WORK AND ENERGY

Work

- We define work to be equal to the product of the force and displacement.
  Work done = force * displacement.
- Work done by 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.
- Unit of work is newton metre (N m) or joule (J)
- Work done on an object by a force would be zero if the displacement of the object is zero.
- The work done by a force can be either positive or negative.
- Work done is negative when the force acts opposite to the direction of displacement.
- Work done is positive when the force is in the direction of displacement.
- When a body falls freely under gravity then the work done by the gravity is positive.
  - **Explanation is** - If a force acting on a body has a component in the direction of displacement, then the work done by the force is positive because when a body falls freely under the influence of gravity the work done by the gravity is positive.
- When a body slides against a rough horizontal surface the work done by friction is negative.
  - **Explanation is** - When a body slides against a rough horizontal surface its displacement is opposite to that of the force of friction so the works done by the friction is negative.

Energy

- Life is impossible without energy.
- An object having capability to do work is said to possess energy.
- Unit of energy is joule. Joule is also unit of work.
- Various form of energy are Mechanical energy, Electrical energy, Atomic energy, Heat energy, Light energy, Chemical energy and sound energy.
- Energy of one form can be transformed into energy of another form.
- The sum of the kinetic and potential energies of an object is called its mechanical energy.

Kinetic Energy

- Kinetic energy is the energy possessed by an object due to its motion.
- The kinetic energy of an object increases with its Speed.
- Example of kinetic energy are Falling coconut, a speeding car, a rolling stone, a flying aircraft, flowing water, blowing wind, a running athlete etc.
- The kinetic energy of a body moving with a certain velocity is equal to the work done on it to make it acquire that velocity.
- An object of mass (m) moving with velocity (v) has a kinetic energy of

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

Potential Energy

- The energy possessed by a body due to its change in position or shape is called the potential energy.
- The potential energy possessed by the object is the energy present in it by virtue of its position or configuration.
- An object increases its energy when raised through a height. This is because work is done on it against gravity while it is being raised. The energy present in such an object is the gravitational potential energy.
- The gravitational potential energy of an object at a point above the ground is defined as the work done in raising it from the ground to that point against gravity.
- The gravitational potential energy of an object of mass (m) raised through a height (h) from the earth's surface is given by = m g h.
- The work done by gravity depends on the difference in vertical heights of the initial and final positions of the object and not on the path along which the object is moved.

Heat Energy

- Heat is a form of energy transferred spontaneously from a hotter to a colder body.

Chemical Energy

- The potential of a chemical substance to experience a transformation through a chemical reaction and transform other chemical substances is known as chemical energy. E.g. Breaking or making of chemical bonds, batteries, etc.
- The chemical energy of a chemical substance can be converted to other forms of energy by a chemical reaction. E.g., green plants convert solar energy to chemical energy commonly of oxygen by the process of photosynthesis.

Electrical Energy

- The energy, derived from electric potential energy or kinetic energy, is known as electrical energy.
- Electricity is normally produced by electromechanical generators at a power station.
- The electromechanical generators primarily are driven by heat engines fueled by the kinetic energy of flowing water and wind.
- The electromechanical generators are also driven by heat engines fueled by chemical combustion or nuclear fission.

Light Energy

- Light is a form of electromagnetic radiation.
- Light energy most likely is the only form of energy that we can really see.
- Light is transferring energy through the space in a natural way. E.g. solar energy.

Law of Conservation of Energy

According to the law of conservation of energy:

- The energy can neither be created nor destroyed.
- Energy can only be transformed from one form to another.
- The total energy before and after the transformation always remains constant.
- An object of mass (m) is made to fall freely from a height (h). At the start, the potential energy is mgh and kinetic energy is zero. Why is the kinetic energy zero. It is zero because its velocity is zero. The total energy of the object is thus mgh. As it falls its potential energy will change into kinetic energy. If *v* is the velocity of the object at a given instant the kinetic energy would be ½mv^*2*. As the fall of the object continues, the potential energy would decrease while the kinetic energy would increase. When the object is about to reach the ground, *h* = 0 and *v* will be the highest. Therefore, the kinetic energy would be the largest and potential energy the least. However, the sum of the potential energy and kinetic energy of the object would be the same at all points.

  Potential energy + kinetic energy = constant
- The sum of kinetic energy and potential energy of an object is its total mechanical energy.

Rate of Doing Work

- Power is defined as the rate of doing work or the rate of transfer of energy

  Power = work/time
- Unit of power is watt
- 1 watt = 1 joule/second or 1 W = 1 J s^{-1}
- The unit joule is too small and hence is inconvenient to express large quantities of energy. We use a bigger unit of energy called kilowatt hour
- 1 kW h = 3.6 * 10^6 J
- The energy used in households, industries and commercial establishments are usually expressed in kilowatt hour.