UNIT 4

WORK AND ENERGY

Q.1 What do you understand by the term work? Explain.

Answer

Work is dot product of force and displacement.

Work done on a body is defined as the product of magnitude of displacement and the component of force in the direction of displacement.

Mathematical form

Let

$\vec{F}$ = constant force applied on a body.

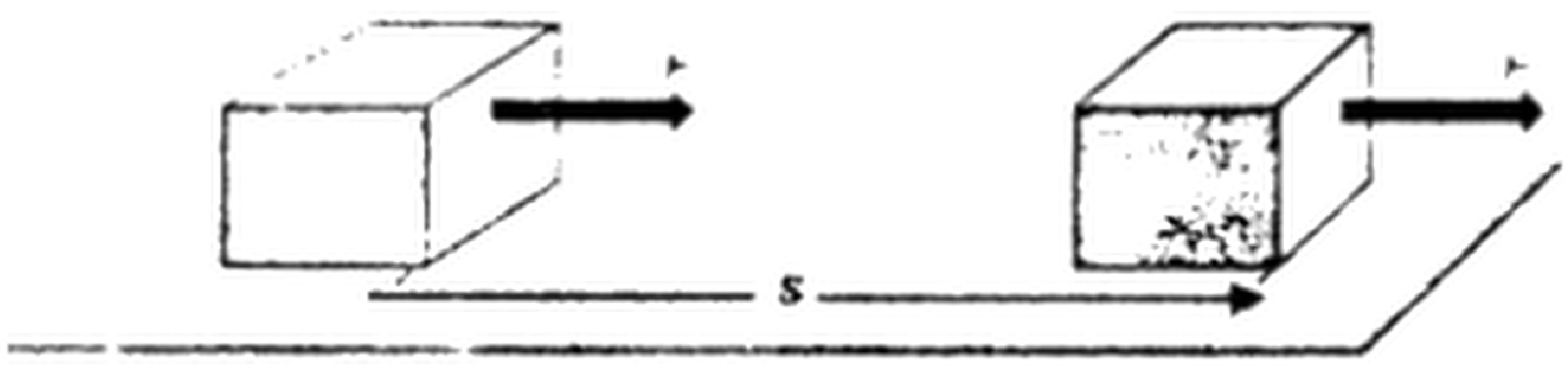
$\vec{d}$ = displacement of the body

θ = angle between force and displacement

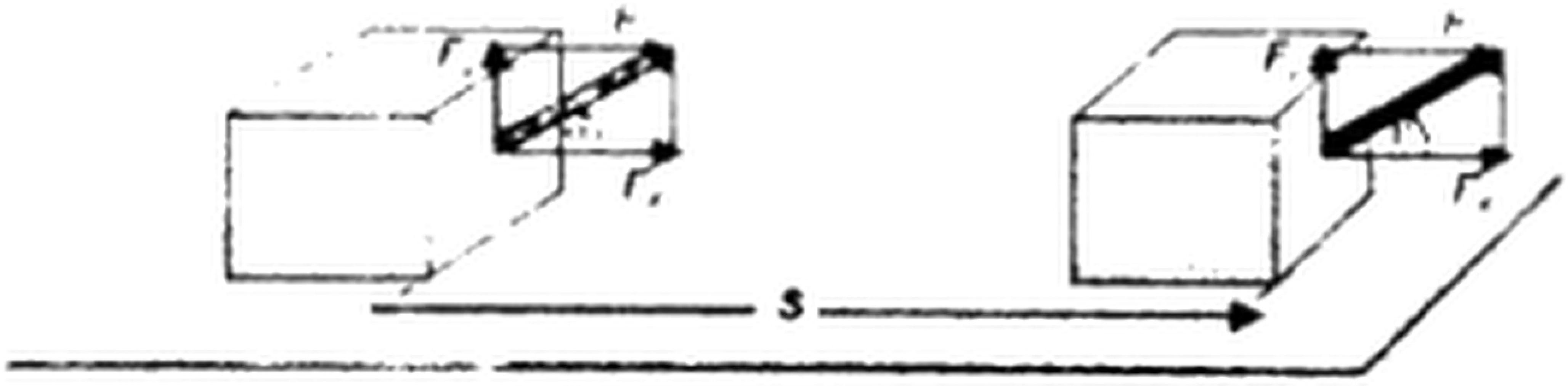
$W = (F \cos\theta)$

$W = Fd\cos\theta$

OR $W = \vec{F}.\vec{d}$



Work done in displacing a body in the direction of force.



Work done by a force inclined with the displacement.

Another definition

Work can also be defined as the dot product of force and displacement.

Unit of Work

Work is scalar quantity. SI unit of work is Nm called joule.

Definition of Joule

When one newton force acts on the body and the body covers a distance of one meter in the direction of force, the work done is said to be one joule.

Dimension of work

The dimension of work is $[ML^2T^2]$

Special cases

1) If $\theta < 90°$, work done is positive.

2) When $\theta > 90°$ and ≤ then work alone is negative.

3) If $\theta = 90°$, no work is done.

4) If $\theta = 0°$, positive work done is maximum.

5) If $\theta = 180°$, negative work done is maximum

Graphical representation of Work

Graphically, the area under the force-displacement curve represents the work done by force. If we plot graph between force and displacement then,

Area under the graph = (OP)(OR)

= Fd

So = W

If force $\vec{F}$ makes an angle θ with horizontal, then the graph is plotted between F cos θ and d.

Q.2 How much work is being done (i) on the wall and (ii) by upward force when a person holding the bag moving upward?

Answer

i) No work is being done

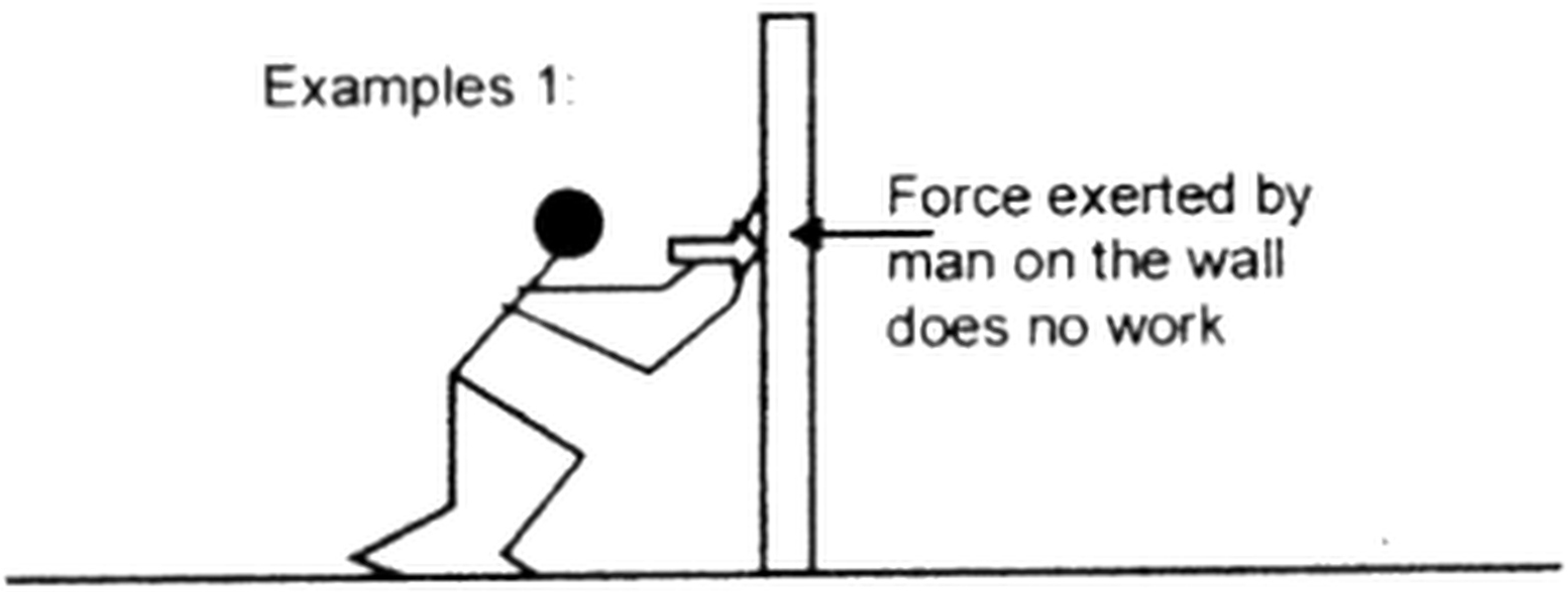
Reason

Because the displacement of wall is zero.

So $W = F(0)\cos\theta$

$W = 0$

Work Done



A person pushing on a wall does no work because the wall does not move.

ii) In this case no work is being done.

Reason

Because the angle between $\vec{F}$ and $\vec{d}$ is 90°.

So $W = Fd\cos 90^\circ$

$W = 0$

If force and displacement are perpendicular, no work is done.

Holding a bag of groceries, you do no work - but you get tired!!

The upward force is perpendicular to the displacement

Thus, W = 0.

Q.3 How can we calculate the work done by variable force?

Answer

Situation in which force is variable

In many cases, the force is not constant, but it varies in magnitude or direction or in both e.g.

- Force of gravity acting on a rocket moving away from earth.
- Force exerted by spring increases by the amount of stretch.

