinetic energy of the body.

(c) The rate of change of total momentum of a many-particle system is proportional to the external force on the system.

Reason: Internal forces, irrespective of their direction, cannot produce any change in the total momentum of a body. Hence, the total momentum of a many- particle system is proportional to the external forces acting on the system.

(d) In an inelastic collision of two bodies, the quantities which do not change after the collision are the total linear momentum of the system of two bodies.

Reason: The total linear momentum always remains conserved whether it is an elastic collision or an inelastic collision.

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.

Ans.

Statement	True/False	Reason
(a) In an elastic collision of two bodies, the momentum and energy of each body is conserved.	False	In an elastic collision, the total energy and momentum of both the bodies, and not of each individual body, is conserved.
(b) Total energy of a system is always conserved, no matter what internal and external forces on the body are present.	False	Although internal forces are balanced, they cause no work to be done on a body. It is the external forces that have the ability to do work. Hence, external forces are able to change the energy of a system.
(c) Work done in the motion of a body over a closed loop is zero for every force in nature.	False	The work done in the motion of a body over a closed loop is zero for a conservation force only.
(d) In an inelastic collision, the final kinetic energy is always less than the initial kinetic energy of the system.	True	In an inelastic collision, the final kinetic energy is always less than the initial kinetic energy of the system. This is because in such collisions, there is always a loss of energy in the form of heat, sound, etc.

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).

Ans. (a) In an elastic collision, the total initial kinetic energy of the balls will be equal to the total final kinetic energy of the balls. This kinetic energy is not conserved at the instant the two balls are in contact with each other. In fact, at the time of collision, the kinetic energy of the balls will get converted into potential energy.

(b) Yes In an elastic collision, the total linear momentum of the system always remains conserved.

(c) In an inelastic collision, there is always a loss of kinetic energy, i.e., the total kinetic energy of the billiard balls before collision will always be greater than that after collision. The total linear momentum of the system of billiards balls will remain conserved even in the case of an inelastic collision.

(d) In the given case, the forces involved are conservation. This is because they depend on the separation between the centres of the billiard balls. Hence, the collision is elastic.

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

Ans. $u = 0$

$v = u + at$

$v = at$

$As\ a\ is\ const.$

$v\ \alpha\ t$

$Also, F = ma$

$As\ both\ m\ and\ a\ are\ const.\ so\ F = const.$

$Now,\quad P = Fv$

$P\ \alpha\ v$

$or\quad P\ \alpha\ t$

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

Ans.
$$P = Fv$$
$$= mav$$
$$= m\frac{dv}{dt}v$$
$$v\,dv = \frac{k}{m}dt \qquad [\because P \text{ is const. so } P = k]$$
$$\int v\,dv = \frac{k}{m}\int dt$$
$$\frac{v^2}{2} = \frac{k}{m}t$$
$$v = \sqrt{\frac{2k}{m}}\,t^{\frac{1}{2}}$$
$$\frac{dx}{dt} = \sqrt{\frac{2k}{m}}\,t^{\frac{1}{2}}$$
$$\frac{dx}{dt} = k' t^{\frac{1}{2}} \qquad \left[\text{Let } k' = \sqrt{\frac{2k}{m}}\right]$$
$$dx = k' t^{\frac{1}{2}}\,dt$$
$$\int dx = \int k' t^{\frac{1}{2}}\,dt$$
$$x = k'\left[\frac{t^{\frac{1}{2}+1}}{\frac{1}{2}+1}\right]$$
$$= k'\left[\frac{t^{\frac{3}{2}}}{\frac{3}{2}}\right]$$
$$x = \frac{2}{3}k' t^{\frac{3}{2}}$$
$$x \,\alpha\, t^{\frac{3}{2}}$$

11. A body constrained to move along the z-axis of a coordinate system is subject to a constant force $\vec{F}$ given by $\vec{F} = \left(-\hat{i} + 2j + 3k\right)N$ where $\hat{i}$, j, 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?

