MBC - MRIDUL BHAIYA CLASSES

WORK POWER AND ENERGY

CLASS -9 (CBSE)

BY MRIDUL BHAIYA

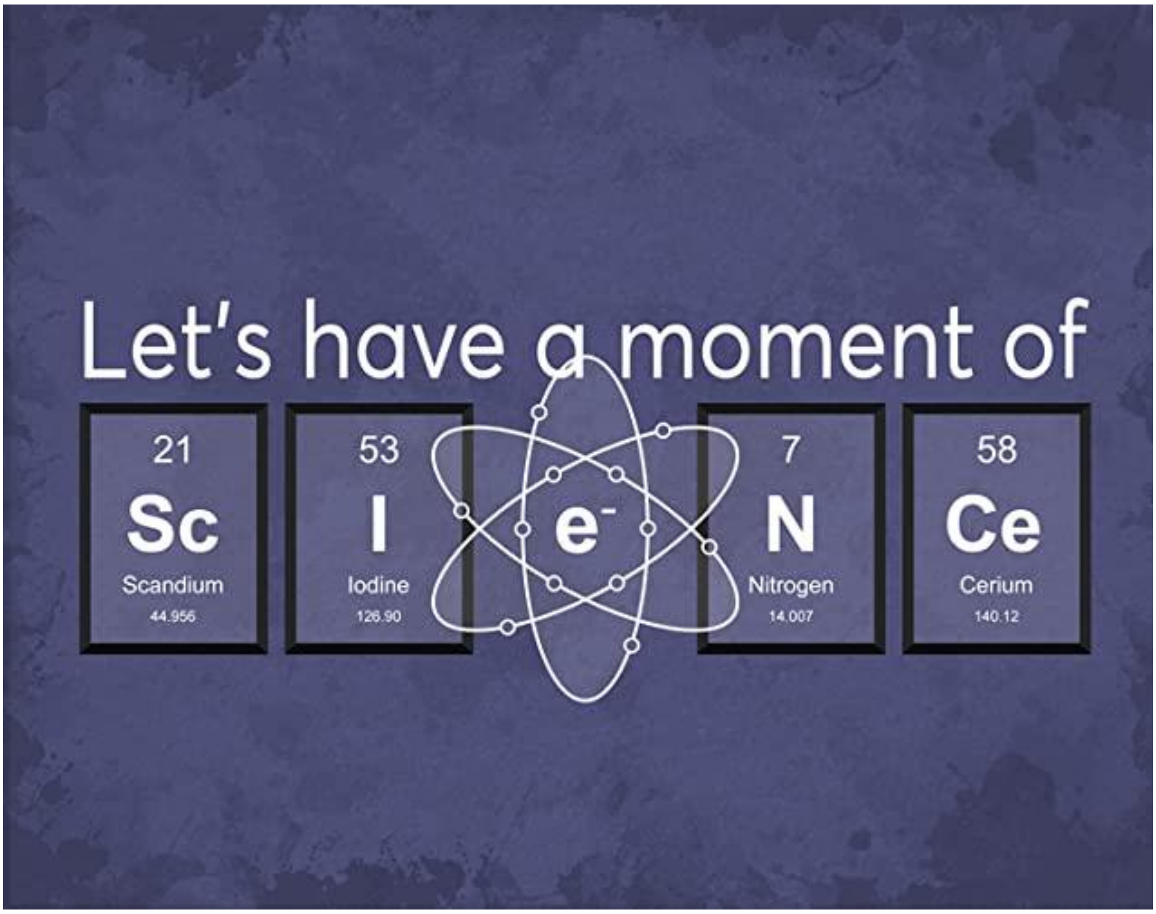
MBC – Mridul Bhaiya Classes

CLASS IX

SCIENCE NOTES

WORK POWER AND ENERGY

- ✓ Detailed notes
- ✓ PYQs with answers
- ✓ Graphics included



WORK POWER AND ENERGY

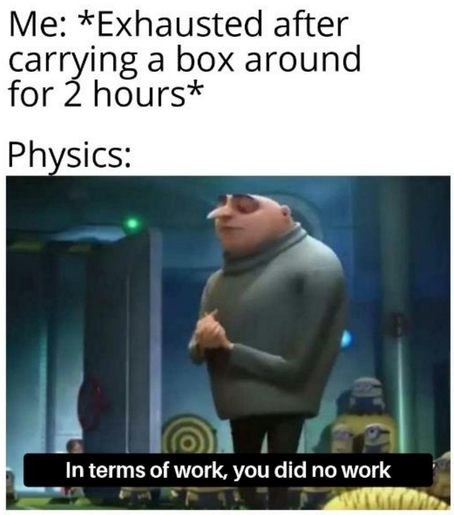
In our daily life work means any kind of mental and physical activity. But in Physics, the term work has entirely different meaning.