Work Done by a Variable Force

Let us consider the path of particle in xy-plan from point a to b as shown in figure.

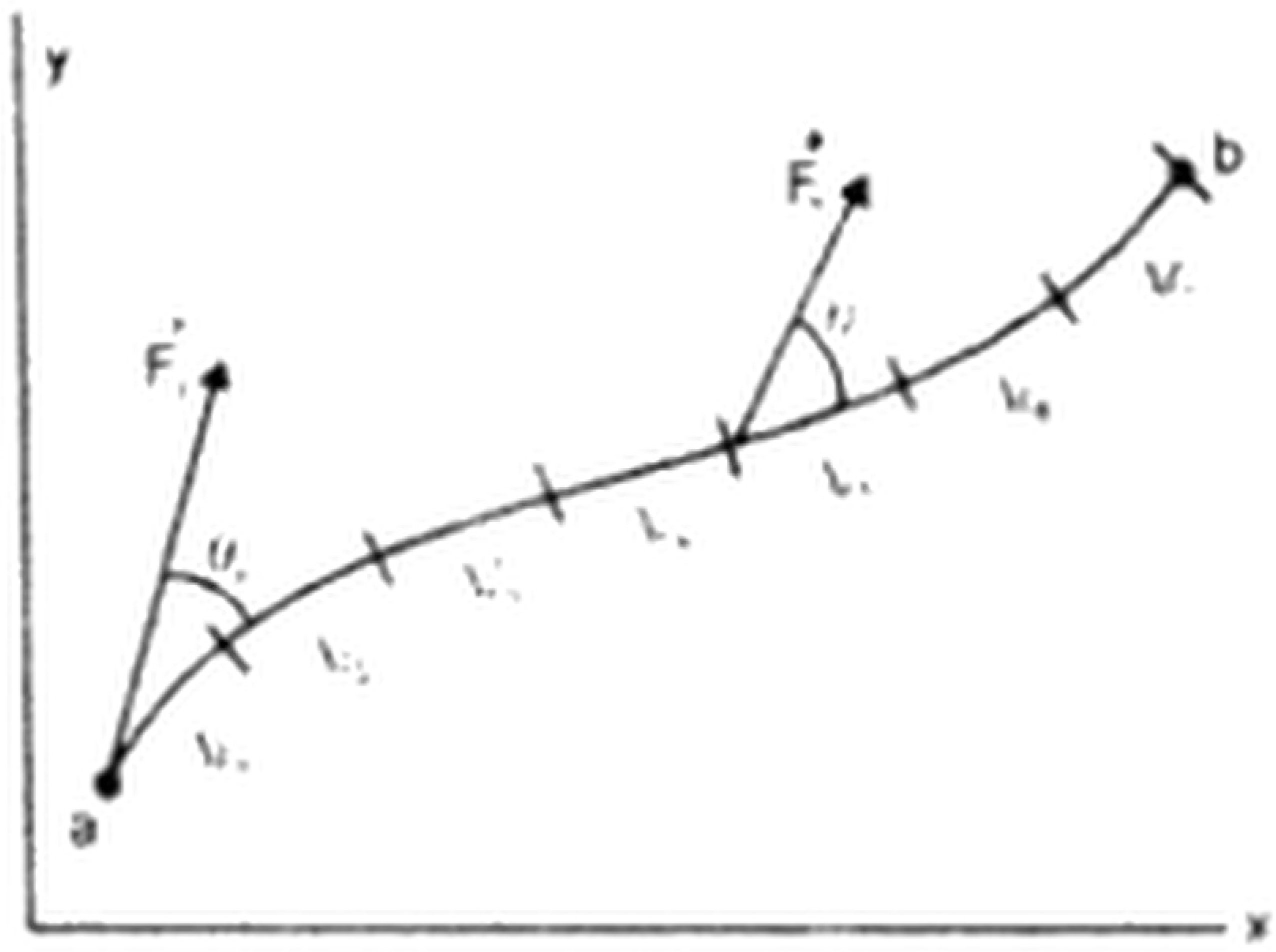
Divide the path into n short intervals of displacement $\Delta\vec{d}_1, \Delta\vec{d}_2, \ldots\ldots\Delta\vec{d}_n$.

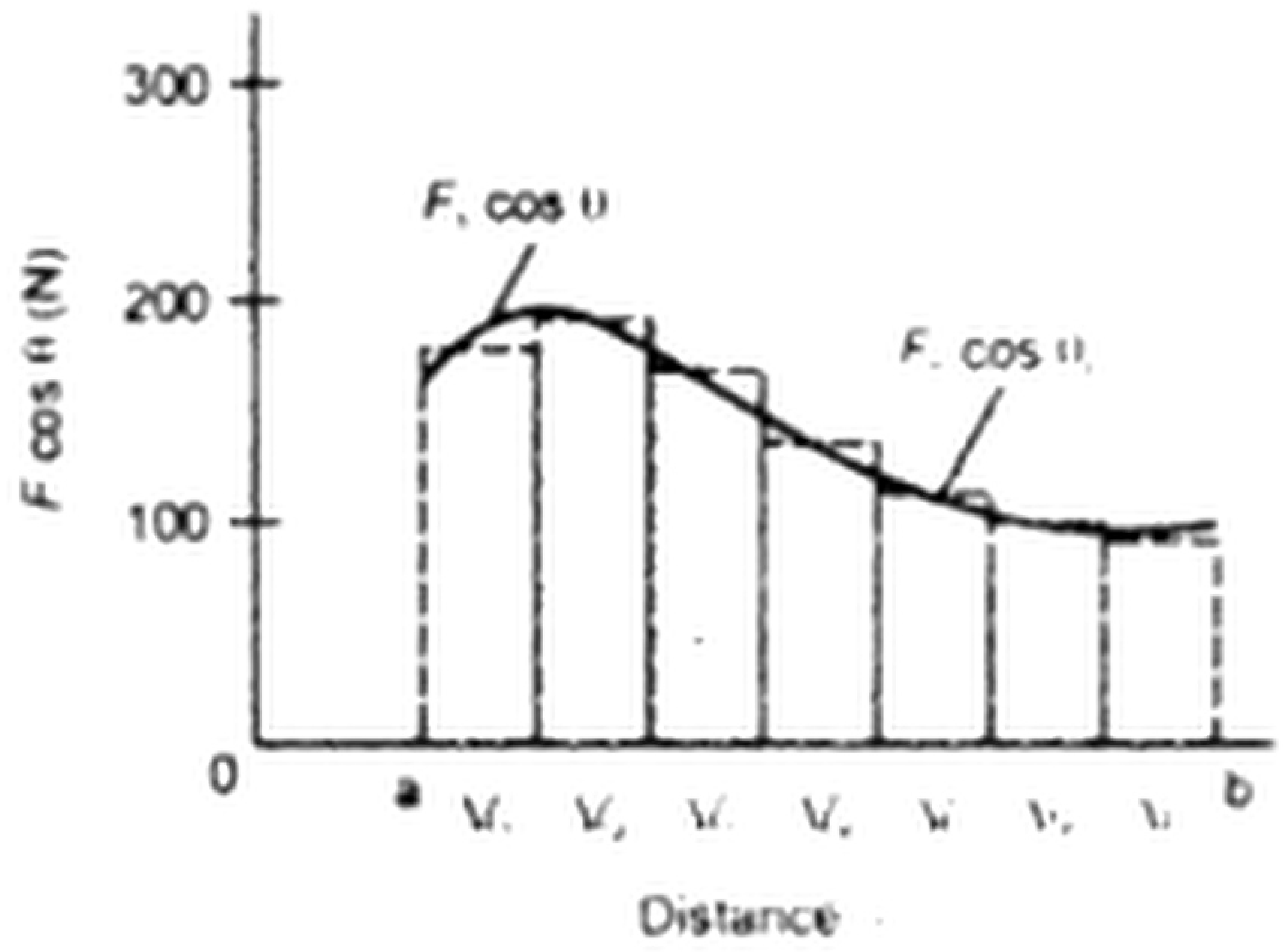
The forces acting during these intervals are $\vec{F}_1, \vec{F}_2 \ldots\ldots \vec{F}_n$ respectively.

The force is considered to be approximately constant for each interval of displacement. So work done for the first interval is

Work Done by a Varying Force

Particle acted on by a varying force
Clearly F is not constant





$$W = \sum_{i=1}^{n} F_i \cos\theta \Delta d$$

$$\Delta W_1 = \vec{F}_1 . \Delta\vec{d}_1 = F_1 \cos\theta \Delta \vec{d}_1$$

Similarly

$$\Delta W_2 = \vec{F}_2 . \Delta\vec{d}_2 = F_2 \cos\theta \Delta \vec{d}_2$$

And upto nth interval

$$\Delta W_n = \vec{F}_n . \Delta\vec{d}_n = F_n \cos\theta \Delta \vec{d}_n$$

Now the total work done in moving the body from point a to b is

$$W = \left(\Delta W_1 + \Delta W_2 + \dots\dots\dots \Delta W_n\right)$$

$$W = \left(F_1 \cos\theta \Delta \vec{d}_1 + F_2 \cos\theta \Delta \vec{d}_2 + \dots\dots\dots F_n \cos\theta \Delta \vec{d}_n\right)$$

OR $$W = \sum_{i=1}^{n} F_i \cos\theta_i \Delta d_i$$

How to calculate work graphically

- To calculate the work done, plot F cosθ verses d.
- Area under the graph is divided into n rectangles from a to b.
- Area of each rectangle represents the work done during that interval.
- The total work done is equal to sum of areas of all the rectangles.