Ans. $\vec{F} = \left(-\hat{i} + 2j + 3k\right)N$

$\vec{s} = 4k$

$W = \vec{F}.\vec{s}$

$= \left(-\hat{i} + 2j + 3k\right).\left(4k\right)$

$= 12J$

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

Ans. $Given: \ m_e = 9.1 \times 10^{-31} kg$

$m_p = 1.67 \times 10^{-27} kg$

$K_e = 10keV = 10 \times 10^3 \times 1.67 \times 10^{-19} = 1.67 \times 10^{-15} J$

$K_p = 100keV = 100 \times 10^3 \times 1.67 \times 10^{-19} = 1.67 \times 10^{-14} J$

$To\ find: \dfrac{v_e}{v_p} = ?$

$Sol^n:$

$$\frac{K_e}{K_p} = \frac{\frac{1}{2} m_e v_e^2}{\frac{1}{2} m_p v_p^2}$$

$$\frac{1.67 \times 10^{-15}}{1.67 \times 10^{-14}} = \frac{9.1 \times 10^{-31} \times v_e^2}{1.67 \times 10^{-27} \times v_p^2}$$

$$\frac{1}{10} = \frac{5.44 \times v_e^2}{10^4 \times v_p^2}$$

$$\frac{v_e^2}{v_p^2} = \frac{1000}{5.44}$$

$$= 183.82$$

$$\frac{v_e}{v_p} = \sqrt{183.82}$$

$$= 13.55$$

$$v_e : v_p = 13.55 : 1$$

13. 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 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 ms^{-1}?

Ans. $r = 2mm = 2\times10^{-3}m$

$V = \frac{4}{3}\pi r^3 = \frac{4}{3}\times3.14\times8\times10^{-9}m^{-3}$

$\rho = \frac{m}{V}$

$10^3 = \frac{m}{\frac{4}{3}\times3.14\times8\times10^{-9}}$

$m = \frac{4}{3}\times3.14\times8\times10^{-6}kg$

$Gravitational\ force\ F = mg = \frac{4}{3}\times3.14\times8\times10^{-6}\times9.8N$

Work done by gravitational force on the drop in the first half $W_1 = Fs = \frac{4}{3}\times3.14\times8\times10^{-6}\times9.8\times250 = 0.082J$

This amount of work is equal to the work done by the gravitational force on the drop in the second half of its journey, i.e., W_2, = 0.082 J

As per the law of conservation of energy, if no resistive force is present, then the total energy of the rain drop will remain the same.

So, total energy at the top $E_T = mgh + 0 = \frac{4}{3}\times3.14\times8\times10^{-6}\times9.8\times500\times10^{-5} = 0.164J$

Due to the presence of a resistive force, the drop hits the ground with a velocity of 10 m/s.

So, total energy at the ground $E_G = \frac{1}{2}mv^2 + 0 = \frac{1}{2}\times\frac{4}{3}\times3.14\times8\times10^{-6}\times9.8\times100 = 1.675\times10^{-3}J$

Now, Resistive force $= E_G - E_T = 0.001675 - 0.164 = 0.162J$

14. A molecule in a gas container hits a horizontal wall with speed 200 ms^{-1} and angle 30° with the normal, and rebounds with the same speed. Is momentum conserved in the collision? Is the collision elastic or inelastic?

Ans.
- The momentum of the gas molecule remains conserved in both elastic and inelastic collision.
- The gas molecule moves with a velocity of 200 m/s and strikes the stationary wall of the container, rebounding with the same speed.
- So, the total kinetic energy of the molecule remains conserved during the collision.
- The given collision is an example of an elastic collision.

15. 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?

