Work and Energy

Work

Work is defined as the force in the direction of displacement times displacement. It is a scalar quantity having S.I unit Joule.

$W=Fs$

where F is the component of force in the direction of displacement.

Definition

Work done by a constant force

When the force is constant, the work done is defined as the product of the force and distance moved in the direction of force.

Example: Suppose a body is kept on the frictionless surface and a force of constant magnitude of 10 N is acting on it, due to the action of forces the body will completed a distance of 5 meter, then the work done will be given as

$W=Fs=10\times5=50$ Joule

Definition

Positive, Negative and Zero work done

1. Positive Work : If a force displaces the object in its direction, then the work done is positive. The example of this kind of work done is motion of ball falling towards ground where displacement of ball is in the direction of force of gravity.

2. Negative Work : If the force and the displacement are in opposite directions, then the work is said to be negative. For example if a ball is thrown in upwards direction, its displacement would be in upwards direction but the force due to earths gravity is in the downward direction.

3. Zero Work : If the directions of force and the displacement are perpendicular to each other, the work done by the force on the object is zero.

For example, when we push hard against a wall, the force we are exerting on the wall does no work, because in this case the displacement of the wall is d = 0. However, in this process, our muscles are using our internal energy and as a result we get tired.

Definition

Energy

Energy is defined as the capacity of a system to perform work. Suppose a body having mass m kg moving with a linear velocity of v meter/sec so its energy is is in the form of kinetic energy which is equal to $K.E=12mv2$

SI unit of energy is Joule.

CGS unit of energy is erg.

Definition

Potential Energy

Potential energy is the energy stored in an object. For example, a body at height h has gravitational potential energy mgh. Its SI unit is Joules.

Definition

Kinetic energy

Kinetic Energy of an object is the energy of an object due to its motion. For an object of mass m, it is given by $KE=12mv2$.

Forms of Potential Energy
The different forms of potential energy are:
Gravitational potential energy-The rock hanging above the ground has a form of stored energy called gravitational potential energy.
Elastic potential energy-Elastic potential energy is the energy stored when an object is squeezed or stretched. This stored energy then can cause the rubber band to fly across the room when you let it go.
Chemical potential energy-Chemical potential energy is the energy stored in bonds between the atoms that make up matter.
Definition
Potential energy with respect to a reference line
Potential energy is always defined with respect to a reference line in space. Usually infinity is taken as the reference line and potential energy defined is zero at infinity. In gravitation, for objects close to surface of earth, ground surface is taken as reference line and energy at ground surface is zero.
Note:
Choice of reference line is not fixed and can be redefined. This helps in solving of problems.
Definition
Application of Conservation of Energy

Law of Conservation of Energy states that the total energy is always conserved in each transformation of energy i.e., total energy before and after transformation remains unchanged.

In case of conservation of Mechanical Energy : Potential Energy (PE) of a body changes into Kinetic Energy (KE) and vice-versa , but the Total Mechanical Energy (TME=PE+KE) remains const
Applications of Conservation of Total Mechanical Energy :
1. Roller Coaster
2. A ball falling vertically from a height h
Definition
Conservation of Energy
Law of conservation of energy states that energy can neither be created nor be destroyed it can only be transformed from one form to another form.

Conservation of Mechanical Energy for simple pendulum

Total mechanical energy is conserved for motion of simple pendulum assuming no losses i.e. Total energy is same at maxima, intermediate point and equilibrium position. Note that total mechanical energy is given as sum of kinetic and potential energy.

Units of power
Different units of power are:
SI unit: 1 W=1 J/s=1 kgms−3
1 hp(horsepower)=746 W
1 erg/s=10−7 J/s

Definition and example of fossil fuels
Natural fuel such as coal or gas, formed in the geological past from the remains of living organisms
Definition
Properties of fossil fuels
Fossil fuels are combustible, burning in the presence of oxygen and forming water vapor, carbon dioxide, ash and other byproducts.
Result
Good sources of energy
A good source of energy has the following characteristics:
It can provide an adequate amount of useful energy at a steady rate.
It does not exhaust (gets used up) over a long period of time.
It should be safe and convenient to use.
It should be economical to use.
It should be easy to store and transport.
Examples: Solar energy, hydel energy, etc.