WORK

Definition : *Work is said to be done by a force on a body or an object if the force applied causes a displacement in the body or the object.*

Conditions for work :

1. A force must act on the body
2. The body must be displaced from one position to another position.



Factors on which work done depends :

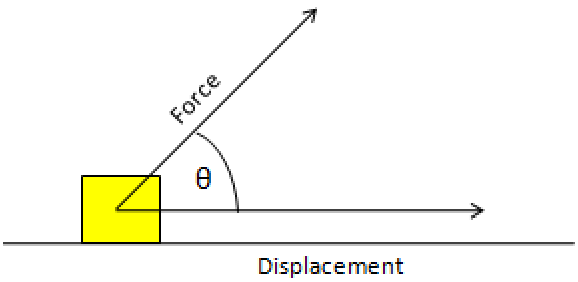
1. The magnitude of the applied force
2. The distance travelled by the body on the application of force (i.e Displacement S)
3. Angle between the force and displacement.

WORK DONE BY A CONSTANT FORCE

Work done is equal to the dot product of constant force and displacement.

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

or $$\boxed{W = F \cos\theta \, S = F\, S \cos\theta}$$



thus, work done on a body by a force is defined as the product of the magnitude of the displacement and the force in the direction of the displacement of the body.

When a constant force is applied in the horizontal direction

$$\boxed{W = F \times S}$$

When work and displacement is on same direction the value of cos θ becomes 1. Therefore work can be written as applied Force multiplied by displacement.

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

POSITIVE and NEGATIVE Work Done

(i) **Positive Work Done** : If $\theta = 0^\circ$ i.e the force (F) acts in the direction of the displacement (S) of the body. Then

$$W = FS \cos 0^\circ = FS$$

Such work done is known as **Positive work done**.

Example :

(a) Work done by the force of gravity on a falling body is positive.

(b) When a coolie lifts a box from the ground.

(c) In tug of war, work done by winning team is positive.

(ii) **Negative Work Done** : If $\theta = 180^\circ$ i.e the force (F) acts in the opposite direction of the displacement (S) of the body. Then

$$W = FS \cos 180^\circ = -FS \left(\because \cos 180^\circ = -1\right)$$

Such work done is known as **Negative work done**.

Example :

(a) Work done by the force of gravity when body is lifed upwards is negative.

(b) Work done on a pulley system of well.

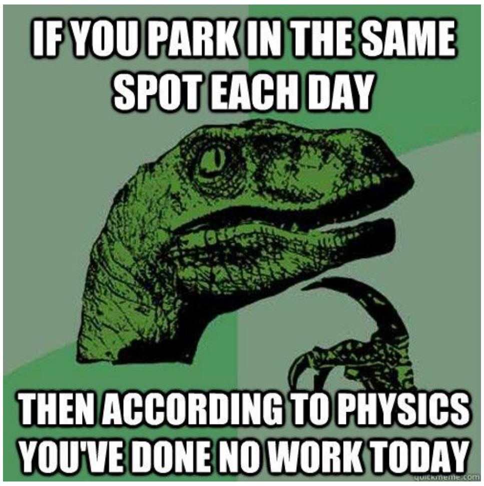
(c) In tug of war, work done by Losing team is negative.

(iii) **No Work Done or Zero Work Done** :

CASE 1 : If $\theta = 90^\circ$ i.e the force (F) acts in the Perpendicular direction of the displacement (S) of the body. Then

$$W = FS \cos 90^\circ = 0 \left(\because \cos 90^\circ = 0\right)$$

Such work done is known as **No work done or Zero Work done**.



CASE 2 : : If S = 0 i.e the displacement (S) of the body is zero. Then

$$W = F.0 = 0$$

Such work done is known as **No work done or Zero Work done**.

CASE 3 : : If the force (F) applied on the body is zero. Then

$$W = 0S = 0$$

Such work done is known as **No work done or Zero Work done**.

Example :

(a) Work done by the centripetal force on a stone moving in a circular path.

(b) Work done by force of gravity on a box lying on the roof of bus.

(c) When a person pushes a wall but fails to move the wall

UNIT OF WORK

S.I Unit – Joule (J) or Nm

Definition of Joule (J) : Work done is said to be 1 joule if newton force acting on a body displaces the body through 1 metre in its own direction.