For more accurate calculation of work

The work done can be calculated more accurately, if we subdivide the distance into a large number of intervals so that each Δd becomes very small i.e. $\Delta d \to 0$.

So

$$W = \lim_{\Delta d \to 0} \sum_{i=1}^{n} F_i \cos\theta_i \, \Delta d_i$$

In this case the total area of rectangles is equal to area under F cosθ verses d graph.

Q.4 What is gravitational field?

Answer

Gravitational Field

The space around the earth in which its gravitational force acts on a body is called the gravitational field.

Sign convention for work done in Gravitational field

- If displacement is in the direction of gravitational force, the work is positive.
- If displacement is against the direction of gravitational force, the work is negative.
- If displacement is perpendicular to the direction of gravitational force, the work done is zero.

Q.5 Show that gravitational field is a conservative field.

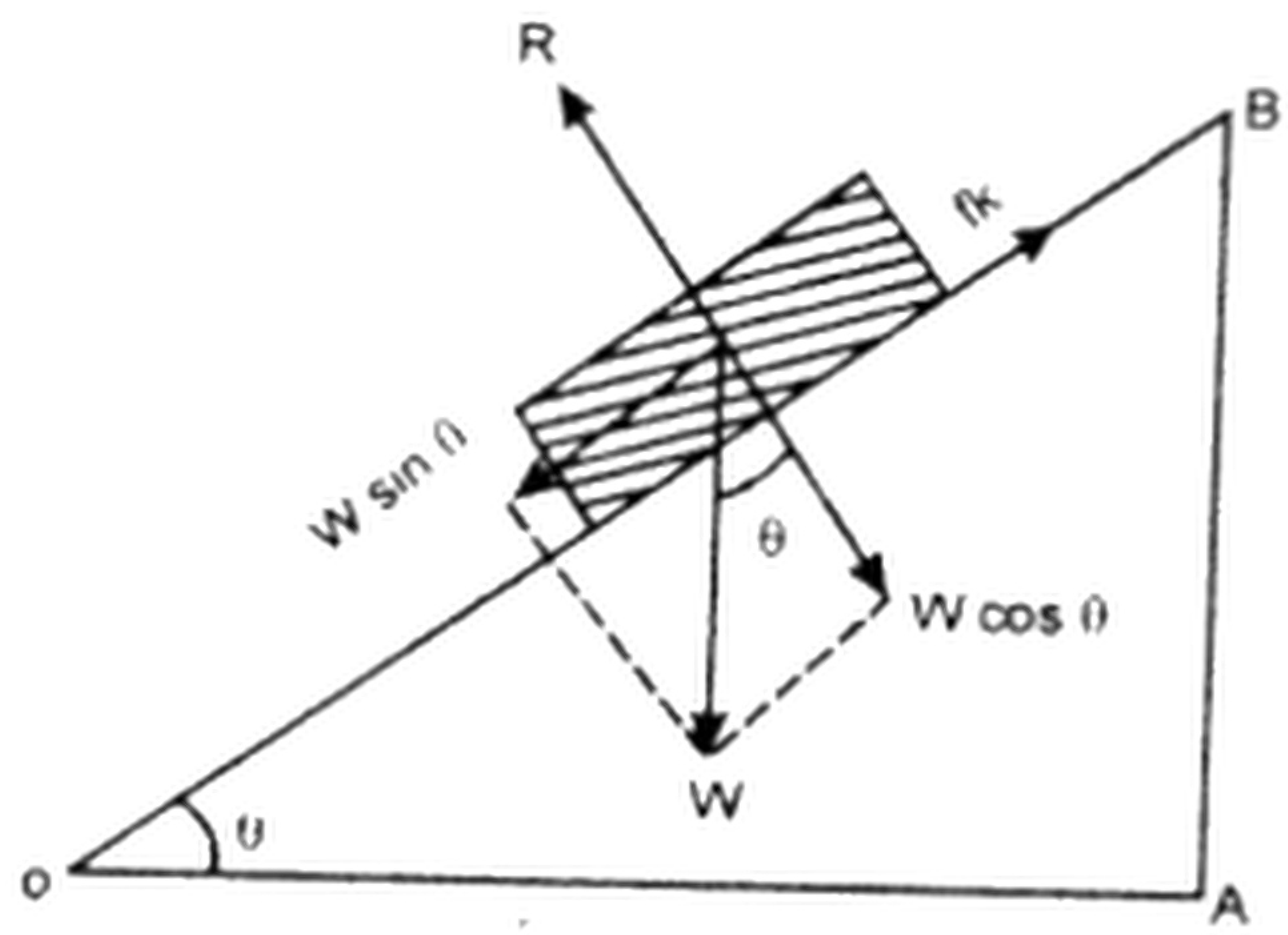
OR

Show that work done in gravitational field is independent of path followed:

Answer

Let us consider a body of mass m. The body is displaced from A to B along different paths with constant velocity in gravitational field as shown in figure.

Gravitational force acting on the body = mg



Body accelerating down an inclined plane

Path-I (Work done along path ADB)

$$\begin{aligned}
W_{ADB} &= W_{A\to D} + W_{D\to B} \\
W_{A\to D} &= mg(AD)\cos 90^\circ \\
&= mg(AD)(0) \\
&= 0 \\
\text{And} \quad W_{A\to D} &= mg(DB)\cos 180^\circ \\
&= mg(DB)(-1) \qquad (\because \cos 180^\circ = -1) \\
&= -mgh \qquad (DB = h) \\
W_{ADB} &= W_{A\to D} + W_{D\to B} \\
&= 0 + (-mgh) \\
&= -mgh \qquad \text{......(1)}
\end{aligned}$$

Path-II (Work done along path ACB)

Work done by gravitational force along path ACB is

$$\begin{aligned} W_{ACB} &= W_{A\to C} + W_{C\to B} \\ W_{A\to C} &= mg(AC)\cos 180^\circ \quad AC = h1 \\ &= mg(AC)(-1) \\ &= -mgh \end{aligned}$$

And
$$\begin{aligned} W_{C\to B} &= mg(CB)\cos 90^\circ \\ &= mg(CB)(0) \\ &= 0 \end{aligned}$$

Thus
$$\begin{aligned} W_{ACB} &= W_{A\to C} + W_{C\to B} \\ &= -mgh + 0 \\ W_{ACB} &= -mgh \qquad ......(2) \end{aligned}$$

Path-III (Work done along curved path)

In order to calculate work done along curve path, divide the path into horizontal and vertical steps as shown in figure.

Work done along horizontal steps

No work is done for these because mg is perpendicular to the displacement for horizontal steps. So

$$W_H = 0$$

Work done along vertical steps

Work done along vertical displacement is

$$\begin{aligned} W_v &= mg\Delta y_1 \cos 180^\circ + \ldots + mg\Delta y_n \cos 180^\circ \\ &= -mg\Delta y_1 - mg\Delta y_2 - mg\Delta y_3 - \ldots\ldots\ldots\ldots mg\Delta y_n \quad (\because \cos 180^\circ = -1) \end{aligned}$$

OR
$$= -mg(\Delta y_1 + \Delta y_2 + \Delta y_3 + \ldots\ldots\ldots\ldots\Delta y_n)$$

OR
$$= -mgh \qquad [\because \Delta y_1 + \Delta y_2 + \Delta y_3 = h]$$

Thus, the work done along curved path is

$$W_{AB} = W_H + W_v$$
$$= 0 + (-mgh)$$
$$W_{AB} = -mgh \qquad ....(3)$$

From equations (1), (2) an (3) it is clear that work done is independent of the path followed i.e.

$$W_{ADB} = W_{ACB} = W_{AB} = -mgh$$

Q.6 Show that the work done along a closed path in a gravitational is zero.

Answer

Work done along a closed Path

Consider a closed path ADBA. The body is moved from A to D, D to B and then from B to A. The total work done is equal to sum of work done along these paths.

$$W_{A\to D} = mg(AD)\cos 90^\circ$$
$$= mg(AD)(0)$$
$$= 0$$

Now $W_{D\to B} = mg(DB)\cos 180^\circ$

And for the curved path

$$W_{B\to A} = mg\Delta y_1 \cos 0^\circ + mg\Delta y_2 \cos 0^\circ + mg\Delta y_n \cos 0^\circ$$
$$= mg(\Delta y_1 + \Delta y_2 + ...\Delta y_n) \qquad (\because \cos 0^\circ = 1)$$
$$= mgh \qquad [\because \Delta y_1 + \Delta y_2 + \Delta y_3 = h]$$

So,

$$W_{ADBA} = W_{A\to D} + W_{D\to B} + W_{B\to A} + W_{B\to A}$$
$$= 0 + (-mgh) + (mgh)$$
$$= 0$$

Hence the work done along a closed path is zero.

Q.7 Define conservative field? Give examples.

Answer

Conservative Field

The field, in which work done is independent of the path followed is called conservative field.

OR

The field, in which work done along a closed path is zero is called conservative field.

Examples

1) Gravitational Field

2) Electric Field

Q.8 Define power and instantaneous power. Give its unit.

Answer

Power

Power is defined as work done per unit time.

