5 Work and Energy

SYLLABUS

1. (a) Work is done when an applied force moves an object in the direction of the force. Examples from daily life.
   (b) Work = Force × Distance moved (in the direction of the force).
2. Work–energy relationship; units of work.
3. Energy is the ability to do work.
   (a) Different forms of energy – kinetic, potential, heat, light, magnetic, electrical, muscular, sound, chemical energy.
   (b) Interchangeability of energy from one form to another – identification of such transformations.
   (c) Energy chains – all start with the Sun.

WORK

We do different types of work in our everyday life. We play, we carry a load, say, our school bag, we pedal a cycle, we go for jogging and so on. These are few examples of physical work. We may read, think, solve problems, *etc*. These are few examples of mental work.

In physics, we recognise only physical or mechanical work and that too if there is some displacement, *i.e.*, the body has moved from one place to another place. In science, we do not recognise mental work as work done, although it also consumes energy.

Work Done

A force tends to move an object upon which it acts. If the object moves in the direction of the force, work is said to be done. Work is also said to be done if the force applied on a body changes its position, decreases or increases its speed, changes its direction of motion, *etc*.

Example 1 : When a crane picks up an accidental car and takes it to a workshop, we say that work is done.

Example 2 : In a school playground, while playing football, when a boy hits the ball and runs towards the goal, we say that work is done.

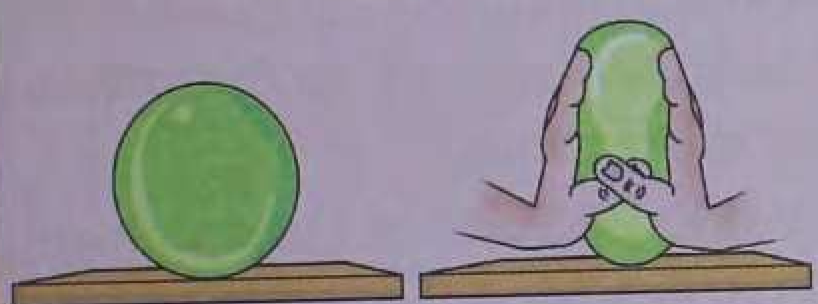
If on applying force on an object, the motion of the object changes or the direction of motion changes, the work is said to be done by the force.

Sometimes, work is said to be done even when there is no displacement, rather there is a change in the shape or size of the body.

Example 3 : Squeezing a rubber ball, squeezing toothpaste from the tube.

Example 4 : A small child sitting at a place is making different shapes of objects with the help of plasticine. He is doing work, because he is changing the shape of the plasticine.

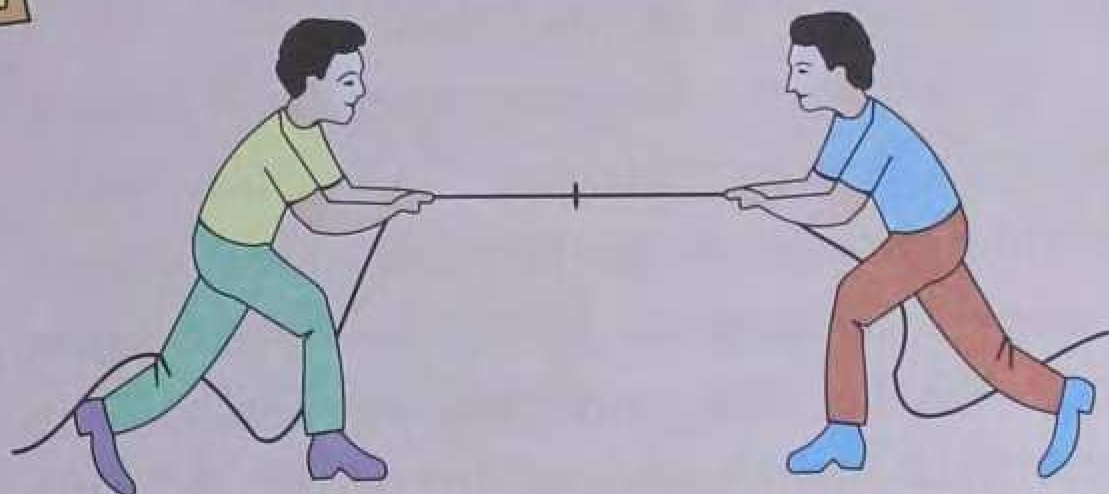
Work is being done when the boy is climbing the stairs.



