APPLIED ELECTRICITY

WORK, ENERGY AND POWER (I)

Lecture#01

(Basic Physics Book)

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WORK

In Physics, work is said to be done when a force produces displacement in a body. It means work is said to be done when a force acts on a body and eventually makes it able to cover some distance in the direction of the force. Thus;

"The product of force and distance covered in the direction of force is equal to the work done"

WORK

Suppose a force F is acting on a body. It makes the body to move from point 'A' to 'B'. If the distance between these two points is 'S', then we say that force has done some work.

For work, the following two conditions must be fulfilled:

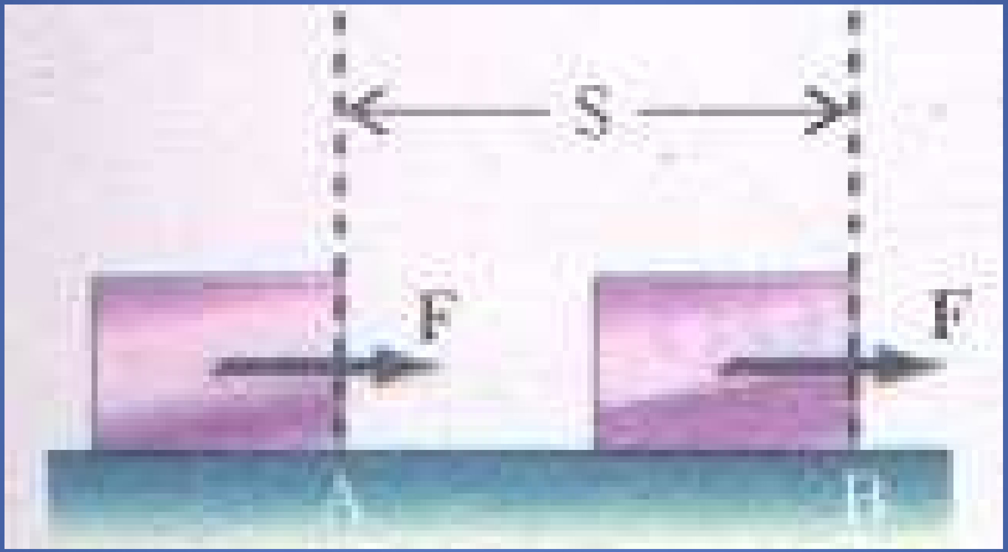
1. A force should act on a body.
2. The body should cover some distance under the action of this force.

If *'W'* stands for work, *'F'* for force and 'S' for distance, then

Work = Force x Displacement

$$W = FS$$

WORK



Power

Commonly, we use electric motor on tube wells to draw water. A bigger motor draws more water as compared to the smaller motor in the same time. We say that power of the bigger motor is greater than the smaller motor. Similarly, consider an example from everyday life.

If two boys of equal weights start climbing up a mountain through similar path simultaneously, the boy who reaches the top of the mountain earlier has greater power than the other boy.

Power can be expressed as:

“Rate of doing work with respect to time”

Power

Thus,

Power = Work / Time

If we represent power by *'P'*, work by *'W'* and time by 't' then

$$P = W / t$$

Power

Units of Power

In System International(SI), the unit of power is watt (W).

It is defined as:

"If a body does a work of one joule in one second then its power will be one watt"

To express power, we can also use bigger units of watt.

For example, kilowatt and megawatt etc.

$$1\ kW = 1000\ W = 10^3 W$$

$$1\ MW = 1000000\ W = 10^6\ W$$

Energy

Energy is a common word in our daily life. We spend energy to provide any facility. It means we need energy to do any type of work, for example, to cook food, to keep our homes warm, to run machines in the factories, to drive a car, an aero plane, a train, to play any game, for example hockey, football, cricket, we need energy.

Thus;

“The ability of a body to do work is called energy”

Energy

When any person is doing work, then he spends energy and his total energy starts decreasing.

The energy lost by the person during the work is transferred to the thing on which work is being done.

Thus during work, energy is transferred from one body to another.

Energy

A body having more energy has ability to do more work. For example, if you have energy you can play hockey, can lift heavy stone and can run fast.

Hence, our all activities depend upon energy.

Energy

Similar to work, energy is also a scalar quantity, its unit is also a joule. There are two basic kinds of energy.

(i) Kinetic Energy (K.E.)

(ii) Potential Energy (P.E.)

These appear in the following different forms:

Chemical, Electrical, Heat, Sound, Light, Nuclear, Gravitational potential energy, Elastic potential energy etc.

Energy

Kinetic Energy

“The energy possessed by a body by virtue of its motion is called kinetic energy”

For example, to stop a moving body, an opposite force has to be applied. Due to which the body comes to rest after covering some distance. It means work is done on the body which is equal to its kinetic energy.

Energy

Kinetic Energy

Let a body of mass m is moving with velocity *v*. An opposing force *F* acting through a distance S brings it to rest. Thus, according to the equation of motion

$$2aS = Vf^2 - Vi^2$$

Since

$$V_i = V, \qquad V_f = 0 \quad and\ a = \frac{F}{m}$$

Hence $$-2 \times \frac{F}{m} \times S = (0)^2 - (V)^2$$

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

Energy

Kinetic Energy

Here *FS* indicates the magnitude of work which has been done by the body against the opposing force. This work is equal to kinetic energy. Thus,

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

Kinetic energy of a moving body can be found with the help of this equation. .