NUMERICALS

Formula used = W = $F \times S$; **Units :** W in **joules (J),** S in **metre (m),** m in **kg**

Q. A force of 10 N cause a displacement of 2 m in a body in its own direction. Calculate the work done by the force.

Q. A coolie lifts a box of 15 kg from the ground to a height of 2.0m. Calculate the work done by coolie on the box.

Q. A force of 10 N acting on a body at an angle of 60° with the horizontal direction displaces the body through a distance of 2 m along the surface of a floor. Now let the force or pull acting on the body makes an angle of 30° with the horizontal. What is the value of the force to displace the body through 2 m along the surface of the floor so that the work done is 10 J ? (Refer Table for values)

Q. Calculate the work done in pushing a cart through a distance of 50m against the force of friction equal to 1250 N. Also state the type of work done.

	0°	30°	45°	60°	90°	120°	180°
cos θ	1	$\sqrt{3}/2$	$1/\sqrt{2}$	½	0	-½	-1

ENERGY

Definition : *The capacity of doing work by a body or an object is known as the energy of the body or the object.*

UNIT OF ENERGY

S.I Unit – Joule (J) or Nm

FORMS OF ENERGY

The various forms of energy are :

1. Mechanical Energy : *The sum of kinetic and potential energy of a body is known as mechanical energy.*

2. **Heat or Thermal Energy** : *The energy possesed by a body due to its temperature is known as heat or thermal energy.*

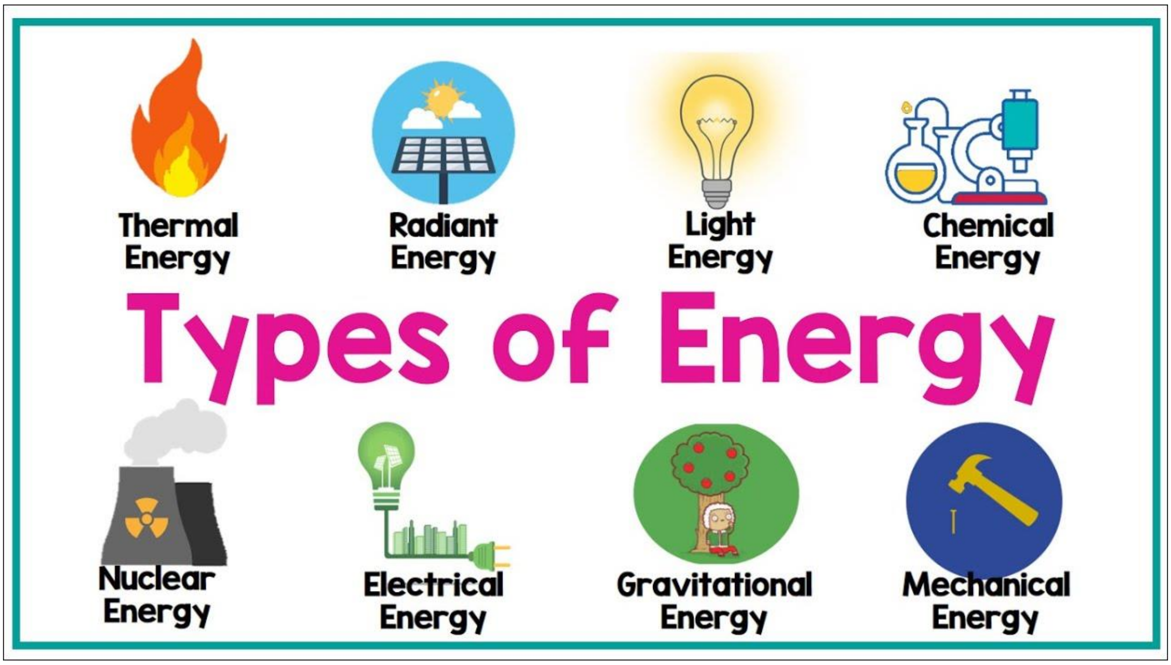
3. Chemical Energy : *The energy released in chemical reactions is known as Chemical energy.*

4. Sound Energy : *The energy of a vibrating body producing sound is known as Sound Energy*

5. Electrical Energy : *The energy of moving electrons in a conductor connected with a battery is known as electrical energy.*

6. Nuclear Energy : *The energy released when two nuclei of light elements combine with each other to form a heavy nucleus or when a heavy nucleus breaks into two light nuclie is known as Nuclear energy.*

7. Solar Energy : *The energy radiated by the sun is known as Solar energy*.



KINETIC ENERGY

Definition : *The energy possessed by a body by a virtue of its motion is known as kinetic energy.*

In other words we can say that, *anything which moves has kinetic energy*

Examples :