Fossil Fuels
Fossil fuels are fuels formed by anaerobic decomposition of buried dead organisms over millions of years. A lot of fuels fall under this category like coal, petroleum and natural gas. They are presently the largest source of energy used on earth. They are exhaustible(limited in amount) and cause air pollution.

Conventional sources of energy
The sources of energy which have been in use for a long time are called conventional sources of energy. Some of the general characteristics of these sources are:

They are exhaustible.
They cause pollution.
They are expensive to be maintained, stored and transmitted.
Examples include coal, petroleum, natural gas and water power.

Production of electricity
Some common methods used to produce electricity are:
Burning fuels (coal, petroleum, etc) in thermal power stations.
From wind energy in windmills.
From nuclear energy in atomic power plants.
From solar energy using solar panels.
From hydel energy in hydroelectric power stations.

Renewable and non-renewable resources of energy
Renewable resources are resources that are replenished by the environment over relatively short periods of time. They are more desirable to use because they will have regenerated by the time we've used it up. Examples: Solar, wind, hydel and bioenergy.
Non-renewable resources are resources that are not easily replenished by the environment. Example: Fossil fuels and minerals.

Differentiate between green and brown energy

Brown energy is the traditional type of electricity that is produced through the normal means. Typically, this refers to electric plants that produce power with coal or some other fossil fuels. It is referred to as brown energy because of the pollution that is caused by this form of energy.

Green energy is a form of power that is renewable and does not pollute the earth in any way. Some examples of green energy are solar power, hydroelectric power, wind power, geothermal power, and biodiesel.

Wind mills

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Solar Energy

Solar energy is radiant light and heat from the Sun that is harnessed using a range of ever-evolving technologies such as solar heating, photovoltaics, solar thermal energy, etc. It is an important source of renewable energy.

Solar energy is used today in a number of ways:

1. As heat for making hot water, heating buildings, and cooking.
2. To generate electricity with solar cells or heat engines.
3. To take the salt away from sea water.
4. To use sun rays for drying clothes and towels.

Benefits and Limitations of Solar Cooker

Benefits: 1) One-time investment
2) Eco-friendly
3) No fuel required

Limitations: 1) Can't be used in cloudy weather
2) Take longer to cook

Energy from sea

The energy potential from sea energy is large but its efficient commercial exploitation is difficult. The following types of energies can be harnessed from the sea:

Ocean wave energy: Kinetic energy in the waves is used to generate electricity.

Ocean thermal energy: The temperature difference at different depths of ocean is converted into mechanical and then into electrical energy.

Tidal energy: The potential energy stored in the tides is used to harness electrical energy.

Advantages and disadvantages of Nuclear Energy
Advantage of using nuclear energy is that it can be used for production of large amount of energies

Disadvantages of using nuclear energy are:
The excess radiations from these reactors are harmful to health and can affect many generations.
Nuclear fuels can be misused to build destructive atomic bombs.
Cost of installation of nuclear power plants is very high and needs to be done in remote areas for safety purposes.
Definition
Nuclear fusion in hydrogen bomb
Nuclear fusion is a process in which two or more lighter nuclei combine to form a heavier nucleus. The mass of the product is always less than the sum of the masses of the individual lighter nuclei.The fusion process can be carried out only at extremely high temperature of the order of 107K because, only at these very high temperatures the nuclei are able to overcome their mutual re
A suitable assembly of deuteron and triton is arranged at the sight of the explosion of the atom bomb. Favorable temperature initiates the fusion of lighter
nuclei in an uncontrolled manner. This releases enormous amount of heat energy.
The fusion reaction in the hydrogen bomb is $_1H^2 + _1H^3 \rightarrow _2He^4 + _0n^1 + Energy$