OR

Power is defined as the rate of doing work.

Average Power

It is defined as total work done divided the total time taken.

Mathematically

$$P_{av} = \frac{\Delta W}{\Delta t}$$

Where

ΔW = the work done and Δt = the time taken

Instantaneous Power

Instantaneous Power is defined as the limiting value of $\frac{\Delta W}{\Delta t}$ as time Δt, following the time t approaches zero.

So,

$$P_{ins} = \lim_{\Delta d \to 0} \frac{\Delta W}{\Delta t}$$

Unit of Power

- Power is a scalar quantity.
- SI unit of power is joule/second called watt.
- Dimension of power is $[ML^2T^{-3}]$

Definition of Watt

The power is said to be one watt if one joule of work is done in one second.

Q.9 Define commercial units of electrical energy.

Answer

Commercial Unit of electrical energy

The commercial unit of electrical energy is kilowatt-hour.

Kilowatt-hour

Kilowatt-hour is the work done in one hour by an agency whose power is one kilowatt.

So,

$1kWh = 1000\ W \times 3600\ sec$ $= 3600000\ J$ $= 3.6 \times 10^6\ J$ $1kWh = 3.6\ MJ$	OR If a power of 1KWh is maintained for one hour then energy consumed is 1kWh.

Q.10 Show that instantaneous power $P = \vec{F}.\vec{v}$

Answer

Proof

Let

$\vec{F}$ = constant force acting on a moving body

$\vec{v}$ = constant velocity of the body

Then the power delivered to the body at any instant is given by

$$P = \lim_{\Delta d \to 0} \frac{\Delta W}{\Delta t}$$

$$P = \lim_{\Delta d \to 0} \frac{\vec{F}\Delta\vec{d}}{\Delta t} \qquad \left[\because \Delta W = \vec{F}\Delta\vec{d}\right]$$

OR $$P = \vec{F}\left[\lim_{\Delta d \to 0} \frac{\Delta\vec{d}}{\Delta t}\right]$$

OR $$\boxed{P = \vec{F}.\vec{v}} \qquad \left[\because \lim_{\Delta d \to 0} \frac{\Delta\vec{d}}{\Delta t} = \vec{v}\right]$$

Another Definition of Power

Power can also be defined as the scalar product of force and velocity

Q.11 Define energy. Give the two types of mechanical energy.

Answer

The capacity of a body to do work is called energy.

1) Kinetic Energy 2) Potential Energy

Kinetic Energy

Energy possessed by a body due to its motion is called kinetic energy.

Mathematically

$$K.E = \frac{1}{2}mv^2$$

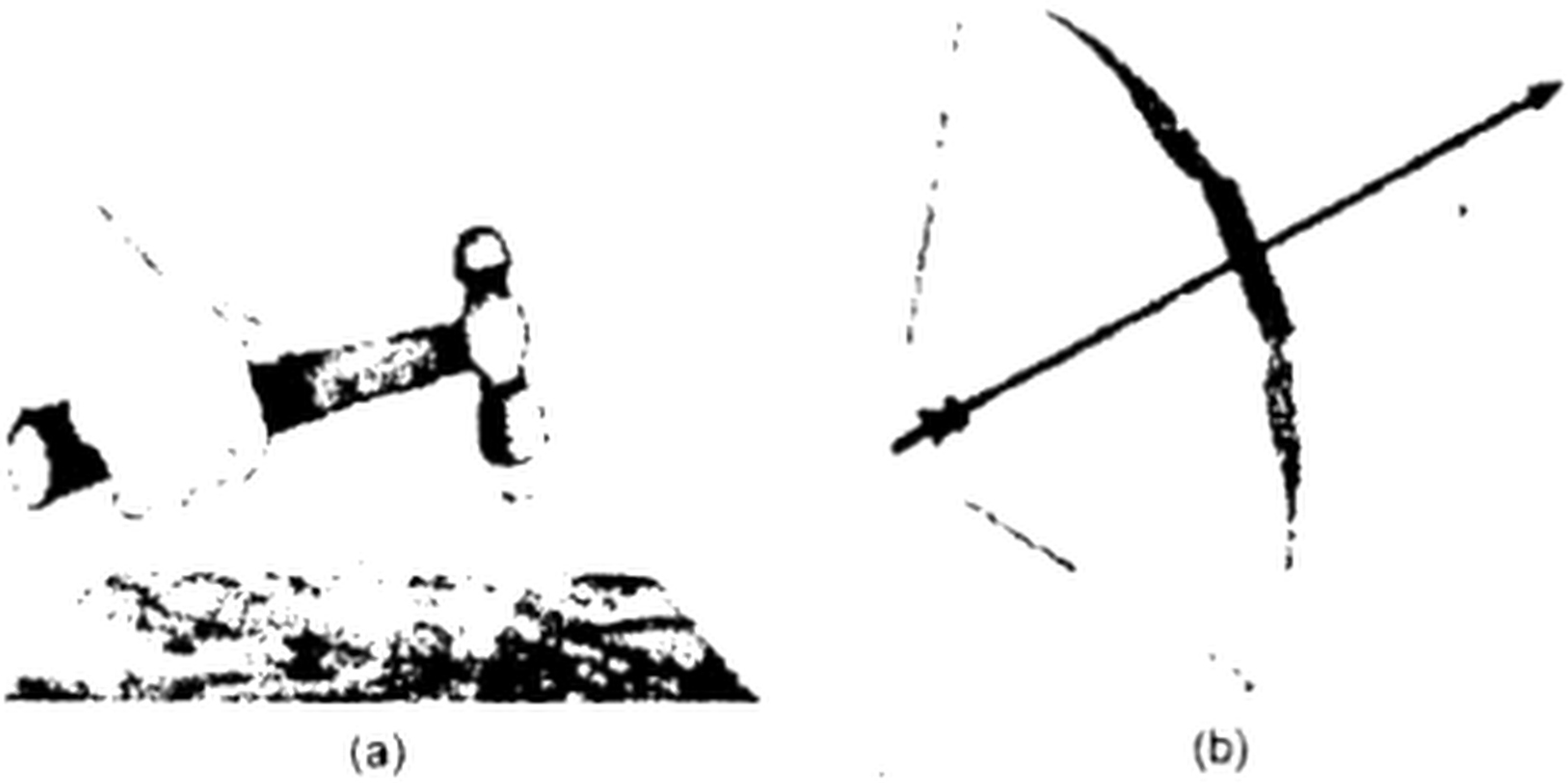
Where m is the mass of body moving with velocity v.

Running water possesses energy.

Energy of the wind moves the sailing boats.

Potential Energy

The energy possessed by a body because of position in a force field or because of its physical condition is called potential energy.



(a) Hammer raised up (b) stretched bow, both possess potential energy.

Gravitational Potential Energy

The energy stored in a compressed / stretched spring is called elastic potential energy.

Elastic potential energy = $\frac{1}{2}kx^2$

Where k is spring constant and x is the extension.

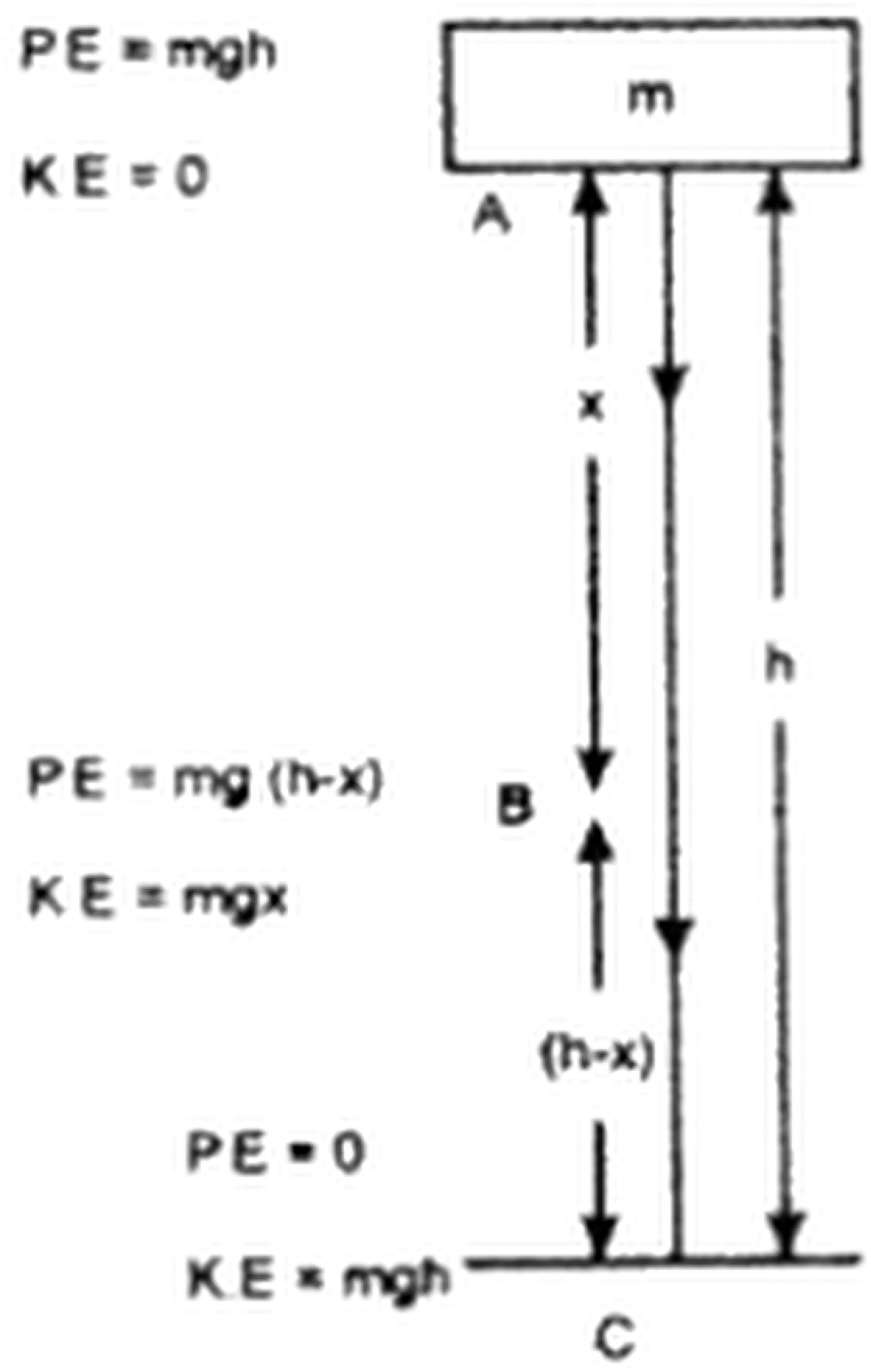
The units of energy are the same as those of work.