(i) A moving bus or car or train has kinetic energy

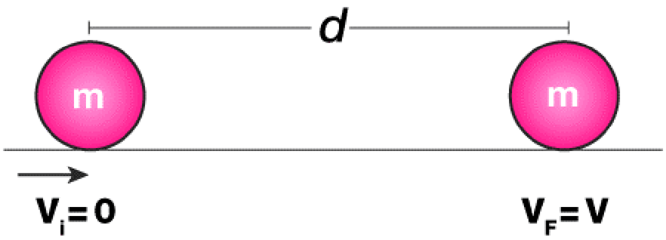
(ii) Moving bullets have kinetic energy

(iii) Flowing water has kinetic energy

(iv) A falling object

EXPRESSION FOR KINETIC ENERGY

Consider a body of mass m lying at rest on a smooth floor. And let force F be applied on the body so that the body attains a velocity v after travelling a distance S.



$$KE = \frac{1}{2} m.v^2$$

KE - Kinetic Energy | m - Mass of object | v - Velocity

Work Done by the force F on the body, W = FS

According to Newton's 2^{nd} law : F = ma

Substituting value of F

$$W = (ma)S$$

Now using, $v^2 - u^2 = 2aS$

We get, $v^2 - 0 = 2aS$

$$S = \frac{v^2}{2a}$$

Substituing Value, $W = ma \times \frac{v^2}{2a}$

This work done is equal to the kinetic energy of the body.

Kinetic Energy, $KE = \frac{1}{2} mv^2$

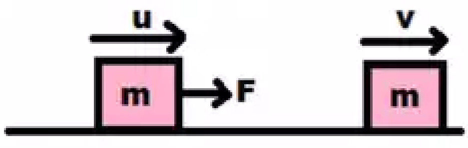
S.I Unit of kinetic energy : **Joule**

K.E of a body is said to be 1 joule, if a body of 1kg mass moves with a speed of $1ms^{-1}$.

WORK ENERGY THEOREM

It states that, " Work done by a force on a body is equal to the change in kinetic energy of the body".

Consider a body of mass m moving with velocity u. And let force F be applied on the body so that the body attains a velocity v after travelling a distance S.



Work Done by the force F on the body, W = FS

According to Newton's 2^{nd} law : F = ma

Substituting value of F

$$W = (ma)S$$

Now using, $v^2 - u^2 = 2aS$

We get, $S = \frac{v^2 - u^2}{2a}$

Substituting Value, $W = ma \times \frac{v^2 - u^2}{2a}$

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

i.e W = Final K.E of body – Initial K.E of body

= Change in K.E of the body

Thus, work done by a force on a body is equal to the change in kinetic energy of the body. This is known as **work-energy theorem**.

RELATION BETWEEN KINETIC ENERGY AND LINEAR MOMENTUM

Kinetic energy, $KE = \frac{1}{2}mv^2$

Dividing and multiplying by m

$$KE = \frac{1}{2}m^2v^2 = KE = \frac{1}{2}(mv)^2$$

Linear momentum , $\rho = mv$

Therefore, $K.E = \frac{\rho^2}{2m}$

NUMERICALS

Formula used : $KE = \frac{1}{2}mv^2$; Work done = change in K.E

Units : W in **joules (J),** S in **metre (m),** m in **kg**

Q. A body of mass 2kg is moving with a speed of $20ms^{-1}$. Find its kinetic energy.

Q. A moving body of mass 30kg has 60 joules of kinetic energy. Calculate its speed.

Q. A force acts on a body of mass 10kg. If the velocity of the body changes from $5ms^{-1}$ to $3ms^{-1}$, then what is the work done by the force on the body.

Q. A bus of mass 10,000kg is moving with a velocity of 60 km h^{-1}. Calculate the work done to stop this bus.

Q. A car and a truck have the same speed of $30ms^{-1}$. If their masses are in the ratio of 1 : 3, find the ratio of their kinetic energy.

Q. A body of mass 5kg initially at rest is subjected to a force of 20N. Find its kinetic energy acquired by the body at the end of 10s.

Q. A force is applied on a car of mass 1500kg, so that its speed increases from 54km/h to 72km/h. Find the work done by the force on the car.

Q. A car and a truck have K.E of 8×10^5 J and 9×10^5 J respectively. If they are brought to halt at the same distance, find the ratio of forces applied to both the vehicles.