Energy

Potential Energy

We know that kinetic energy indicates the ability of a body to do work due to the motion of any body. Now we will come to know about the kind of energy, which indicates the ability of a body to do work due to its position. Thus

Ability of a body to do work due to its position is called potential energy

Energy

Potential Energy

A metallic ball lying on the surface of the Earth has potential energy equal to zero relative to Earth s surface but if this ball is lifted to a height *h*, then due to its new position, it has the ability to do work.

Similarly the potential energy of water stored in a dam is due to its height.

Energy

Potential Energy

There are many kinds of potential energy. The potential energy in the examples given above is due to the force of attraction of the Earth.

Therefore, it is also called gravitational potential energy. The potential energy in the spring of a watch is called elastic potential energy and the potential energy in the chemicals of the battery of a car is called chemical potential energy.

Energy

Elastic Potential Energy

When a spring is compressed, we have to do work against its elasticity, which is stored in it in the form of potential energy. As the spring is released, at once it tries to come in its original shape. In this way it has the ability to do work due to the potential energy stored in it. This potential energy is called elastic potential energy.

This energy is produced due to the change in the shape of the spring. A good example of elastic potential energy is the energy stored in the spring of a wrist watch or a clock due to which the arms of the wrist watch get necessary kinetic energy for their movement.

Energy

Gravitational Potential Energy

“The ability of a body to do work due to its specific height from the surface of the Earth is called gravitational potential energy”

Energy

Gravitational Potential Energy

Suppose a ball of mass *'m'* is lifted from the surface of the Earth to a height *'h'* we have to do work against gravity to lift this ball up. To find the magnitude of the work done, force 'F' and distance covered 'S' should be known.

The force *'F'* applied on the ball to lift it up with uniform velocity is equal to the weight *'mg'* of the ball but is opposite in direction.

Energy

Gravitational Potential Energy

Weight of the ball = Force

$$F = w = mg$$

Distance covered = S = h

Since;

Work = Force x Distance covered

$$W = mg \times h$$

Energy

Gravitational Potential Energy

The work done on the ball to lift it to a height *'h'* is stored in it in the form of energy. Thus

$$\textbf{Gravitational Potential Energy} = mgh$$

Hence the gravitational potential energy of a body of mass 'm' at a height *'h' from* the surface of the Earth is equal to *mgh*.

Inter-conversion of K.E. and P.E.

All around us we observe physical processes in which energy is continuously being transferred from one form into another form.

Suppose that a ball of mass 0.25 kg is lifted to position A at height 10m from the surface of the Earth, see Figure below. As the ball is at rest at this position, so its velocity will be zero. Due to this its kinetic energy will also be zero and its whole energy will be potential energy.

Interconversion of K.E. and P.E.

Thus at position 'A'

$$P.E. = mgh$$

$$P.E. = 0.25\ kg \times 10\ ms^{-2} \times 10\ m$$

$$P.E. = 25\ kgm^{2}s^{-2} = 25J$$

Inter-conversion of K.E. and P.E.

Now drop the ball from this height. W hen the ball will strike the ground, its potential energy will be zero because its height from the Earth will be zero. But with the help of the third equation of motion we can find the final velocity of the ball with which it will strike the ground. It means $V_i = 0$; $V_f = ?$

$$S = h = 10m \quad ; \quad a = g = 10ms^{-2}$$

Putting the values in the third equation of motion

$$V_f^2 - V_i^2 = 2aS$$

$$V_f^2 - 0 = 2 \times 10\, ms^{-2} \times 10m$$

$$V_f = \sqrt{200} ms^{-1}$$

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

$$K.E = \frac{1}{2} \times 0.25kg \times 200m^2 s^2$$

$$K.E = 25kgm^2 s^{-2} = 25J$$

Inter-conversion of K.E. and P.E.

Thus potential energy of the ball at the point 'A' is equal to the kinetic energy of the ball at the point 'B’. It means

P.E. at point 'A' = K.E. at point 'B‘

provided that the air friction is ignored. Thus, we can say that inter-conversion of energy is possible. It means

One form of energy can be converted into another form of energy. The decrease in one form of energy results in the increase of other form of energy.

Inter-conversion of K.E. and P.E.

It can be expressed as

Increase in K.E. = Decrease in P.E.

Similarly, if the ball is thrown upward with any velocity, then due to decrease in the velocity of the ball there is a decrease in K.E. but with the increase in height, P.E. will increase.

Therefore, we can say that

Increase in P.E. = Decrease in K.E.

LAW OF CONSERVATION OF ENERGY

When a body is dropped from some height, the sum of K.E. and P.E. remains constant at every point, provided, that air friction is ignored. At the highest point whole of the energy is P. E. and just before hitting the ground the whole of the energy is K.E. It means the whole K.E. is converted into P.E. at the top and the whole P.E. is converted into K.E. at the bottom. From this, we conclude that

Energy can be converted from one form to another but total energy of the body remains constant. This is called the law of conservation of energy.

This law is found correct for all forms of energy.