Q.12 State and prove work-energy principle.

Answer

Work-Energy Principle

Work done on a body is equal to the change in its kinetic energy.



Proof

m = mass of a body

v_i = initial velocity of the body

f = force applied on the body

d = distance covered by the body

v_f = final velocity of the body

The work done by the body is

$$\text{Work done} = Fd \qquad (1)$$

Now, according to equation of motion

$$2ad = vf^2 - vi^2 \ (\text{as } S = d)$$

OR $$d = \frac{1}{2a}\left(vf^2 - vi^2\right) \qquad (2)$$

And according to Newton's second law of motion

$$F = ma$$

Using equation (2) and (3)in(1), we get

$$\text{Work done } = ma\frac{1}{2a}\left(vf^2 - vi^2\right) = \frac{1}{2}m\left(vf^2 - vi^2\right)$$

OR Work done $= \frac{1}{2}mvf^2 - \frac{1}{2}mvi^2$

OR Work done $=$ Final K.E − Initial K.E $=$ Change in K.E

Note

- If a body is raised from the surface of earth, the work done changes its gravitational P.E.
- If a spring is a compressed, the work done on it is equal to the increase in elastic potential energy.

Q.13 Define absolute potential energy. Derive relation for absolute P.E. of body of mass m at distance r from the centre of earth.

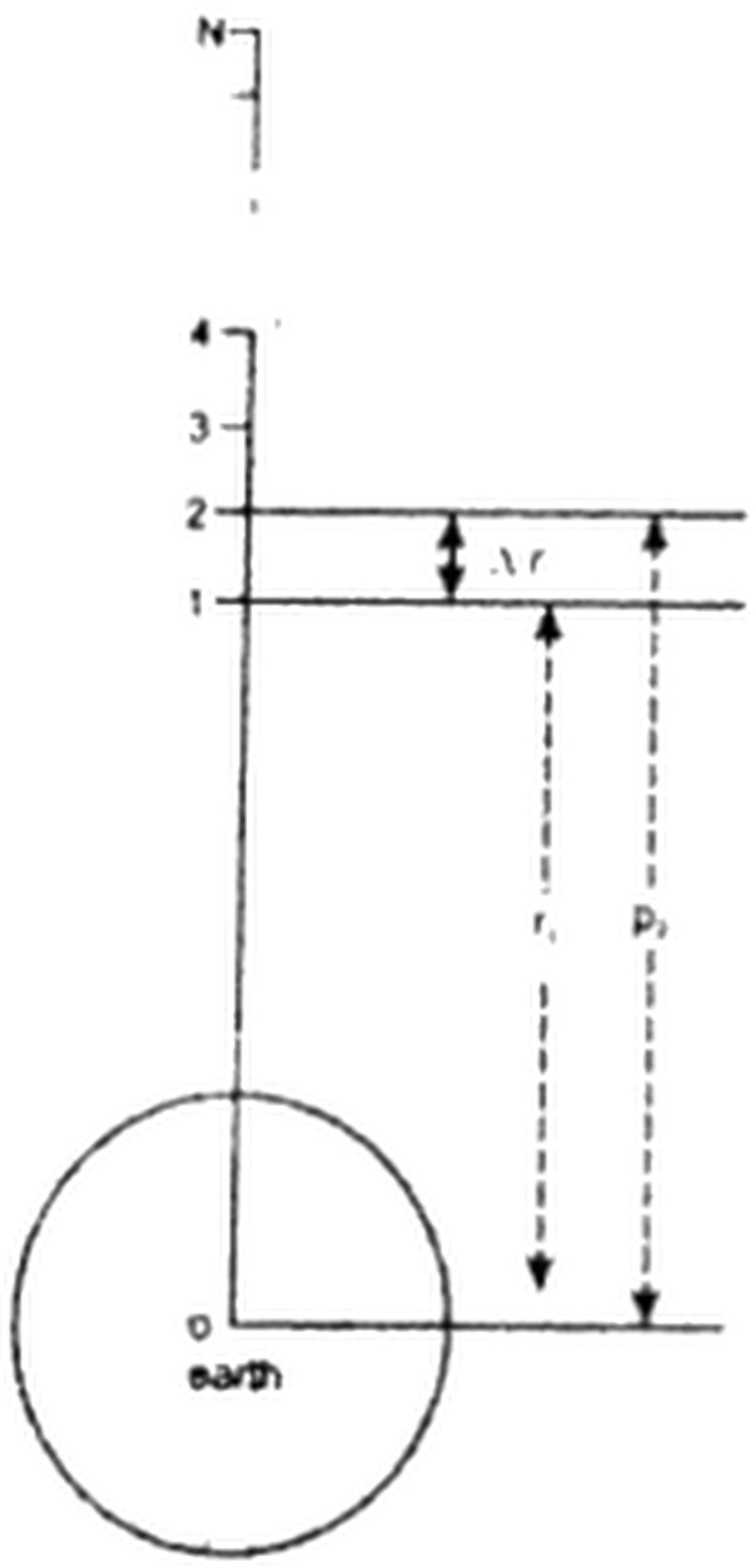
Answer

Absolute Potential Energy

The absolute gravitational potential energy of an object at a certain position is the work done by gravitational force in displacing the object from that position to infinity where the force of gravity becomes zero.

Calculation of Absolute P.E

- Let a body of mass m is displaced in space from paint 1 to N in the gravitational field.
- The gravitational force does not remain constant during this displacement.
- In order to calculate the work done by gravitational force, the distance between 1 to N is divided into equal small steps of lengths Δr, so that the value of force remains constant for each step.



Work done during 1st step (1→ 2)

Suppose

m = mass of the body

m = mass of Earth

r_1 = distance of point 1 from the centre of the Earth

r_2 = distance of point 2 from the center of the Earth

Calculation of r

The distance between the center of this step and center of the earth is

$$r = \frac{r_1 + r_2}{2} \qquad .....(1)$$

Also displacement of body from point 1 to 2 is

$$\Delta r = r_2 - r_1 \qquad .....(2)$$

OR $r_2 = \Delta r + r_1$ ......(3)

$$r = \frac{r_1 + \Delta r + r_1}{2}$$

$$r = \frac{2r_1 + \Delta r}{2}$$

$$r = \frac{2r_1}{2} + \frac{\Delta r}{2}$$

$$r = r_1 + \frac{\Delta r}{2} \qquad ....(4)$$

Squaring both sides, we have

$$r^2 = \left(r_1 + \frac{\Delta r}{2}\right)^2$$

$$r^2 = r_1^2 + \frac{\Delta r^2}{4} + r_1 \Delta r$$

Since $(\Delta r)^2 < r_1^2$, so this term can be neglected as compared to r_1^2

$$r^2 = r_1^2 + r_1 \Delta r$$

$$r^2 = r_1^2 + r_1(r_2 - r_1)$$

$$r^2 = r_1^2 + r_1 r_2 - r_1^2$$

$$\boxed{r^2 = r_1 r_2} \qquad ......(5)$$

Now, the gravitational force F at the center of this step is

$$F = \frac{GMm}{r^2} \qquad ......(6)$$

Using equation (5) in (6), we have

$$F = \frac{GMm}{r_1 r_2} \qquad ......(7)$$

Thus work done during 1st step is

$$W_{1\to 2} = \vec{F} . \Delta \vec{r}$$

$$= F\Delta \cos 180^\circ \qquad \left(\because \vec{F} \text{ is opposite to } \Delta \vec{r}\right)$$

$$= 1F\Delta r$$

$$= -G\frac{Mm}{r_1 r_2}(r_2 - r_1) \qquad \text{Using equation (2) and (7)}$$

$$W_{1\to 2} = -GMm\left[\frac{r_2}{r_1 r_2} - \frac{r_1}{r_1 r_2}\right]$$

$$W_{1\to 2} = -GMm\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$$

Work done during 2nd step $(2 \rightarrow 3)$

$$W_{2\rightarrow 3} = -GMm\left[\frac{1}{r_2} - \frac{1}{r_3}\right]$$

Work done during last step $(N-1 \rightarrow N)$

For last step work done is

$$W_{N-1\rightarrow N} = -GMm\left[\frac{1}{r_{N-1}} - \frac{1}{r_N}\right]$$

Total work done from 1 to N

$$W_{total} = W_{1\rightarrow 2} + W_{2\rightarrow 3} + \ldots\ldots + W_{N-1\rightarrow N}$$

$$= -GMm\left[\left(\frac{1}{r_1} - \frac{1}{r_2}\right) + \left(\frac{1}{r_2} - \frac{1}{r_3}\right) + \ldots\ldots\ldots\left(\frac{1}{r_{N-1}} - \frac{1}{r_N}\right)\right]$$

$$W_{total} = -GMm\left[\frac{1}{r_1} - \frac{1}{r_N}\right]$$

Absolute P.E

If N lies at infinity, then

$$r_N = \infty \text{ and } \frac{1}{r_N} = \frac{1}{\infty} = 0$$

So $\quad W_{total} = -GMm\left[\frac{1}{r_1} - 0\right] = -GMm\left[\frac{1}{r_1} - \frac{1}{\infty}\right]$

