UNIT 4–WORK, ENERGY AND POWER

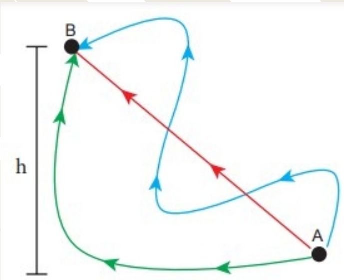
GREETINGS Students, This class we are going to discuss about Conservative and non conservative forces, Law of conservation of energy.

CONSERVATIVE AND NONCONSERVATIVE FORCES

Conservative force

A force is said to be a conservative force if the work done by or against the force in moving the body depends only on the initial and final positions of the body and not on the nature of the path followed between the initial and final positions.

Let us consider an object at point A on the Earth. It can be taken to another point B at a height h above the surface of the Earth by three paths.



$F_x = - dU/dx$

Table 4.3 Comparison of conservative and non-conservative forces

S.No	Conservative forces	Non-conservative forces
1.	Work done is independent of the path	Work done depends upon the path
2.	Work done in a round trip is zero	Work done in a round trip is not zero
3	Total energy remains constant	Energy is dissipated as heat energy
4	Work done is completely recoverable	Work done is not completely recoverable.
5	Force is the negative gradient of potential energy	No such relation exists.

Non-conservative force

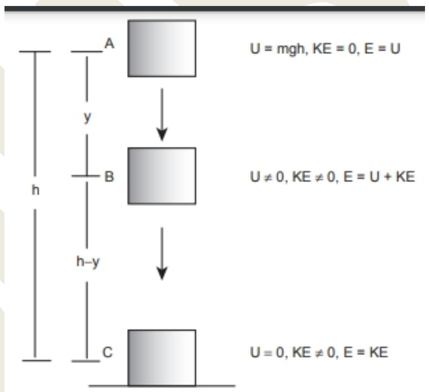
A force is said to be non-conservative if the work done by or against the force in moving a body depends upon the path between the initial and final positions. This means that the value of work done is different in different paths.

1. Frictional forces are non-conservative forces as the work done against friction depends on the length of the path moved by the body.

2. The force due to air resistance, viscous force are also non-conservative forces as the work done by or against these forces depends upon the velocity of motion.

Law of conservation of energy

* When an object is thrown upwards its kinetic energy goes on decreasing and consequently its potential energy keeps increasing (neglecting air resistance).
* When it reaches the highest point its energy is completely potential. Similarly, when the object falls back from a height its kinetic energy increases whereas its potential energy decreases. When it touches the ground its energy is completely kinetic.
* At the intermediate points the energy is both kinetic and potential.
* When the body reaches the ground the kinetic energy is completely dissipated into some other form of energy like sound, heat, light and deformation of the body etc.
* In this example the energy transformation takes place at every point.
* The sum of kinetic energy and potential energy i.e., the total mechanical energy always remains constant, implying that the total energy is conserved.
* This is stated as the law of conservation of energy.



* *The law of conservation of energy states that energy can neither be created nor destroyed. It may be transformed from one form to another but the total energy of an isolated system remains constant*.
* When the object is about to touch the ground, the potential energy is zero and total energy is purely kinetic.

EXAMPLE 4.13

An object of mass 1 kg is falling from the height h = 10 m. Calculate

(a) The total energy of an object at h =10 m

(b) Potential energy of the object when it is at h = 4 m

(c) Kinetic energy of the object when it is at h = 4 m

(d) What will be the speed of the object when it hits the ground? (Assume g =10 m s-2)

Solution

(a) The gravitational force is a conservative force. So the total energy remains constant throughout the motion. At h =10 m, the total energy E is entirely potential energy.

$$E = U = mgh = 1 \times 10 \times 10 = 100\ \text{J}$$

(b) The potential energy of the object at $h = 4$ m is

$$U = mgh = 1 \times 10 \times 4 = 40\ \text{J}$$

(b) Since the total energy is constant throughout the motion, the kinetic energy at h = 4 m must be KE = = E U- - 100 40 60 = J

Alternatively, the kinetic energy could also be found from velocity of the object at 4 m. At the height 4 m, the object has fallen through a height of 6 m. The velocity after falling 6 m is calculated from the equation of motion,

$$v = \sqrt{2gh} = \sqrt{2 \times 10 \times 6} = \sqrt{120}\ \text{m s}^{-1};$$

$$v^2 = 120$$

The kinetic energy is $KE = \frac{1}{2}mv^2 = \frac{1}{2} \times 1 \times 120 = 60\ \text{J}$

(c) When the object is just about to hit the ground, the total energy is completely kinetic and the potential energy, U = 0.

$$E = KE = \frac{1}{2}mv^2 = 100\ \text{J}$$

$$v = \sqrt{\frac{2}{m}KE} = \sqrt{\frac{2}{1} \times 100} = \sqrt{200} \approx 14.12\ \text{m s}^{-1}$$

EXAMPLE 4.15

An object of mass m is projected from the ground with initial speed v 0. Find the speed at height h.

Solution

Since the gravitational force is conservative; the total energy is conserved throughout the motion.

	Initial	Final
Kinetic energy	$\frac{1}{2}mv_0^2$	$\frac{1}{2}mv^2$
Potential energy	0	mgh
Total energy	$\frac{1}{2}mv_0^2 + 0 = \frac{1}{2}mv_0^2$	$\frac{1}{2}mv^2 + mgh$

Final values of potential energy, kinetic energy and total energy are measured at the height h.

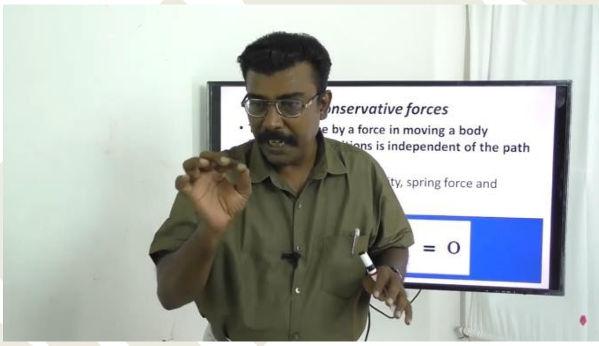
By law of conservation of energy, the initial and final total energies are the same.

$$\frac{1}{2}mv_0^2 = \frac{1}{2}mv^2 + mgh$$

$$v_0^2 = v^2 + 2gh$$

$$v = \sqrt{v_0^2 - 2gh}$$

However, calculation through energy conservation method is much easier than calculus method.



URL: https://www.youtube.com/watch?v=_8zpk4x71WQ