ATOMIC ENERGY CENTRAL SCHOOL,ANUPURAM

CH-6 Work Power and Energy(module4/6)

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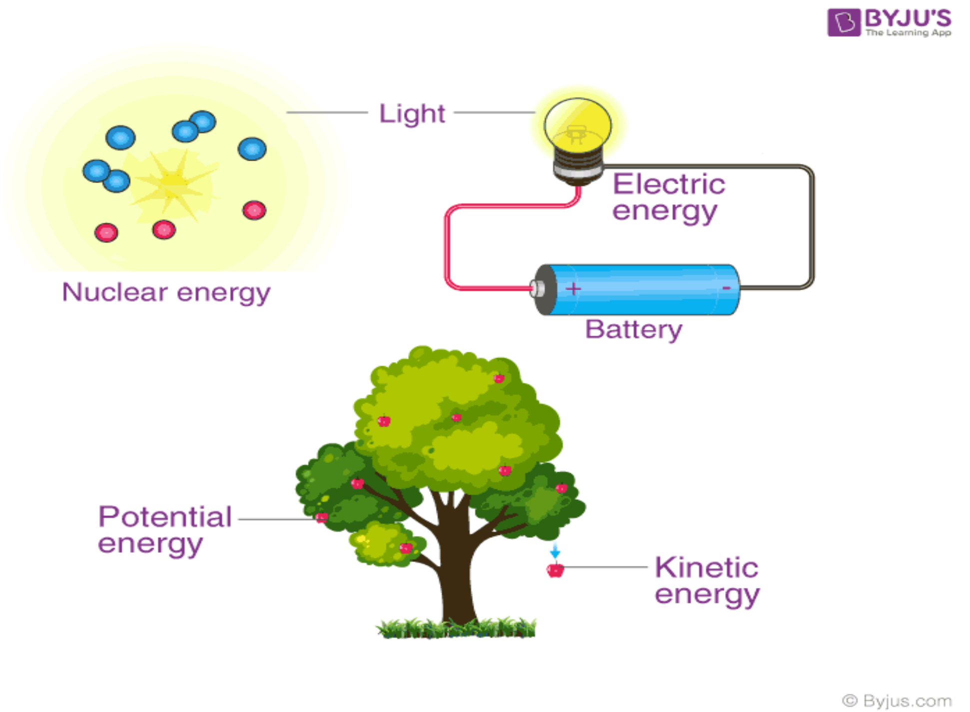
What is the Law of Conservation of Energy?

The law of conservation of energy states that **energy can neither be created nor be destroyed. Although, it may be transformed from one form to another.** If you take all forms of energy into account, the total energy of an isolated system always remains constant. All the forms of energy follow the law of conservation of energy.

In brief, the law of conservation of energy states that

In a closed system, i.e., a system that is isolated from its surroundings, the total energy of the system is conserved.



- So in an isolated system such as the universe, if there is a loss of energy in some part of it, there must be a gain of an equal amount of energy in some other part of the universe. Although this principle cannot be proved, there is no known example of a violation of the law of conservation of energy.
- The amount of energy in any system is determined by the following equation:

$$U_T = U_i + W + Q$$

- U_T is the total energy of a system
- U_i is the initial energy of a system
- Q is the heat added or removed from the system
- W is the work done by or on the system

The change in the internal energy of the system is determined using the equation

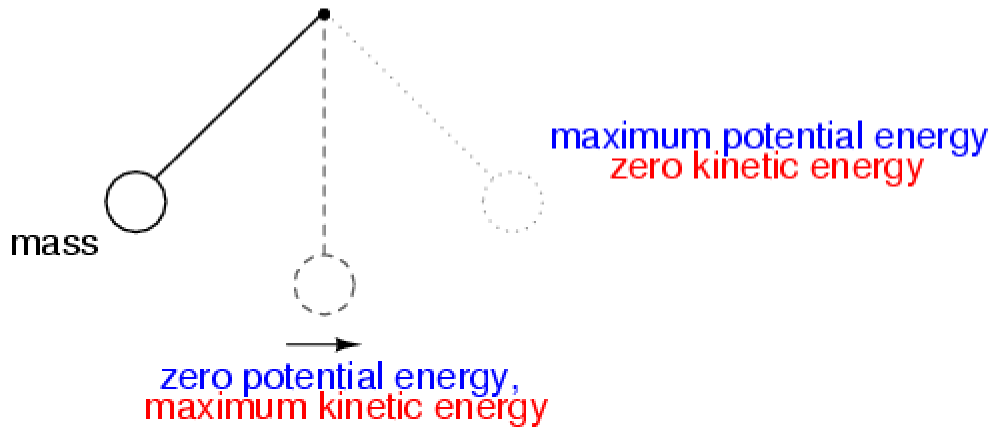
$$\Delta U = W + Q$$

Law of Conservation of Energy Examples:

- In Physics, most of the inventions rely on the fact that energy is conserved when it is transferred from one form to another. A number of electrical and mechanical devices operate solely on the law of conservation of energy. We will discuss a few examples here.
- In a torch, the chemical energy of the batteries is converted into electrical energy, which is converted into light and heat energy.
- In hydroelectric power plants, waterfalls on the turbines from a height. This, in turn, rotates the turbines and generates electricity. Hence, the potential energy of water is converted into the kinetic energy of the turbine, which is further converted into electrical energy.
- In a loudspeaker, electrical energy is converted into sound energy.
- In a microphone, sound energy is converted into electrical energy.
- In a generator, mechanical energy is converted into electrical energy.
- When fuels are burnt, chemical energy is converted into heat and light energy.
- Chemical energy from food is converted to thermal energy when it is broken down in the body and is used to keep it warm.

Conservation of mechanical energy

- Mechanical energy is the sum of kinetic energy and potential energy in an object that is used to do a particular work. In other words, it describes the energy of an object because of its motion or position, or both.
- Let us consider the example of an ideal simple pendulum (friction-less). We can see that the mechanical energy of this system is a combination of its kinetic energy and gravitational potential energy. As the pendulum swings back and forth, a constant exchange between the kinetic energy and potential energy takes place. When the bob attains its maximum height, the potential energy of the system is the highest, whereas the kinetic energy is zero. At the mean position, the kinetic energy is the highest, and the potential energy is zero. Between these two extreme points, we see that the system possesses both kinetic and potential energy, the sum of which is constant. These observations tell us a lot about the conservation of mechanical energy. But how can we prove it for every other system? In the next section, we shall learn more about the conservation of mechanical energy using a suitable example.



Conservation of mechanical energy

According to the principle of conservation of mechanical energy,

The total mechanical energy of a system is conserved i.e., the energy can neither be created nor be destroyed; it can only be internally converted from one form to another if the forces doing work on the system are conservative in nature.

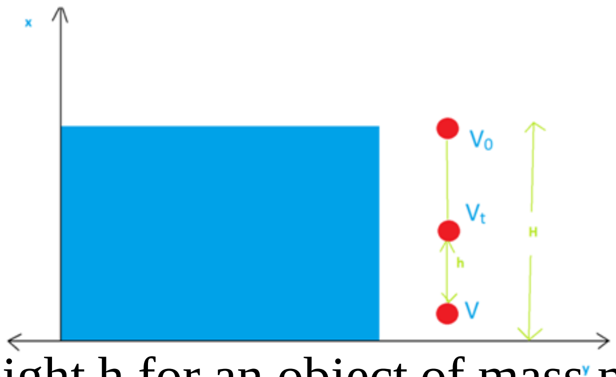
Let us understand this principle more clearly with the following example. Let us say, a ball of mass m is dropped from a cliff of height H, as shown above.

At height H:

Potential energy (PE) = m×g×H

Kinetic energy (K.E.) = 0

Total mechanical energy = mgH



At height h:

Potential energy(PE) = m×g×h

Kinetic energy (K.E.) =1/2(mv_1 ^2)

Using the equations of motion, the velocity v_1 at a height h for an object of mass m falling from a height H can be written as $V_1 = \sqrt{2g(H-h)}$

Hence, the kinetic energy can be given as, $\frac{1}{2}m(\sqrt{2g(H-h)}\,)^2$ = mgH - mgh

Total mechanical energy = (mgH – mgh) – mgh = mgH

At height zero:

Potential energy: 0

Kinetic energy: 1/2(mv^2)

Using the equations of motion we can see that velocity v at the bottom of the cliff, just before touching the ground is $V = \sqrt{2gH}$

Hence, the kinetic energy can be given as, kinetic energy (KE) = $\frac{1}{2}m\sqrt{2gH}^2$ = mgH

Total mechanical energy: mgH