Change in the shape and size of a ball is a kind of work.

No work is done while standing with heavy luggage

No work is said to be done if there is no displacement in the position of the car to which the force is applied.



No work is done if the force applied on both sides is equal

Fig. 5.1 Various conditions when work is said to be done and not done

No Work Done

If you apply a force on a heavy object and the object does not move, no work is done though the force is applied on it.

- Is work done when leaves fly in the wind ?
- Is work done when you close your eyelids ?

Example 5 : If two teams of a tug-of-war apply the pulling force with equal amount, no work is done because there is no change in the position of both the teams.

Reading is a kind of mental work; no work is done

No work is done in case of pushing a wall

Fig. 5.2

Example 6 : If you push a wall, you waste a lot of energy. But no work is said to be done since there is no displacement.

Example 7 : There may be a case when a man applies a force to push his car forward but the car does not move inspite of a great deal of strong pushing. Although the man has applied much force, *no work has been done* because the force neither succeeded in moving the car nor did it change its shape.

Example 8 : When a porter is standing still on a railway platform with a heavy luggage on his head, he is not doing any work. Since there is no displacement, hence no work is said to be done.

From the above examples we come to the conclusion that work is said to be done only if the following two conditions are satisfied :

(a) *A force must be applied on the object.*

(b) *The object should move from its resting position* or *there should be a change in the shape or size of the object.*

DEFINITION OF WORK

When a force displaces a body in the direction of applied force then the product of the force and displacement is called the work done by the force on the body.

Example 9 : Suppose a person A pushes an object through a distance of 10 metres, while another person B pushes the same object through a distance of 20 metres by the same force. We say that work done by person B is more than the work done by person A. This means that for a given force the work depends on the distance moved by the object in the direction of the applied force.

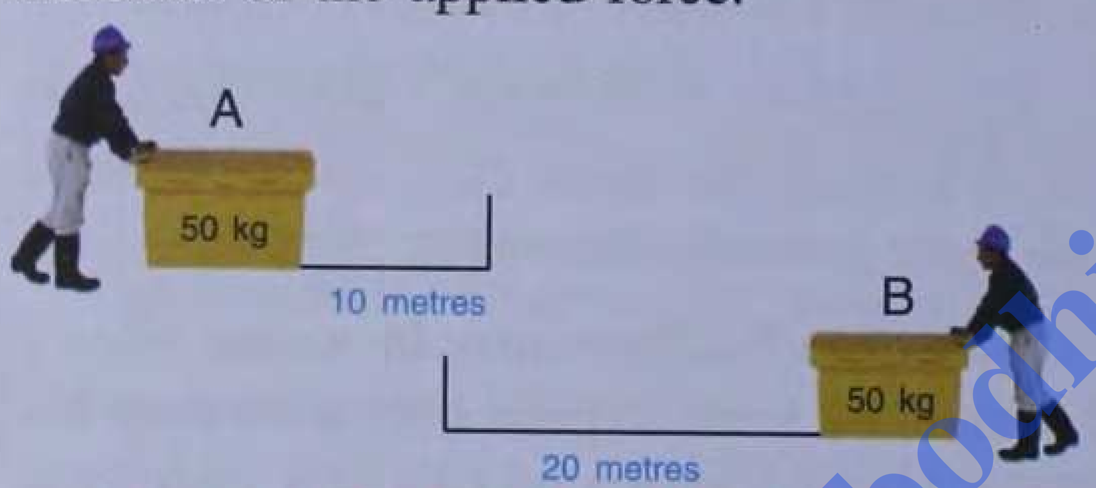


Fig. 5.3 Work done depends on the distance moved by the object

Example 10 : Suppose you push a trolley (load) weighing 50 kg to a distance of 10 metres, while your brother pushes another trolley (load) weighing 100 kg to the same distance *i.e.* 10 metres. Then the work done by your brother is more than that of yours, as your brother had to apply more force. This means that work depends on the magnitude of the force applied.

