**How is WORK defined?**
In scientific terms work is defined as follows:

Work is done when a force acting on a body produces displacement in it. Work is said to have been done by the agent applying this force. For example, when a boy kicks a football to move it, the boy is said to have done some work.

When the displacement of a body takes place in the direction of the force, the work is said to be done by the force on the body.

When the displacement of the body takes place in the direction opposite to the direction of the force, the work is said to be done by the body against the force.

**Work is a scalar quantity. The SI unit of work is joule.** ( denoted as **j**).

**On what factors does the amount of work done depend?**

The amount of work done depends upon the following two factors:

(i) Magnitude of the force ( F)

(ii) Displacement of the body(S) in the direction of the force, i.e., the distance through which the body moves (S) in the direction of the force.

**What is meant by Energy?**

Any thing that can do work is said to have energy. The work a body could do is a measure of its energy. A body possessing more energy can do more work. Thus, energy may be defined **as the capacity of the body to do work.**

Thus, the amount of energy possessed by a body is equal to the amount of work it can do when that energy is released. The **SI unit of energy is joule ( J ) .** Quite often, a bigger unit called **Kilojoule ( KJ )** is used.

**Energy is a scalar quantity.**

There are many different forms of energy, such as mechanical energy, magnetic energy, chemical energy, thermal energy, nuclear energy etc.

**What is Mechanical Energy?**

Energy by the virtue of which a body can do some mechanical work directly is called Mechanical Energy. The common forms of mechanical energy are,

(a) Kinetic energy (b) Potential energy.

The some of the potential and kinetic energies of a body is called its mechanical energy.

Mechanical energy = Kinetic energy + Potential energy

**How is Kinetic Energy defined?**

**The energy possessed by a body by virtue of its motion is called kinetic energy.** So, a moving can do some work due to its kinetic energy. Certain examples of the bodies having Kinetic energy are,

(i ) A high speed bullet, a fast moving cricket ball , a stone thrown with a high speed.

(ii) Flowing Wind, and flowing water.

**How is Kinetic Energy of a body expressed?**

The total amount of work which a moving body could do before coming to rest is equal ti its kinetic energy. So, the kinetic energy of a moving body can be determined by measuring the total work it could do before coming to rest.

**Derivation of the formula for Kinetic Energy.**

Let us consider a body of mass *m* moving with a velocity *v*. If this body moves against an opposing force ***F,*** then its velocity decreases gradually. Let the body come to rest after covering a distance ***S.*** Then, Total work done by the body =***F X S***

But, the total work done by a moving body before coming to rest is equal to its kinetic energy.

So, Kinetic Energy of the body = ***F X S***

For the body, we have

Initial velocity = ***v***

Final Velocity = O

Acceleration = - a

(Therefore the body is under retardation)

Distance traveled = ***S***

Using the equation,

(Final velocity)$^2$ – ( Initial velocity )$^2$ = 2 X Acceleration X Distance traveled

$$O - v^2 = 2 \text{ X } (-a) \text{ X } S$$

$$v^2 = 2 a S$$

Or

$$a = v^2 / 2 S \qquad (5.10)$$

According to Newton's Second Law of Motion, the retarding force is given by

$$F = \text{Mass X Acceleration} = ma \qquad (5.11)$$

Where "*a*" is the acceleration of the body.

From Eq. 5.11, one can write

$$a = F/ M \qquad (5.12)$$

Substituting the value of "a" from Eq. 5.12 into Eq. 5.10

$$F / M = v^2 / 2 S$$

0r $$F S = 1 / 2 \; mv^2 \qquad (5.13)$$

But,

F X S = work done by the body

So,

Work done by the body = 1 / 2 $mv^2$

The kinetic energy of the body when it is in motion is equal to the amount of work done by it. Therefore,

Kinetic energy of the body = 1 / 2 $mv^2$

Thus, the Kinetic Energy (K.E.) of a body having mass *m* and velocity *v* is equal to 1 / 2 $mv^2$. One can then write,

K.E. = 1 / 2 $mv^2$

**What is Potential Energy?**

Potential Energy is defined as follows:

Energy possessed by a body by virtue of its position (e.g., height above the ground) or configuration (e.g., Shape) is called potential energy.

The Potential Energy of a body by virtue of its height above ground level is called gravitational potential energy. For example, the energy stored in a body held at a certain height from the ground is gravitational potential energy. Potential Energy is abbreviated as P.E. Potential energy is denoted by the letter ***U*** or by ***E***.

