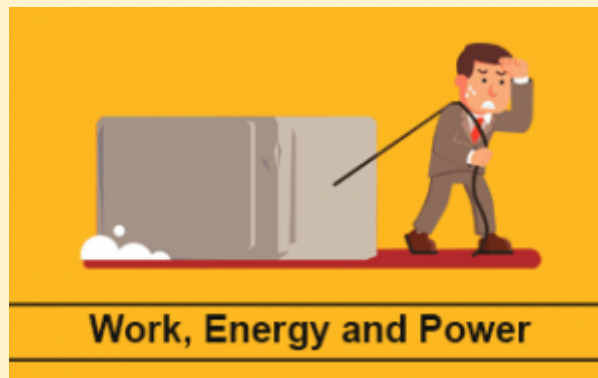


Chapter-11 : Work and Energy

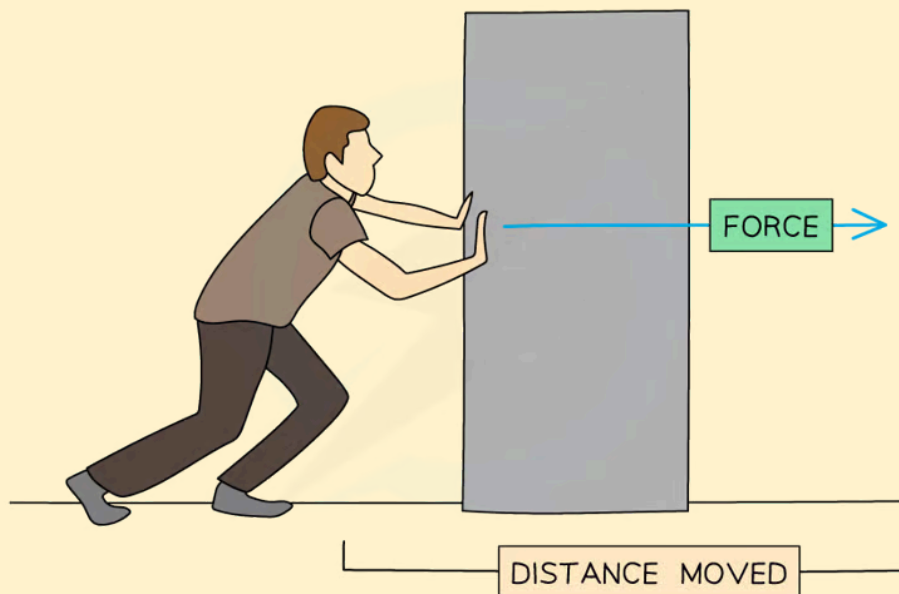


Work : Work is said to be done when a force acts on an object and the object is displaced in the direction of force.

- The work done on an object is the product of the force applied and the displacement.

Work done = Force x displacement

$$W = F \times S$$



- The unit of work is joule (J).
- If F is 1 N and displacement is 1 metre then the work done is 1 Nm or 1 joule (J).
- So, 1 joule is the amount of work done when a force of 1 N displaces an object by 1 metre. E.g.- If a force of 5 N acts on

an object is displaced through 2 m in the direction of force then work done is $5 \text{ N} \times 2 \text{ m} = 10 \text{ Nm}$ or 10 J .

- The work done by a force may be positive or negative.
- The work done by a force is positive if the force and displacement are in the same direction.
- The work done by a force is negative if the force and displacement are in opposite directions. E.g.- When we lift an object the object moves upward in the direction of force. Here the work done is positive. But there is the force of gravity acting downward on the object. The work done by the force of gravity is negative.
- The work done by a force is zero if there is no displacement.
- The work done by a force is zero if the force is perpendicular to the displacement.

Energy : The energy of an object is its capacity for doing work.



- The unit of energy is the same as that of work that is joule (J).
- 1 joule is the energy required to do 1 joule of work.