Ans. *Given*: $V = 30m^3$

$t = 15\,\text{min.} = 900s$

$h = 40m$

$\eta = 30\%$

To find: $P = ?$

Sol^n :

$$\rho = \frac{m}{V}$$

$$10^3 = \frac{m}{30} \qquad \left[Density\ of\ water = 10^3\,kgm^{-3} \right]$$

$$m = 30\times10^3\,kg$$

$$Output\ power\ \ P_o = \frac{W}{t}$$

$$= \frac{mgh}{t}$$

$$= \frac{30\times10^3\times9.8\times40}{900}$$

$$= 13.06\times10^3 W$$

$$Now, \quad \eta = \frac{P_o}{P_i}$$

$$\frac{30}{100} = \frac{13.06\times10^3}{P_i}$$

$$P_i = 43.6\times10^3 W$$

16. Two identical ball bearings in contact with each other and resting on a frictionless table are hit head-on by another ball bearing of the same mass moving initially with a speed *V*. If the collision is elastic, which of the following (Fig. 6.14) is a possible result after collision?

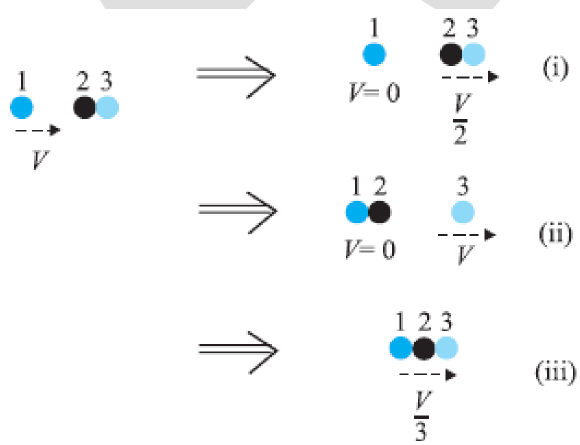


Fig. 6.14

Ans. Total kinetic energy before collision $= \frac{1}{2}mV^2 + \frac{1}{2}(2m)(0)^2 = \frac{1}{2}mV^2$

Case (i) Total kinetic energy after collision $= \frac{1}{2}m(0)^2 + \frac{1}{2}(2m)\left(\frac{V}{2}\right)^2 = \frac{1}{4}mV^2$

Total kinetic energy before collision $\neq$ Total kinetic energy after collision

So, kinetic energy is not conserved.

Case (ii) Total kinetic energy after collision $= \frac{1}{2}m(0)^2 + \frac{1}{2}(2m)(V)^2 = \frac{1}{2}mV^2$

Total kinetic energy before collision $=$ Total kinetic energy after collision

So, kinetic energy is conserved.

Case (iii) Total kinetic energy after collision $= +\frac{1}{2}(3m)\left(\frac{V}{3}\right)^2 = \frac{1}{6}mV^2$

Total kinetic energy before collision $\neq$ Total kinetic energy after collision

So, kinetic energy is not conserved.

17. The bob A of a pendulum released from 30^{o} to the vertical hits another bob B of the same mass at rest on a table as shown in Fig. 6.15. How high does the bob A rise after the collision? Neglect the size of the bobs and assume the collision to be elastic.

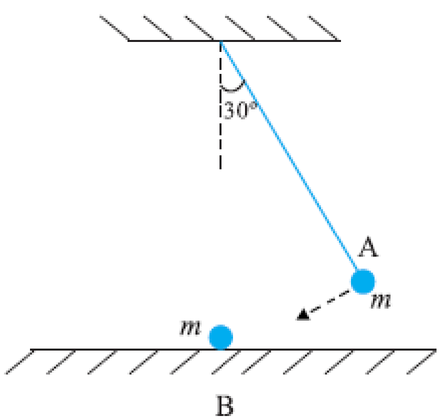


Fig. 6.15

Ans.

- In an elastic collision between two equal masses in which one is stationary, while the other is moving with some velocity, the stationary mass acquires the same velocity, while the moving mass immediately comes to rest after collision.
- In this case, a complete transfer of momentum takes place from the moving mass to the stationary mass.
- So, bob A of mass *m*, after colliding with bob B of equal mass, will come to rest, while bob B will move with the velocity of bob A at the instant of collision.

18. The bob of a pendulum is released from a horizontal position. If the length of the pendulum is 1.5 m, what is

the speed with which the bob arrives at the lowermost point, given that it dissipated 5% of its initial energy against air resistance?