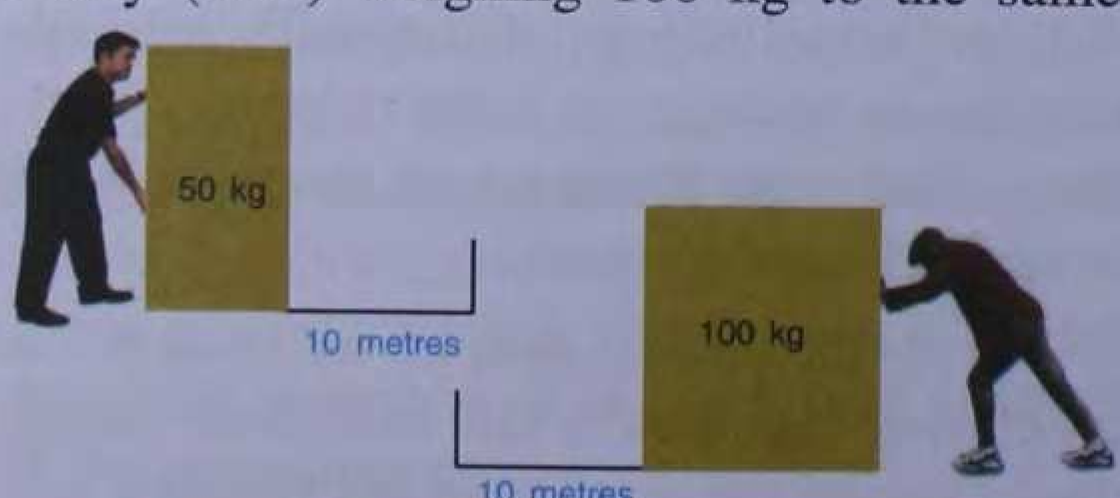


Fig. 5.4 Amount of work done depends on the force applied

Hence, we conclude that the work done depends on the following two factors :

(a) force applied and

(b) the displacement (shortest possible distance in the direction of force applied).

We can now define work as the product of force and displacement.

$$\text{Work} = \text{Force} \times \text{Displacement}$$
$$= F \times S$$

Unit of Work

The unit of work is, therefore, the product of a unit of force and a unit of distance. Since the unit of force is newton (N) and the unit of distance is metre (m), therefore the unit of work is **newton-metre** (Nm). A newton-metre is also called a **joule** (J) named after J.P. Joule, a scientist who did a number of experiments in the field of energy. Sometimes, a larger unit called **kilojoule** (kJ) is also used.

$$\text{Unit of work} = 1 \text{ Newton} \times 1 \text{ metre}$$
$$= 1 \text{ Nm}$$
$$= 1 \text{ Joule}$$
$$\text{and} \quad 1\text{kJ} = 1000 \text{ J}$$

Do You Know ?

James Prescott Joule (1818-1889) was a British Physicist and famous for extensive work on heat and conversion of heat into work. The S.I. unit of work and energy is named after him. He verified the law of conservation of energy. He was also instrumental to work with Lord Kelvin to develop the Kelvin scale of temperature.

Example 11 : If a boy lifts a textbook weighing 10 N from the floor to a table of height 2 m. How much work does he do ?

Solution :

Work done = Force × Distance moved in the direction of the force

$= 10\ N \times 2\ m = 20\ J$

Example 12 : A man needs a force of 2000 N to pull his car. He pulls it to a distance of 30 m. How much work is done by him ?

Solution :

Work done = Force × Distance moved in the direction of the force.

$= 2000\ N \times 30\ m$

$= 60000\ J$ or 60 kJ

Example 13 : A man drags a trunk through a distance of 5 m and for that he does 30000 J of work. What is the force required ?

Solution :

Work = Force × Distance moved in the direction of force

$30000\ J = F \times 5\ m$

$\therefore \quad F = \frac{30000\ J}{5\ m} = 6000\ N$

Example 14 : A force of 1500 N is required to do a work of 20000 J to drag an object. Through what distance will it move ?

Solution :

Work = Force × Distance moved in the direction of force

$\frac{\text{Work}}{\text{Force}} = \text{Distance}$

Distance moved in the direction of force

$= \frac{20000\ J}{1500\ N} = 13{\cdot}33\ m$

ENERGY

If a boy while playing football runs about all over the field or if he cycles to some distance, he gets tired. He has used something to do these things. If he had stayed at home and sat down at a place, he would not have felt so tired. What has he used to do these things ? He has used his energy.

