WORK, POWER AND ENERGY

INTRODUCTION AND DEFINITION OF WORK

Work, Energy and Power are fundamental concepts of Physics. Work is said to be done when a force (push or pull) applied to an object causes a displacement of the object. We define the capacity to do the work as energy. Power is the work done per unit of time. This article discusses work, energy and power in detail.

Defining Work

The scientific definition of work is different in many ways from its everyday meaning. The definition of work in physics reveals its relationship to energy – whenever work is done, energy is transferred.

For a work to be done, in a scientific sense, a force must be exerted, and there must be displacement in the direction of the force. With this said, we can say that

Work is the product of the component of the force in the direction of the displacement and the magnitude of this displacement.

WORK

For work to be done, a force must be exerted and there must be motion or displacement in the direction of the force. The work done by a force acting on an object is equal to the magnitude of the force multiplied by the distance moved in the direction of the force. Work has only magnitude and no direction. Hence, work is a scalar quantity.

Formula of Work

The work done by a force is defined to be the product of the component of the force in the direction of the displacement and the magnitude of this displacement.

$$W = F\cos\ \Theta = \vec{F}\vec{d}$$

Where W is the work done, F is the force, d is the displacement, θ is the angle between force and displacement and F cosθ is the component of force in the direction of displacement.

We understand from the work equation that if there is no displacement, there is no work done, irrespective of how large the force is. To summarize, we can say that no work is done if:

the displacement is zero

the force is zero

the force and displacement are mutually perpendicular to each other.

Unit of Work

The SI unit of work is Joule (J). For example, if a force of 5 newtons is applied to an object and moves 2 meters, the work done will be 10 newton-meter or 10 Joule. It should be noted that $1\ J = 1\ N \cdot m = 1\ kg \cdot m^2/s^2$.

Example of Work

An object is horizontally dragged across the surface by a 100 N force acting parallel to the surface. Find out the amount of work done by the force in moving the object through a distance of 8 m.

Solution:

Given:

$F = 100\ N, d = 8\ m$

Since F and d are in the same direction, $\theta = 0$, [θ is the angle of the force to the direction of movement], therefore

$W = FdCos\ \theta$

$W = 100 \times 8 \times Cos\ 0$

$W = 800\ J$ [Since $Cos\ 0 = 1$]

Energy

Energy is the ability to perform work. Energy can neither be created nor destroyed, and it can only be transformed from one form to another. The unit of Energy is the same as of Work, i.e. Joules. Energy is found in many things, and thus there are different types of energy.

All forms of energy are either kinetic or potential. The energy in motion is known as Kinetic Energy, whereas Potential Energy is the energy stored in an object and is measured by the amount of work done.

Types of Energy

Some other types of energy are given below:

- Mechanical energy
- Mechanical wave energy
- Chemical energy
- Electric energy
- Magnetic energy
- Radiant energy
- Nuclear energy
- Ionization energy
- Elastic energy
- Gravitational energy
- Thermal energy
- Heat Energy
- Unit of Energy

The SI unit of energy is Joules (J), named in honour of James Prescott Joule.

Power

Power is a physical concept with several different meanings, depending on the context and the available information. We can define power as the rate of doing work, and it is the amount of energy consumed per unit of time.

Formula of Power

As discussed, power is the rate of doing work. Therefore, it can be calculated by dividing work done by time. The formula for power is given below.

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

Where, P is the power, W is the work done and t is the time taken.

Unit of Power

As power doesn't have any direction, it is a scalar quantity. The SI unit of power is Joules per Second (J/s), which is termed as Watt. Watt can be defined as the power needed to do one joule of work in one second. The unit Watt is dedicated in honour of Sir James Watt, the developer of the steam engine.

Example of Power

A garage hoist lifts a truck up 2 meters above the ground in 15 seconds. Find the power delivered to the truck. [Given: 1000 kg as the mass of the truck]

First we need to calculate the work done, which requires the force necessary to lift the truck against gravity:

$F = mg = 1000 \times 9.81 = 9810$ N.

$W = Fd = 9810N \times 2m = 19620$ Nm $= 19620$ J.

The power is $P = W/t = 19620J / 15s = 1308$ J/s $= 1308$ W.