Q. Calculate the K.E of body of mass 50kg moving with 5 ms^{-1}.

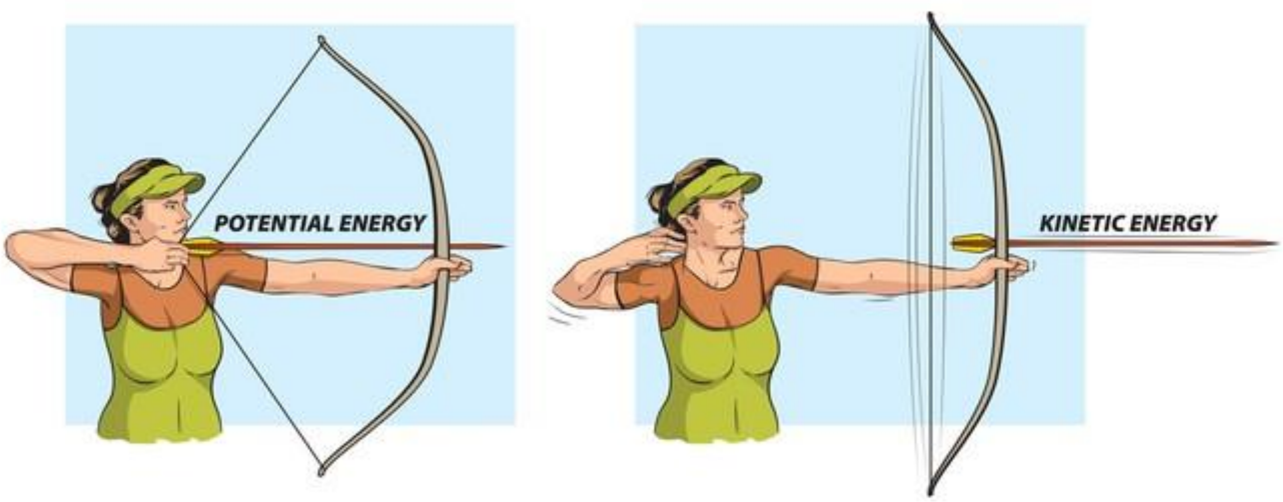
Q. A body of mass 5kg is moving with a velocity $10ms^{-1}$. Find its K.E. Find the ratio of intial K.E and Final K.E if (a) Its mass is doubled (b) its velocity is made three times

POTENTIAL ENERGY

Definition : *The energy possessed by an object by virtue of its position or shape or configuration.*

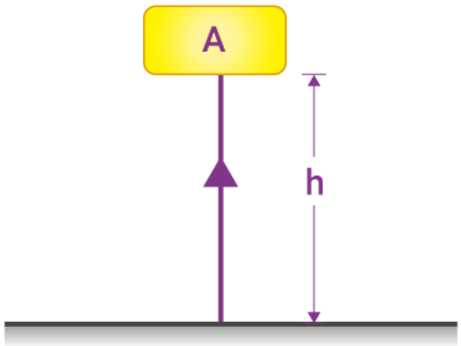
Examples :

(i) Water stored in a dam has potential energy due to its position.
(ii) A stone lying on the top of hill or a mountain has potential energy due to its position.
(iii) A stretched or a compressed spring has potential energy due to its shape.
(iv) A stretched bow and arroe has potential energy.



POTENTIAL ENERGY OF AN OBJECT AT A HEIGHT

The potential energy stored in an object due to its vertical position with respect to the surface of the earth is called gravitational potential energy.



Consider an object of mass m raised to height h against gravity.

Minimum Force required to lift object, F = weight of body.

Therefore, W = mg

Distance travelled, S = h

Work Done, W = FS

W = mgh

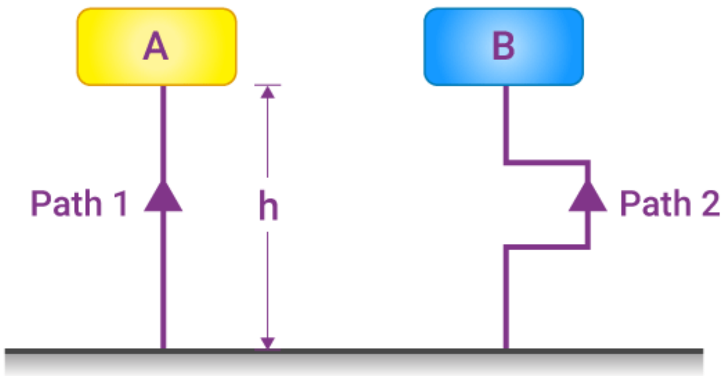
This work done against force of gravity is equal to the potential energy or **gravitational potential energy** of the object.

i.e P.E = mgh

thus, Gravitational Potential Energy of an object depends upon

(i) The weight (mg) of the object and
(ii) The height (h) of the object from the surface of the earth.

S.I Unit : Joule (**J**)



Gravitational potential energy depends upon the difference in heights of the initial position and final position of a body but is independent of the path followed by the body while going from initial position to final position.

NUMERICALS

Formula used : PE = mgh

Units : Joule (J) ; m in kg ; h in m

Q. Calculate the energy possessed by a stone of mass 10g kept at a height of 5m

Q. A bag of wheat weighs 50 kg. Calculate the height to which it should be raised so that its potential energy is 5000 J.

Q. A man whose mass is 70kg climbs from a hill station 'A' to another hill Station 'B'. The height of hill station A is 1200 m above the sea level and that of B is 1800 m above the sea level. Calculate the work done in going from A to B.