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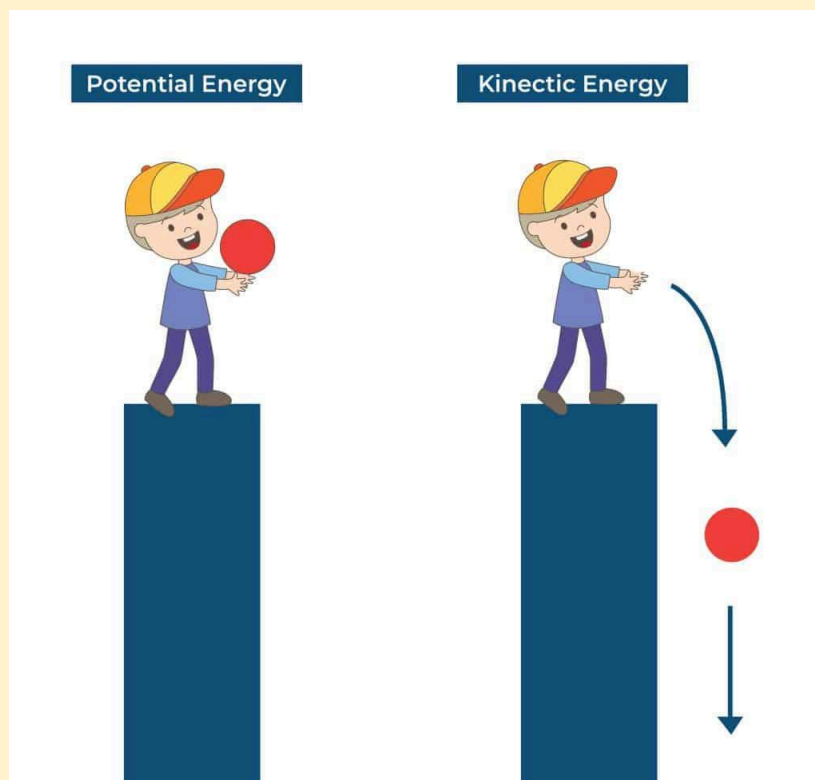
1000 J = 1 kilo joule (kJ).

- There are different forms of energy. They are heat energy, light energy, electrical energy, chemical energy, mechanical energy (potential energy + kinetic energy) etc.

Kinetic energy : The kinetic energy of an object is the energy possessed by the object due to its motion.

- All moving objects possess kinetic energy. A falling coconut, a speeding car, a flying aircraft, flowing water, blowing wind, a running athlete etc. possess kinetic energy.
- The kinetic energy of an object depends upon its speed. An object moving faster has more kinetic energy than an object moving slower.
- The kinetic energy possessed by an object of mass m and moving with uniform velocity v is

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



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Potential energy : The potential energy of an object is the energy possessed by the object due to its position or shape.

E.g.-

- If a rubber band is stretched and then released it regains its original position. When the rubber band is stretched, energy is transferred to it and stored as potential energy.
- If we wind the key of a toy car and place it on the ground it moves. When we wind the key of the car, energy is transferred to the spring inside and stored as potential energy.
- If we lift an object to a height and release it, it falls down. When the object is lifted energy is transferred to it and stored as potential energy.

Potential energy of an object at a height : When an object is raised to a height, its energy increases because work is done on it against gravity. The energy present in such an object is called gravitational potential energy.

- If an object of mass m is raised to a height h from the ground, the force required to raise the object is equal to the weight of the object mg .

Work done = Force \times displacement

$$\text{Or, } W = mg \times h$$

$$= mgh$$

- Potential energy gained by the object.