OR $\quad W_{total} = \frac{-GMm}{r_1} \qquad \ldots\ldots\ldots(8)$

In general, the absolute gravitational potential of body at distance r from the center of the earth is

$$U = \frac{-GMm}{r} \qquad \ldots\ldots\ldots\ldots(9)$$

Absolute P.E on the surface of Earth

When the body lies at the surface of the earth then, r = R. so, equation (9) becomes

$$U = \frac{-GMm}{R} \qquad \ldots\ldots\ldots\ldots(10)$$

Q.14 How absolute potential energy changes with distance r from the centre of earth increases?

Answer

- When body moves away from earth, r increases, the gravitational force does negative work and U increases (i.e. it becomes less negative).
- When the body moves falls toward the earth, r decreases, the gravitational force does positive work and U decreases (i.e. it becomes more negative).

Note: (Zero reference point)

- The choice of zero point is arbitrary.
- We can take the surface of the earth or the point at infinity as zero P.E reference.
- The difference of P.E from one point to another is significant.
- The change in P.E as we move a body above the earth's surface will always positive.

Q.15 Define escape velocity and derive the mathematics expression for escape velocity? Answer

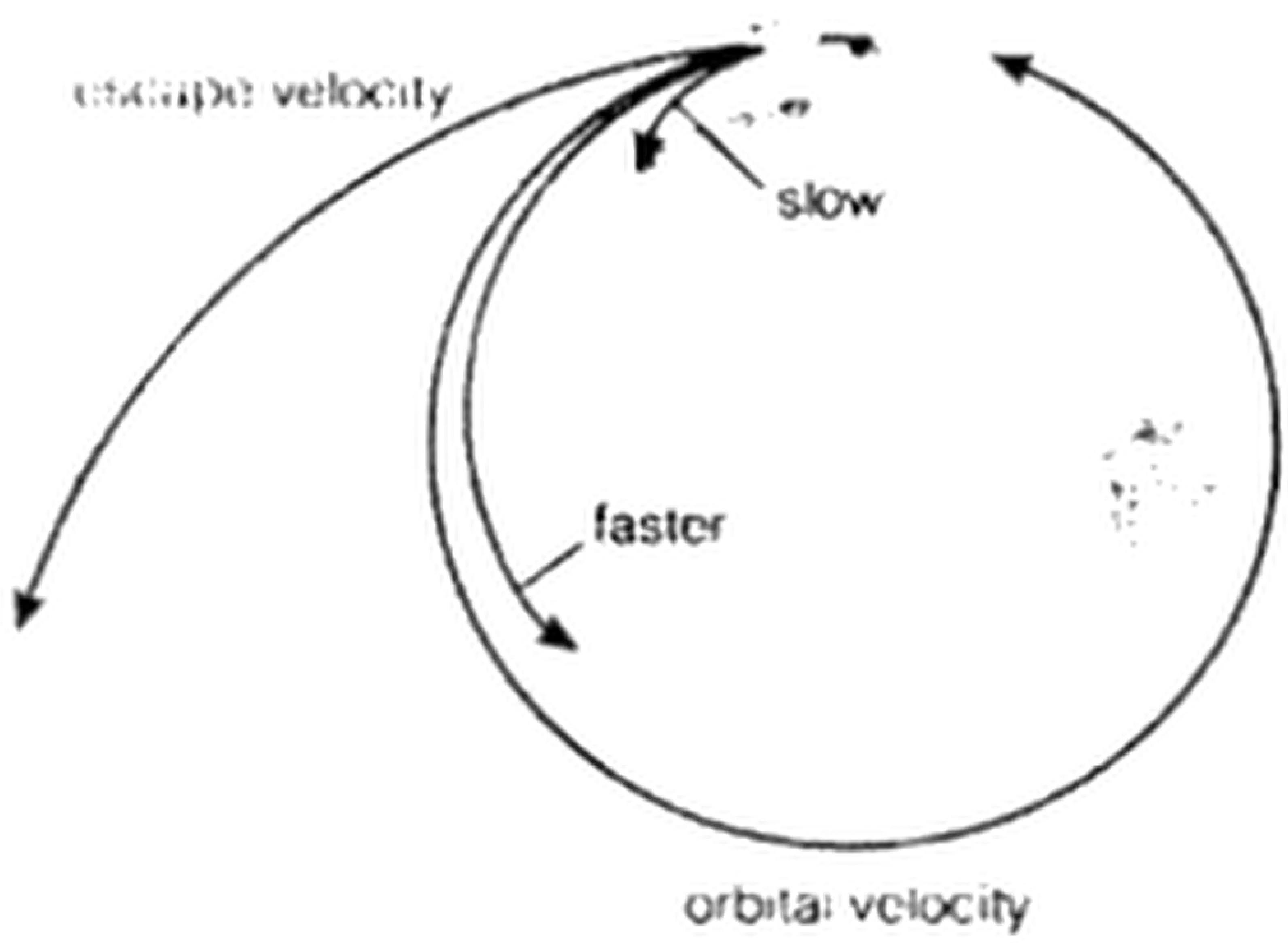
Escape Velocity

The initial velocity of a body with which it goes out of the earth's gravitational field is called escape velocity.

Explanation

- When a body is thrown upward, it returns back after reaching a certain height. That is due to gravitational force acting downward.
- If we increase the initial velocity of the body then it gains more height.

- If we go on increasing the initial velocity, then at certain velocity, the body will not return back to the ground. This particular velocity is called escape velocity.



Expression for escape velocity

We know that the absolute P.E. of a body of mass m on the surface of earth is

$$U_g = -\left(\frac{-GMm}{R}\right) \qquad ....(1)$$

As the body goes out of gravitational field, its P.E. becomes zero.

So, Increase in P.E $= 0 = -\left(\frac{-GMm}{R}\right) = \frac{GMm}{R}$

Thus, the initial K.E needed by the body to reach infinity (i.e. out of gravitational field) is

$$\text{Initial K.E} = \frac{GMm}{R}$$

OR $$\frac{1}{2}mv^2_{esc} = \frac{GMm}{R}$$

Where m = the mass of the body; M = mass of the earth and R = radius of earth.

OR $$mv^2_{esc} = \frac{2GMm}{R}$$

OR $$v^2_{esc} = \frac{2GM}{R}$$

OR $$v_{esc} = \sqrt{\frac{2GM}{R}} \qquad ....(2)$$

This is also formula for the escape velocity of a body.

Another formula for escape velocity

As the gravitational force for a mass m placed on the surface of the earth of mass is