Q. A porter lifts a luggage of 15 kg from the ground and puts it on the head 1.7 m above the ground. Find the work done by the porter on the luggage.

Q. An object is dropped from a height of 10m. If the energy of the object reduses by 40% after striking the ground, how much high can the object bounce back?

Q. A 5kg ball is thrown upward with a speed of $10ms^{-1}$

(a) Calculate the maximum height attained by it
(b) Find the P.E when it reaches the highest point

Q. A shot put player throws a shot put of mass 3kg. If it crosses the top of wall of 2m high at a speed of $4ms^{-1}$. Compare the total mechanical energy gained by the shot put when it crosses the wall.

Q. Sarita lives on 3rd floor of buillding at the height of 15m. She carries her school bag weighing 5.2 kg from the ground floor to her house. Find the amonut of work done by her and identify the force against which she had done work.

Transformation of Energy

The process of changing or converting one form of energy to another form is known as **transformation of energy**.

Examples :

(i) A stone on a certain height has entire potential energy. But when it starts moving downward, potential energy of stone goes on decreasing as height goes on decreasing but its kinetic energy goes on increasing as velocity of stone goes on increasing.

At the time stone reaches the ground, potential energy becomes zero and kinetic energy is maximum. Thus, its entire potential energy is transformed into kinetic energy.

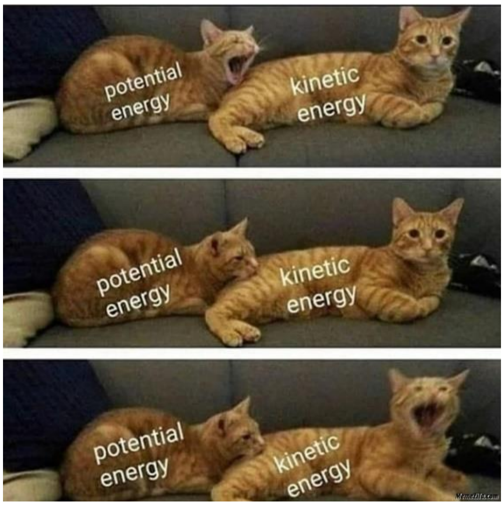
(ii) At hydroelectric power house, the potential energy of water is transformed into kinetic energy and then into electrical energy.

(iii) At thermal power house, chemical energy of coal is changed into heat energy, which is further converted into kinetic energy and electrical energy.

NOTE : The sun is the ultimate source of all forms of energy available on the earth

Device used to Transform Energy from One form to Another

1. Heat engine converts hear energy into mechanical energy
2. A thermal power plant converts chemical energy of the coal into electrical energy
3. Electric generator converts mechanical energy into electrical energy
4. Electric motor converts electrical energy into mechanical energy
5. An electric heater converts electrical energy into heat energy
6. Dry cell converts chemical energy into electrical energy
7. Microphone converts sound energy into electrical energy
8. Photocell converts light energy into electrical energy
9. Lever transforms muscular energy into useful mechanical work or mechanical energy.



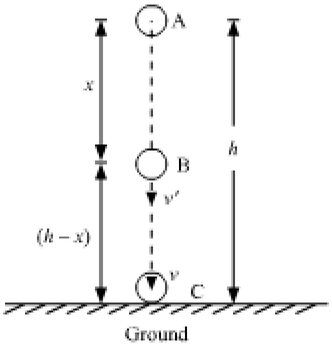
LAWS OF CONSERVATION OF ENERGY

According to this law, " *Energy can neither be created nor be destroyed, but can be changed from one form to another form* "

OR

When one form of energy is changed or transformed into other forms of energy, the total energy of an isolated system remains the same I.e the total energy before transformation = the sum of the different energies transformed.

THE LAW OF CONSERVATION OF ENERGY OF A FREELY FALLING BODY



Consider a body of mass m at a height h above the ground. Suppose this position of the body is A.