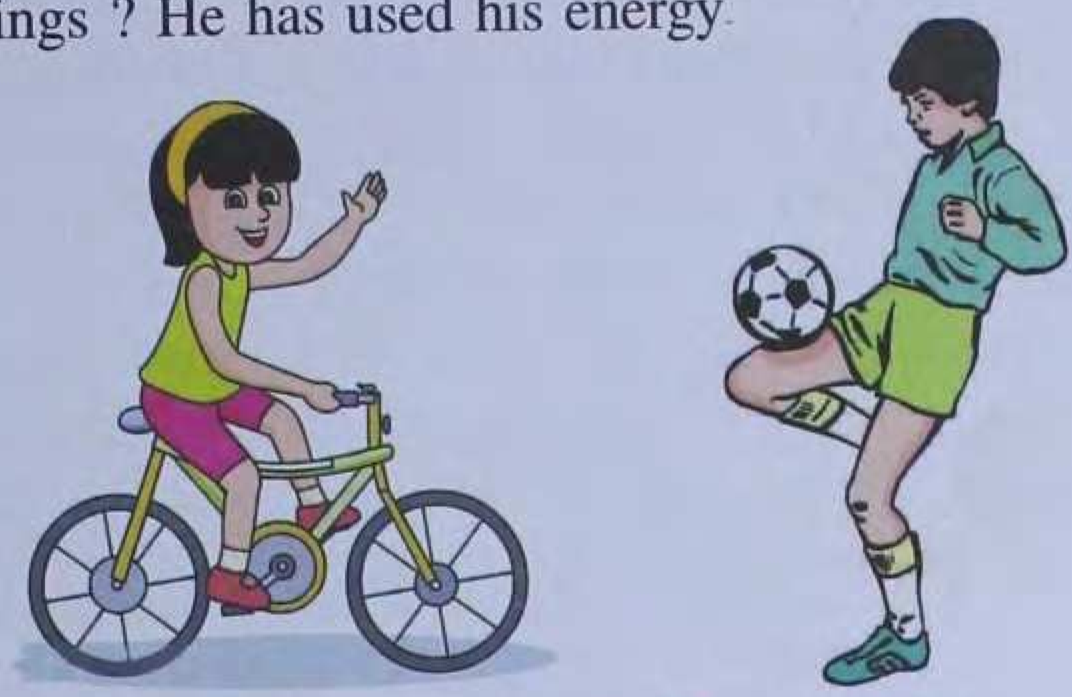


Fig. 5.5 Energy is required for working

Everything in this universe is either matter or energy.

Matter is the physical state of a substance which exists in nature in different forms and occupies some space.

> Energy is the ability or capacity to do work.

To do more amount of work, we need more amount of energy.

After doing sufficient amount of work, one feels tired because lot of energy has been spent during this process. Hence we say, there is a direct relationship between work and energy. The energy is the cause and work is its effect. The unit of energy is joule (J) which is the same as that of work.

Different forms of Energy

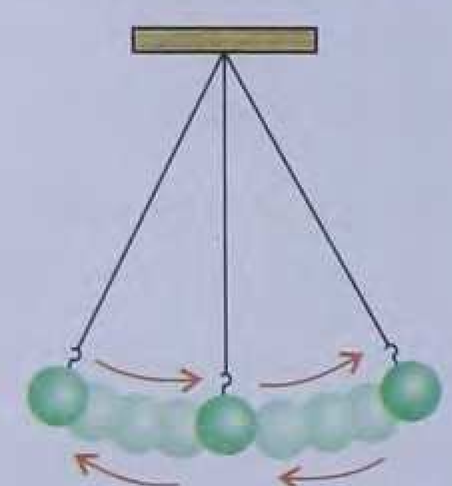
Energy exists in several forms. Some forms are explained below.

Mechanical Energy : Whenever a body is in motion or it is taken to a certain height with respect to the earth's surface, it possesses mechanical energy.

> **Mechanical Energy :** The energy possessed by a body either due to its state of rest or state of motion is called mechanical energy.

Mechanical energy is of two forms, namely, kinetic energy and potential energy.

Kinetic Energy : The energy that the moving bodies possess is called motional energy or kinetic energy. (The word *kinetic* comes from the Greek word kinesis which means motion). Swinging pendulum, running water, and moving air are examples of bodies that possess kinetic energy.



Swinging of pendulum

Movement of plants by air

Flow of running water

Fig. 5.6

The amount of kinetic energy depends on the mass and velocity of the moving object.

Example : An apple falling from a tree, blowing wind, a bird flying, etc. are few examples of kinetic energy.