Ans. At the horizontal position, Total energy = $E_p + E_k = mgl + 0 = mgl$

At the lowermost point, Total energy = $E_p + E_k = 0 + ½ mv^2 = ½ mv^2$

As the bob moves from the horizontal position to the lowermost point, 5% of its energy gets dissipated.

The total energy at the lowermost point is equal to 95% of the total energy at the horizontal point.

$$\frac{1}{2}mv^2 = 95\% mgl$$

$$\frac{1}{2}v^2 = \frac{95}{100} \times 9.8 \times 1.5$$

$$v = 5.28 ms^{-1}$$

19. 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 floor of the trolley at the rate of 0.05 kg s^{-1}. What is the speed of the trolley after the entire sand bag is empty?

Ans.
- The sand bag is placed on a trolley that is moving with a uniform speed of 27 km/h.
- No external forces acting on the system of the sandbag and the trolley.
- As the leaking of sand does not produce any external force on the system so, there won't be any change in the velocity of the trolley.

20. A body 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 $x = 0$ to $x = 2$ m?

Ans. $m = 0.5 kg$

$$a = 5 m^{\frac{-1}{2}} s^{-1}$$

$$v = ax^{\frac{3}{2}}$$

$$u = 0 \qquad [\because x = 0]$$

$$v = 5(2)^{\frac{3}{2}} = 10\sqrt{2} ms^{-1} \quad [\because x = 2]$$

$$Acc.\ to\ work - energy\ theorem$$

$$W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

$$= \frac{1}{2} \times 0.5 \times 200 - 0$$

$$= 50 J$$

21. 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 $1.2\ kg\ m^{-3}$. What is the electrical power produced?

Ans. (a) Let A – Area of circle swept by the windmill

v – velocity of wind

ρ – density of air

Volume of the wind flowing through the windmill per sec = Av

Mass of the wind flowing through the windmill per sec = ρAv

Mass of the wind flowing through the windmill in time 't' = ρAvt

(b) Kinetic energy of air $K = \frac{1}{2}mv^2 = \frac{1}{2}(\rho Avt)v^2 = \frac{1}{2}\rho Av^3 t$

(c) Electric energy produced = 25% of the wind energy $= \frac{25}{100}K = \frac{1}{4}\left(\frac{1}{2}\rho Av^3 t\right) = \frac{1}{8}\rho Av^3 t$

$$Electrical\ Power = \frac{Electrical\ energy}{time} = \frac{\frac{1}{8}\rho Av^3 t}{t} = \frac{1}{8}\rho Av^3 = \frac{1}{8}\times 1.2\times 30\times 1000 = 4.5kW \qquad [\because v = 36kmhr^{-1}$$

22. A person trying to lose weight (dieter) lifts a 10 kg mass, one thousand times, to a height of 0.5 m each time. 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?

Ans. $Given:\ m = 10kg \qquad n = 1000 \qquad h = 0.5m$

$To\ find: (a) W = ? \quad (b) m_f = ?$

$Sol^n:$

$(a) W = nmgh$

$= 1000\times 10\times 9.8\times 0.5$

$= 4.9\times 10^4\ J$

$(b)\ E_f = 3.8\times 10^7\ J$

$\eta = 20\%$

$\therefore E = 20\% E_f$

$= \frac{20}{100}\times 3.8\times 10^7$

23. A family uses 8 kW of power.

(a) Direct solar energy is incident on the horizontal surface at an average rate of 200Wm^{-2} . If 20% of this energy can be converted to useful electrical energy, how large an area is needed to supply 8kW?

(b) Compare this area to that of the roof of a typical house.

Ans. $(a) P = 8kW = 8 \times 10^3 W$

$E = 200W$

$\eta = 20\%$

ATQ

$8 \times 10^3 = 20\% (A \times 200)$

$8000 = \frac{20}{100} \times A \times 200$

$A = 200m^2$

(b) The area of a solar plate required to generate 8 kW of electricity is almost equivalent to the area of the roof of a building having dimensions 14 m × 14 m.