At position A

P.E of body = mgh

K. E of body = 0

Total energy (Mecahnical energy) = P.E + K.E = **mgh**

At position B

Total energy = P.E + K.E

$$= mg(h-x) + \frac{1}{2}mv^2$$

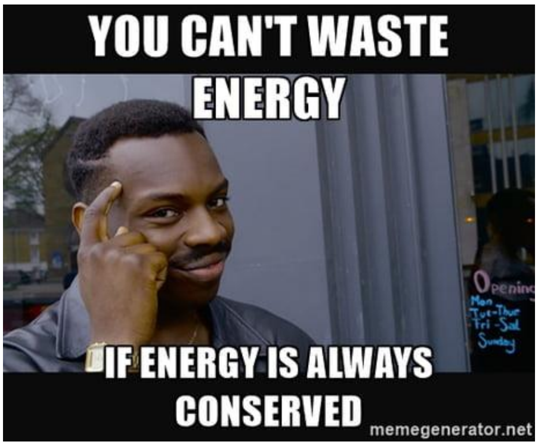
Calculation for V^2

We know, $v^2 - u^2 = 2aS$

Here, $u = 0$

$a = g$ and $S = x$

$V^2 = 2gx$



Putting value

$$= mg(h-x) + \frac{1}{2} m\, 2gx$$

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

$$= mgh - mgx + mgx$$

$$= \mathbf{mgh}$$

At position C

Total energy = P.E + K.E

P.E = 0

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

We know, $v^2 - u^2 = 2aS$

Here, $u = 0$

$a = g$ and $S = h$

$V^2 = 2gh$

Putting value

$$= 0 + \frac{1}{2} m\, 2gh$$

$$= 0 + mgh$$

$$= \mathbf{mgh}$$

It is clear that the total energy (mechanical energy) of a body at any instant during free fall of the body remains constant.

Hence, law of conservation of energy is verified.

POWER

Definition : Power is defined as the rate of doing work

$$P = \frac{Work\ done}{time} = \frac{W}{t}$$

Since total Work done = Energy Supplied

$$P = \frac{Energy\ Supplied}{time} = \frac{E}{t}$$

UNITS OF POWER

S.I Unit of power = watt (W)

Power of a machine or an agent is 1 watt if it dows 1 joule work in 1 second.

Practical Unit of Power

The power of machines (like engines of a scooter or a car or a bus) is usually expressed in horse power (h.p)

1 h.p = 746 W

Bigger Units of Power

1 kilowatt (1kW) = 1000 = 10^3 W

1 megawatt (MW) = 10^6 W

1 gigawatt (GW) 10^9 W

Comercial Unit of power

KiloWatt-Hour (kWh)

A kilowatt-hour is the amount of electric energy used by 1000 watt electric appliance when it operates for one hour

kWh is also known as **Board of Trade Unit (B.O.T)**

Relation between kWh and Joule

1 kWh = 3.6 × 10^6 J

POWER IN TERMS OF FORCE AND VELOCITY

P = $\frac{W}{t}$ But W = FS

P = $\frac{F \times S}{t} = F\frac{S}{t} = Fv$

Thus, power of an agent is also defined as the product of force applied and the velocity of the body.

NUMERICALS

Formula used : P = $\frac{W}{t} = \frac{E}{t} = Fv$

Q. A machine does 1920 joule of work in 240 seconds. What is the power of the machine

Q. A 150 kg car engine develops 500 W for each kg. What force does it exerts in moving the car at a speed of 20 ms^{-1} ?

Q. An athlete weighing 60 kg runs up a staircase having 10 steps each of 0.5 m in 30s. Calculate his power.

Q. An engine develops 10kW of power. How much time will it take to lift a mass of 200kg to a height of 40m ?

Q. How much water per minute the pump of power 2kW can raise to a height of 10m ?

Q. A force of 10 N moves a body with a constant velocity of 2 ms^{-1}. Calculate the power of the body.

Q. Water falls on the blades of turbine from a height of 50m. 100kg water pours on the blades in 1s. Assuming whole energy to be transferred, what is the power developed to the turbines?

Q. Two children say A and B each weigh 20kg climb a rope upto the height of 10m. The child A takes 10s and child B takes 20s to climb. (i) State whether the work performed by both the children is equal or different. (ii) out of these two children, who have more power ? Compare their power

Q. Man whose mass is 50 kg moves up 15 steps each of height 15cm in 45 seconds of time. Calculate the power used in climbing those stairs.

Q. Calculate the electrical energy consumed in joule if a toaster of 60W is used for 30 minutes.

Q. Four electric heaters of power 500 W each are switched on in a building. Calculate the energy in kWh consumed in 10 hours by these heaters.

Q. If an electic iron of 1200 W is used for 30 minutes everyday, find electric energy consumed in the month of April

Q. Calculate the electricity bill amount for a month of April, if 4 bulbs of 40 W for 5hrs, 4 tube lights of 60W for 5hrs, a T.V of 100W for 6hrs, a washing machine of 400W for 3 hrs are used per day. The cost per unit is Rs 1.80

Q. A geyser of 2.5 kW is used for 8 hours daily. Calculate the monthly consumption (30 days) of electrical energy unit. Also calculate the cost of electricity per unit consumed if rate per unit is Rs 3.50

Q. An electric bulb of 60W is used for 6 hr per day. Calculate the 'units' of energy consumed in one day by the bulb.

Important NCERT Questions

Q1. Write an expression for the kinetic energy of an object.