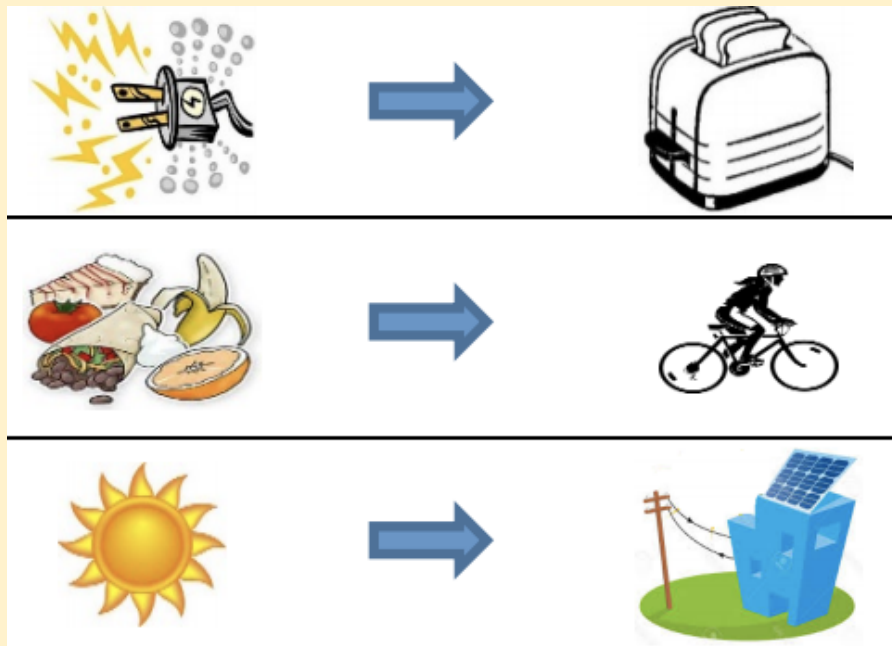
$$E = mgh$$

Transformation of energy : The conversion of energy from one form into another form is called transformation of energy.

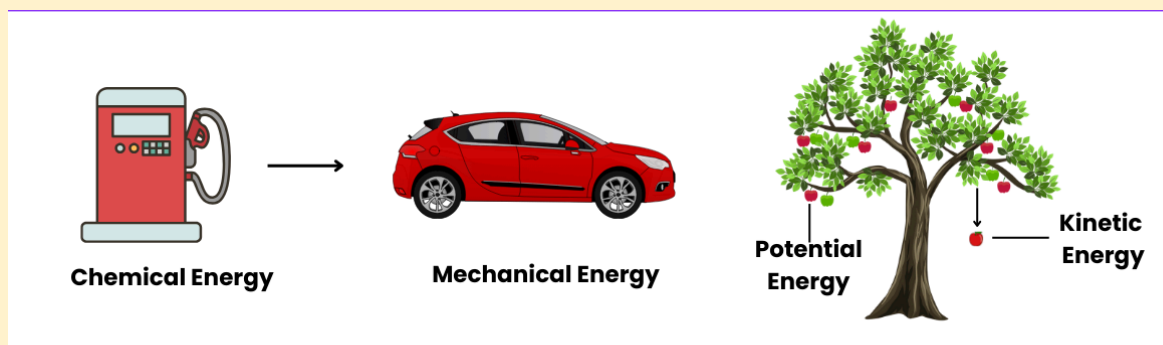
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- When energy is converted from one form into another, the total energy always remains the same.



Law of conservation of energy : The law of conservation of energy states that energy can only be converted from one form into another, it can neither be created nor destroyed i.e. The total energy before and after the transformation remain the same.



- For Example : Let an object be allowed to fall freely from a height. At the start the potential energy is more. As it falls down the potential energy changes into kinetic energy.

The potential energy decreases and the kinetic energy increases. When the object is about to reach the ground the kinetic energy is the largest and the potential energy is the least. But the sum of the potential energy and kinetic energy is the same at all points. So, potential energy + kinetic energy = constant. The sum of the potential energy and kinetic energy is the total mechanical energy.

Power : Power is the rate of doing work.

- If W is the work done in time t , then
- Power = work done / time taken
or, $P = W / t$
- The unit of power is watt (W).
- 1 watt is the power of an agent which does work at the rate of 1 joule per second.
- 1 watt = 1 joule / second or, $1 W = 1 J/s$
 $1 \text{ kilowatt} = 1000 \text{ watts}$
 $1 kW = 1000 W$
 $1 kW = 1000 J/s$

Commercial unit of Energy :

- The commercial unit of energy is kilowatt hour (kWh).
- 1 kilowatt hour is the energy used in one hour at the rate of 1 kilowatt (1000 J/s).
- $1 kWh = 1 kW \times 1 h = 1000 W \times 1 h = 1000 W \times 3600 s = 3600000 J = 3.6 \times 10^6 J$
- The electrical energy used in homes and industries are expressed in kilowatt hour. The electrical energy used during a month is expressed in 'units'. Here, 1 unit means 1 kilowatt hour.

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