Some examples of the bodies having Potential Energy are given below:

(i) Water stored in a overhead tank possess gravitational potential energy by virtue of its position (height above ground level).
(ii) The coiled spring of a watch/ clock possesses elastic potential energy by virtue of its configuration.
(iii) A compressed/ stretched spring possesses elastic potential energy by virtue of its configuration.
(iv) A raised hammer possesses gravitational potential energy by virtue of its height above the ground level.

**Derivation of the formula for Gravitational Potential Energy.**

The gravitational potential energy of a body can be calculated by the following method.
The gravitational potential energy of a body at a certain height from the ground is equal to the amount of work done by it while falling to the ground from that height.

So, the gravitational potential energy of a body can be obtained by calculating the work done by the body while falling to the ground under gravity. This is done as follows.

Let a body of mass '*m*' be placed at a height '*h*' above the ground .
If $g$ is the acceleration due to gravity, then

Force acting on the body due to gravity = $m \times g$

The body falls vertically downwards in the direction of the force.

So, Displacement = $h$

Then, Work done by the body = Force $\times$ Displacement

Or $W = mg \times h = m\,g\,h$

Since the gravitational potential energy of a body at a certain height is equal to the work done by it while falling through this height, hence
Gravitational Potential Energy of the body at height $h = mgh$
Or P.E. of the body at height $h = mgh$
Where, $m$ is the mass of the body, $g$ is the acceleration due to gravity, $h$ is the height of the body above the ground.

**What is the unit of Potential Energy?**

The potential energy of a body of mass $m$ held at a height $h$ from the ground is given by,

Potential Energy $= m \times g \times h = mgh$

Thus the unit of potential energy depends upon the units of $m$, $g$ and $h$.

In SI units,

$M$ is expressed in Kg
$G$ is expressed in m/s$^2$
And $h$ is expressed in m
So,

SI unit of Potential Energy = 1 Kg $\times$ 1 m/s$^2$ $\times$ 1m
= 1 N $\times$ 1 m = 1 J

So, the SI unit of Potential Energy in Newton – meter or joule (J).
The SI unit of work is also Newton – meter or joule. So, work and energy both have the same unit

**What is meant by Power?**

Power in science is defined as follows:

The rate of doing work is called power. Thus,

Power (P) = Total work done (W) / Time taken (t)

or P = W/ t

Power may also be defined as the amount of work done in one unit of time. Power is a scalar quantity.

**What are the units of Power?**

By definition,

Power = Work done / Time taken

Therefore, the unit of power depends upon the units of work done, and of the time taken. The SI unit of work done is Joule ( J), While that of time is second (s). So, SI unit of power = SI unit of work / SI unit of time = 1 Joule (J)/ 1 Second (s) = 1 J /s or 1 J $s^{-1}$. The unit of 1J / s is called watt (W). So the SI unit of power is watt (W).

Or, 1 W = 1 J /s

Thus, when a body works at the rate of 1 J per second, then its power is 1 watt, (W)
Generally, a bigger unit called kilowatt (kW) is used.

1 kilowatt = 1000 watt

or, 1 kW = 1000 W

Then unit of power in the British Engineering System is horse power, denoted by hp.

1 hp = 764 W = 0.746

**Transformation and conservation of energy.**

Energy is available in several forms. We get energy from the chemical energy of food. Cars run on the chemical energy of petrol/ diesel. Flying birds and moving people have energy by virtue of their motion, called *kinetic energy*.

A stretched bow and the stretched elastic in a catapult both have stored energy called *potential energy.*

*Electrical* and *nuclear energies* are some other forms of energy. Light energy is another wonderful form of energy.

These various forms of energy can be converted from one form to another.

**The change of one form of energy into another is known as the transformation of energy.**

The following are some typical examples of the transformation of energy.

(i) The chemical energy of the fire work is converted into thermal energy (heat) and light and sound energies when it explodes.

(ii) The potential energy of the stretched elastic of a catapult gets converted in to the kinetic energy of the pellet released fro the catapult.

**What is meant by law of conservation of energy?**

The law of conservation of energy may be stated as any one of the following statements.

*Statement 1.* **Energy can be transformed from one form to another but the total amount of all the energies remains the same.**

*Statement 2.* **Energy can neither be created nor destroyed but can be transformed from one form to another.** For example, when a body falls from a certain height, its potential energy gradually changes into kinetic energy but the total sum of both the energies remains the same

*Statement 3.* **Whenever one form of energy disappears, an equivalent amount of energy in another form appears.** For example, when coal is burnt in steam engine, the chemical energy of coal disappears and an equivalent amount of heat and light energies are obtained.

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