Sol. If a body of mass m is moving with a speed v, then its K. E. E_k is given by the expression,

$E_k = ½ m v^2$

Its SI unit is Joule (J).

Q2. What is the kinetic energy of an object?

Sol. The energy possessed by a body by the virtue of its motion is termed mechanical energy or kinetic energy. Every moving object possesses mechanical energy. A body uses mechanical energy to try to work. Kinetic energy of the hammer is employed in driving a nail into a log of wood, mechanical energy of air is employed to run wind mills, etc.

Q3. An object thrown at a certain angle to the ground moves in a curved path and falls back to the ground. The initial and the final points of the path of the object lie on the same horizontal line. What is the work done by the force of gravity on the object?

Sol. Work done by the force of gravity on an object depends solely on vertical displacement. Vertical displacement is given by the distinction in the initial and final positions/ heights of the object which is zero.

Work done by the gravity is given by the expression,

$W = m \times g \times h$

Where,

h = Vertical displacement = 0

$W = mg \times 0 = 0$ J

Hence, the work done by the gravity on the given object is zero joule.

Q4. Certain force acting on a 20 kg mass changes its velocity from 5 m S^{-1}. to 2 m S^{-1}. Calculate the work done by the force.

Sol. Given

Initial velocity u = 5 m/s

Mass of the body = 20 kg

Final velocity v = 2 m/s

The initial kinetic energy

$E_i = (1/2)mu^2 = (1/2)\times 20\times(5)^2$

= 10 × 25

= 250 J

Final kinetic energy

$E_f = (1/2)mv^2 = (1/2) \times 20 \times (2)^2$

= 10 × 4

= 40 J

Therefore,

Work done = Change in kinetic energy

Work done = $E_f - E_i$

Work done = 40 J – 250 J

Work done = – 210 J

Q5. A mass of 10 kg is at a point A on a table. It is moved to a point B. If the line joining A and B is horizontal, what is the work done on the object by the gravitational force? Explain your answer.

Sol. Work done by gravity depends solely on the vertical displacement of the body. It doesn't rely on the train of the body. Therefore, work done by gravity is given by the expression,

W = m g h

Where,

Vertical displacement, h = 0

$\therefore W = m \times g \times \text{zero} = 0$

Therefore the work done on the object by gravity is zero.

Q6. A certain household has consumed 250 units of energy during a month. How much energy is this in joules?

Sol. 1 unit of energy = 1 kWh

Given

Energy (E) = 250 units

1 unit = 1 kWh

1 kWh = 3.6×10^6 J

Therefore, 250 units of energy = $250 \times 3.6 \times 10^6$

= 9×10^8 J.

Q7. Calculate the work required to be done to stop a car of 1500 kg moving at a velocity of 60 km/h?

Sol. Given data :

The mass of the body = 1500 kg

Velocity v = 60 km/hr

$$= \frac{60 \times 1000\text{m}}{3600\text{s}}$$

$$= \frac{50}{3}\text{m/s}$$

The work required to stop the moving car = change in kinetic energy

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

$$= \frac{1}{2} \times 1500 \times \left(\frac{50}{3}\right)^2$$

= 208333.3 J

Q8. Find the energy in kW h consumed in 10 hours by four devices of power 500 W each.

Sol. Given

Power rating of the device (P) = 500 W = 0.50 kW

Time for which the device runs (T) = 10 h

Energy consumed by an electric device can be obtained by the expression

Power = Energy consumed / Time taken

Energy consumed = 0.50 × 10

Energy consumed = 5 kWh

Thus, the energy consumed by four equal rating devices in 10 h will be

$\Rightarrow$ 4 × 5 kWh

= 20 kWh

Q9. An electric heater is rated 1500 W. How much energy does it use in 10 hours?

Sol. Given Power of the heater = 1500 W = 1.5 kW

Time taken = 10 hours

Energy consumed by an electric heater can be obtained with the help of the expression

Power = Energy consumed / Time taken

Hence,

Energy consumed = power × Time taken

Energy consumed = 1.5 × 10

Energy consumed = 15 kWh

Q10. Does the transfer of energy take place when you push a huge rock with all your might and fail to move it? where is the energy you spend going?

Sol. When we push a huge rock, there's no transfer of muscular energy to the stationary rock. Also, there's no loss of energy since muscular energy is transferred into heat energy, which causes our body to become hot.

Ab Phod Do!

This Chapter Ends here !! But not your work

Go to Practice Questions, Solve Dpps attend MCQs and revise the notes after some 2nd 4th and 7th day

To get 95+ you have to keep on revising what you studied.

[Remember Consistency and HardWork Gives Great Result]

NOTES MADE BY

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WORK POWER AND ENERGY

CLASS -9 (CBSE)

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