$$F = \frac{GMm}{R^2}$$

But $$F = mg$$

So $$mg = \frac{GMm}{R^2}$$

OR $$g = \frac{GM}{R^2}$$

OR $$GM = gR^2 \qquad ......(3)$$

Putting value from eq (3) in (2), thus equation (2) becomes,

$$v_{esc} = \sqrt{\frac{2gR^2}{R}}$$

$$v_{esc} = \sqrt{2gR^2} \qquad ......(4)$$

As $g=9.8\ m/sec^2$ and $R=6.4 \times 10^6$

So $$v_{esc} = \sqrt{2 \times 9.8 \times 6 / 4 \times 10^6}$$

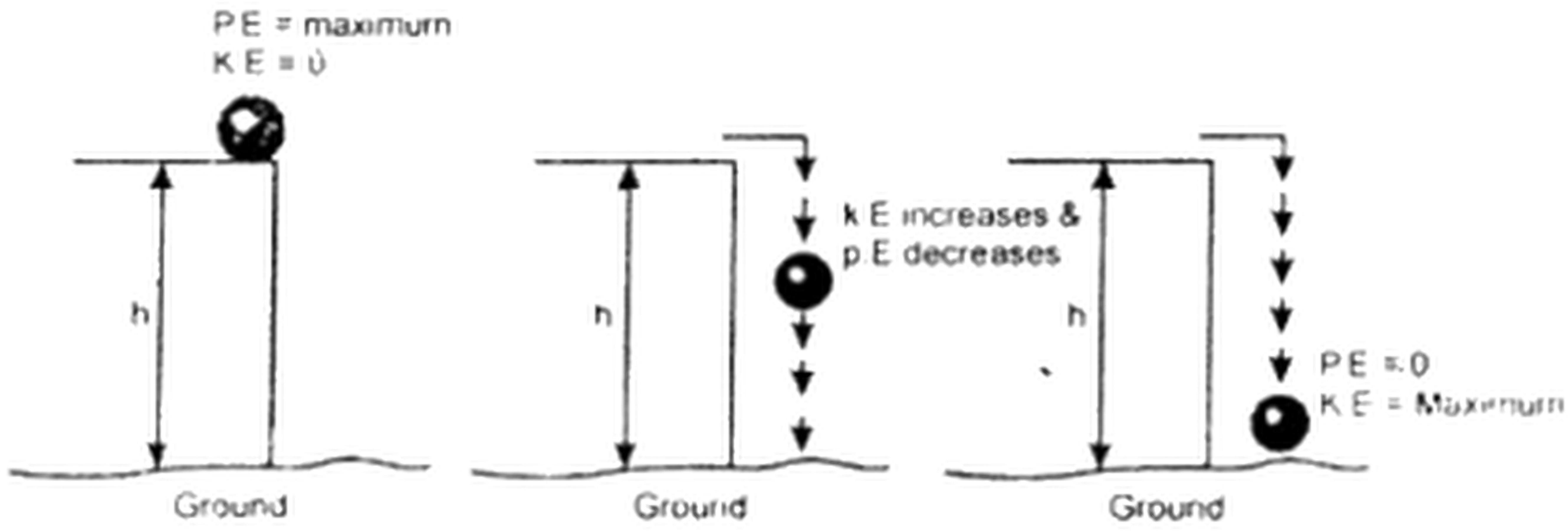
$$v_{esc} = 11.2 \times 10^3\ m/sec$$

Q.16 Discuss inter-conversion of potential energy and kinetic energy.

Answer

Inter-conversion of Potential Energy & Kinetic Energy

Suppose a body of mass m is at rest at height h above the surface of earth.



At position A

Potential energy of the body = mgh

Kinetic energy of body = 0

The total energy at A is

$$E_A = mgh + 0$$

$$E_A = mgh \quad \text{....(1)}$$

Change in P.E. & K.E. when body falls at Position B

Let

Downward distance covered by the body = x

Height of body from the surface of earth = (h-x)

Potential energy of the body = mg(h-x) = mgh - mgx

Kinetic energy of body = $\frac{1}{2}mv_B^2$ ......(2)

Where v_B = is the velocity of body at point B.

Calculation of v_B

By equation of motion

$$2ad = v_f^2 - v_i^2$$

OR $v_f^2 = 2ad + v_i^2$

OR $v_B^2 = 2gx = 0$ $\quad [\because v_i = 0, v_f = v_B, d = x \text{ and } a = g]$

OR $v_B^2 = 2gx$

Putting this value of v_B^2 in equation (2) we have

$$K.E = \frac{1}{2}m(2gs) = mgx$$

So, total energy at position B

$$E_B = mg(h - x) + mgx$$

$$E_B = mgh - mgx + mgx$$

OR $E_B = mgh \quad ....(3)$

At position C [Just before hitting the ground]

Downward distance covered by the body = h

Height of the body from the surface of earth = 0

Potential energy of the body = 0

Kinetic energy of body = $\frac{1}{2}mv_C^2 \quad ......(4)$

Where v_C is the velocity of body at point C.

Calculation of v_c

By equation of motion

$$2ad = v_f^2 - v_i^2$$

$$v_f^2 = 2as + v_i^2$$

$$v_C^2 = 2gh = 0 \quad [\because v_i = 0, v_f = v_C, d = h \text{ and } g = g]$$

$$v_C^2 = 2gh$$

Putting this value of v_C^2 in equation (4) we have

$$K.E = \frac{1}{2}m(2gh) = mgh$$

So, total energy at position C

$$E_C = 0 + mgh$$

$$E_C = mgh \quad ....(5)$$

Conclusion

- P.E. and K.E. are inter-convertible but the total energy remains unchanged.
- In the absence of friction, loss in P.E. = gain in K.E.
- In the presence of friction, loss in P.E. = gain in K.E. + work done against friction

  i.e. $mgh = \frac{1}{2}mv^2 + fh$

Note:

If a body falls from a height h_1 , then at height h_2 above the surface earth

Loss in P.E. = Gain in K.E.

$$mgh_1 - mgh_2 = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$$

OR $$mg(h_1 - h_2) = \frac{1}{2}m\left(v_2^2 - v_1^2\right)$$

Where v_1 and v_2 are the velocities at height h_1 and h_2 respectively.

Q.17 State law of conservation of energy. Why new sources of energy have to be developed if energy is conserved?

Answer

Conservation of energy

Statement

Energy cannot be destroyed. It can be transformed from one form into another, but the total amount of energy remains constant.

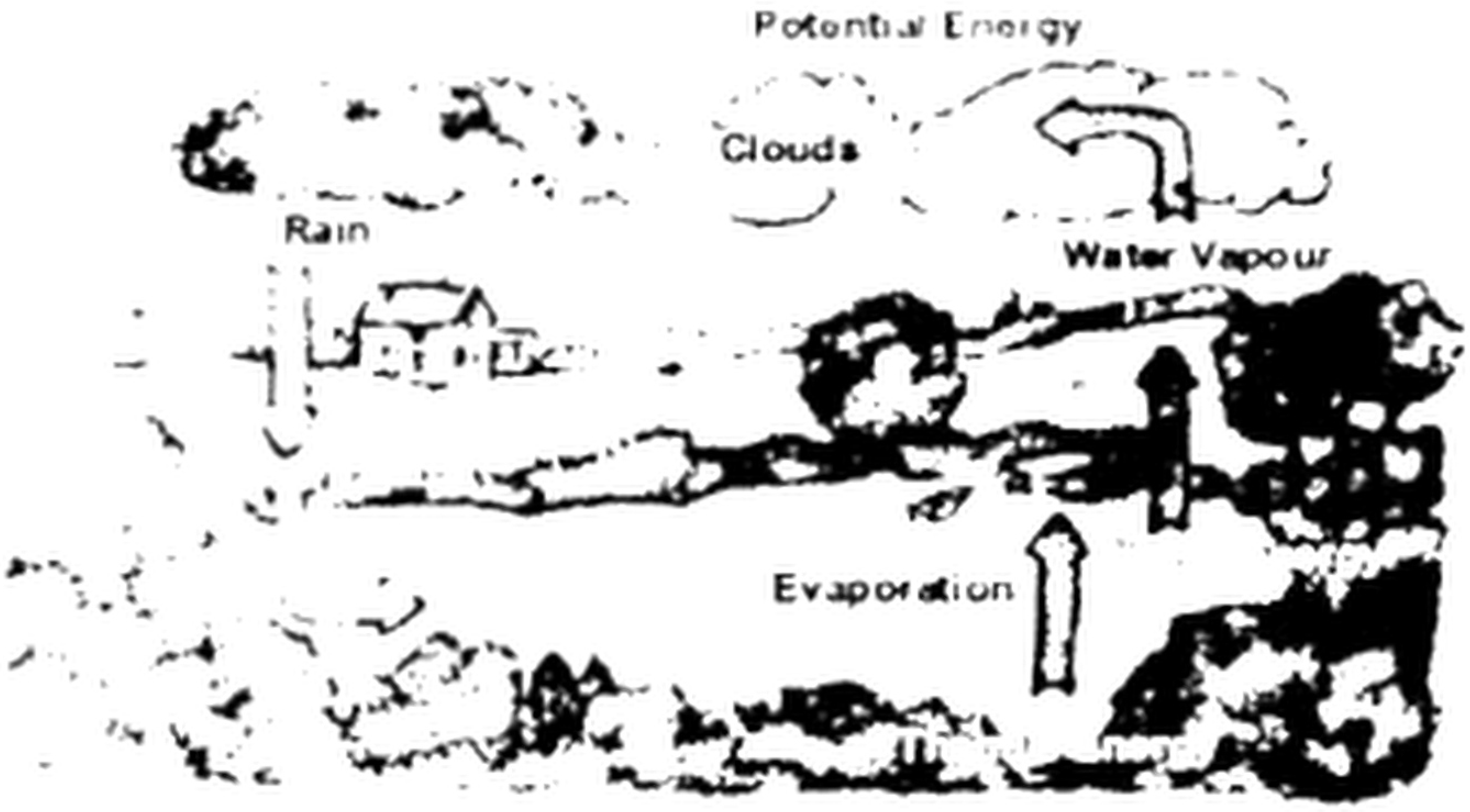
Conservation of mechanical energy

The K.E and P.E are the different forms of mechanical energy. The total mechanical energy of the body is equal to the sum of K.E and P.E.

P.E may change into K.E. Similarly, the K.E may also be change into P.E, but total energy remains constant.

Mathematically, total energy = P.E + K.E = constant.

This is the special case of conservation of energy.



Interconversion of Energy

Need for new sources

In daily life we observe many energy changes from one form to another. At last all energy transfers the heat to the environment and energy is lost in the form of heat which is useless. So, useful energy is decreasing though total energy is conserved. That's why we need to develop new sources of energies.

Q.18 Discuss the different non-renewable energy sources.

Answer

Non-renewable Energy Sources

These sources are not very common these days. Some of them are given below.

Coal

Coal is a solid form fossil fuel that can be classed into three types: lignite, bituminous and anthracite. Lignite coal is found close to the Earth surface, making it easy to mine, but it has high sulphur content. Bituminous coal is the most common coal we burn, and it is less polluting than lignite. Anthracite is the highest quality of coal - it is dark and shiny and found deeper in the Earth.

Oil

Oil is a liquid fossil fuel that can be dark brown, yellow or even green. It is easier to mine once it is found because, being a liquid, it will flow through pipes, which makes it easier for transport. However, it can be difficult to locate - oil forms in reservoirs and, to find these reservoirs, scientists must study rocks and Landforms to find potential drilling sites.

Once a hole is drilled and if oil is found, it is then piped to the surface. In this form, it is called 'crude oil'. Crude oil is transported to a refinery that heats up the oil to different temperatures and sorts out the different types of fuel (such as petrol, jet-fuel and diesel) through a process called fractional distillation. Oil is used not just for transport but also in many different products such as plastics, tires and synthetic material such as polyester.

A gas field

Natural gas

As the name suggests, this is a fossil fuel in the form of a gas (for example, methane and LPG). It is often found under the oceans and near oil deposits. Surveying for natural gas reservoirs is similar to oil exploration. Once a natural gas field is found, the drilling process is similar to oil.

Gas can be piped from the source and stored for later use. Natural gas is used for cooking and heating as well as making a number of products such as plastics, fertilizers and medicines.

Q.19 Discuss the different Renewable energy sources.

Answer

Renewable energy sources

Energy from tides

Gravitational force of moon produces tides in the sea. The tide raises the water in the sea roughly two times a day.

Explanation

- Water at high tide can trapped in a basin by constructing a dam.
- Dam is filed at high tide.
- Then, water is released in a controlled way at low tide to derive the turbines.
- The dam is filled again for next high tide and the fall of water also derive the turbines.
- This process is used to generate the current.

Energy from waves

- The tides and waves blow across the surface of ocean.
- These waves produce strong water waves.
- The energy of these waves can generate electricity.

Salter's duck

The device which is used for this purpose was invented by Professor Salter called Salter's duck.

It has two parts (i) Duck float. (ii) Balance float.

The wave energy produces the movement in duck float relative to balance float. The relative motion of duck float is used to run electricity generators.

Solar energy

Sun is the major source of energy on earth. Solar energy at normal incidence outside the earth's atmosphere is about 1.4KW/m^2. Which is called solar constant. While passing through atmosphere, the total energy is reduced due to reflection, scattering and absorption by dust particles, water vapors and other gases. On a clear day at noon, the solar energy at the surface of the earth is 1KW/m^2.

Solar energy is used to heat the water by solar reflection and thermal absorbers. It can also be used to generate electrical energy. For this purpose, the surface of the collector is blackened to absorb the heat energy. It can heat up the water up to 70°C.

To get higher temperature, we use the reflectors or lens of larger size. Sunlight can be converted into electrical energy by photo voltaic cells. They are made up of silicon. Electrons in the silicon gains energy from sunlight to create voltage Solar panel are expensive but of long life time and have low running cost.

A solar panel fixed at the roof of a house.

Electric energy:

Energy from water power is very cheap. Dams are being constructed at suitable locations in different parts of the world. Dams serve many purposes. They help to control floods by storing water. The water stored in dams is used for irrigation and also to generate electrical energy without creating much environmental problems.

Energy stored in the water of a dam is used to run power plants

Wind energy:

Wind has been used as a source of energy for centuries. It has powered sailing ships across the oceans. It has been used by windmills to grind grain *and* pump water. More recently, wind power is used to turn wind turbines (Figure 6.24). When many wind machines are grouped together on wind farms, they can

Wind turbines

generate enough power to operate a power plant. In the United States, some wind farms generate more than 1300 MW of electricity a day. In Europe, many wind farms routinely generate hundred megawatts or more electricity a day.

Energy from Biomass:

It includes the organic materials such as crop residue, natural vegetation, trees, animal dung and sewage. Biomass energy refers to the use of materials as fuel. Two common methods of conversion of biomass into fuels are direct combustion and fermentation.

Direct combustion method:

Direct combustion method is applied to get energy from waste product commonly known as solid waste and confined it into chamber and ignite it, The heat product is then use in a boiler to run the turbine of generator.

Fermentation Method:

Bio fuel such as ethanol is a replacement of gasoline, which is obtained by fermentation of biomass using enzymes and by decomposition through bacterial action in the absence of air. The rotting of biomass in a dosed tank called a digester produces Biogas which can be piped out to use of cooking and heating.

Geothermal Energy:

The heat extracted from inside the earth is in the form of hot water or steam. It can be generated by following methods.

Radioactive decay

Due to decay or radioactive elements, the energy heating the rocks is constantly being released.

Residual Heat of the Earth

Hot igneous rocks within 10 km of the earth are present in molten form. They conduct heat energy from interior part of the earth. The temperature of these rocks is 200°C or more.

Compression of Material:

In deep inside the earth, the compressed materials cause for the generation of heat energy.

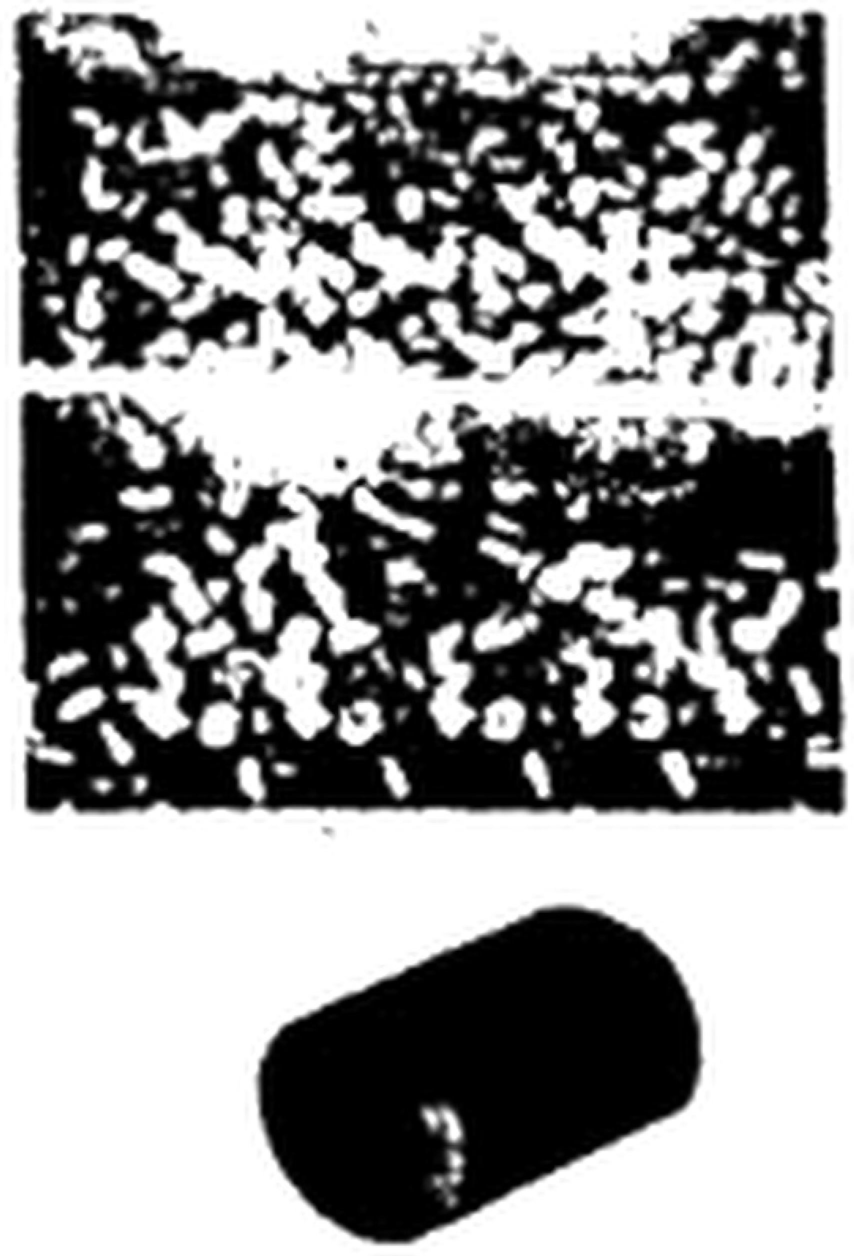
In some places, water beneath the ground is in contact with hot rocks and is raised to high temperature and pressure in form of hot springs, geysers or steam vents. The steam produced in this way can run the turbines or for heating purpose.

Geo thermal energy may cause to produce hot geyser releasing with an explosive column into the air. That usually occur in volcanic region and erupt with irregular intervals. This extraction of geo thermal seriously disturbs geyser system by reducing heat flow and aquifer pressure.

"**Aquifer** is a layer of rock holding water that allows water to percolate through it with pressure."

Nuclear Fuels:

In nuclear power plants, we get energy as a result of fission reaction. During fission reaction, heavy atoms, such as Uranium atoms, split up into smaller parts releasing a large amount of energy. Nuclear power plants give out a lot of nuclear radiations and vast amount of heat. A part of this heat is used to run power plants while lot of heat goes waste into the environment.



Nuclear fuel pallets used in nuclear reactors