> The energy possessed by a body due to its motion is called **kinetic energy**.

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

where 'm' is the mass of the body, 'v' is its velocity and KE is the kinetic energy possessed by the body.

You might have observed that a bullet is capable of penetrating into human body, a storm can uproot big trees, *etc*. These are all because of the high speed which increases the kinetic energy of the bullet or air by a very large amount.

ACTIVITY 1

In the game of carom, all the coins are placed in the middle of the caromboard and they are hit by a plastic striker. The coins move to some distance due to the force of the striker. If more force is applied to the striker and it strikes the coins, the coins move to a larger distance. So this moving striker has *kinetic energy*. From this we conclude that if the moving body has more speed, it will have more kinetic energy.

ACTIVITY 2

You regularly play and also watch cricket matches. Do you observe that when a batsman hits the ball with a little force, the ball goes near about to fetch him one or two runs. But when he hits the ball with full force, it goes for a boundary, *i.e.*, four or six runs.

So, we conclude that, more the speed of hitting the ball, the higher is its kinetic energy.

Potential Energy : "Potential" is a Latin word which means "to be able". Potential energy is the energy possessed by a body by virtue of its position with reference to the earth.

As the body gains height its potential energy increases. It means that the energy is inactive at the moment but has the potential for doing work.

The stored up energy of a body due to its position which has the potential to do work is called **potential energy**.

Example : If you bend a branch of a tree and let it go, it gets back into its original position. Displacement occured both when the branch was pulled down and also when it went back to its first place. Hence, work was done in both cases. What was the source of energy for this work ?

Force is applied for bending the branch. That is why, it was displaced. The branch could go back to its position when you let it go, because energy was stored in it.

ACTIVITY 3

Place an ordinary coil spring on a table and fix its lower end with the table top. Now place a small ball on it. You will see that nothing happens to the ball. Now press the ball and the spring with your fingers. As soon as you release the spring the ball will bounce away, why ? Because when the compressed spring is released, its potential energy converts into kinetic

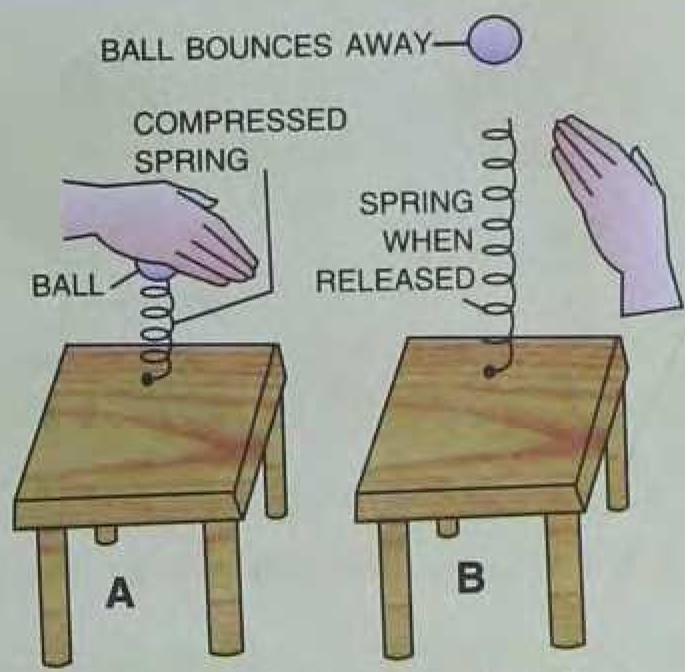


Fig. 5.7 A compressed spring has potential energy

energy of the ball. Thus, we say that the compressed spring has **potential energy**.

Hence, we conclude that potential energy depends on the change in the configuration or shape of the body.

Potential energy of a body depends on :

- mass of the body (m),
- acceleration due to gravity (g) and
- height of the body with respect to ground (h).

Potential energy $= m \times g \times h$

Its unit is same as the unit of work *i.e.*, the unit of potential energy is **joule**.

Potential energy is of *two* types; gravitational potential energy and elastic potential energy.

Gravitational Potential Energy is the energy stored when an object is lifted above the surface of the earth. The higher the object is lifted, the greater is its gravitational potential energy.

For example, in Fig. 5.8, a stone kept at some height has the potential energy. This potential energy is because of its position at a height. When this stone falls on a nail fixed

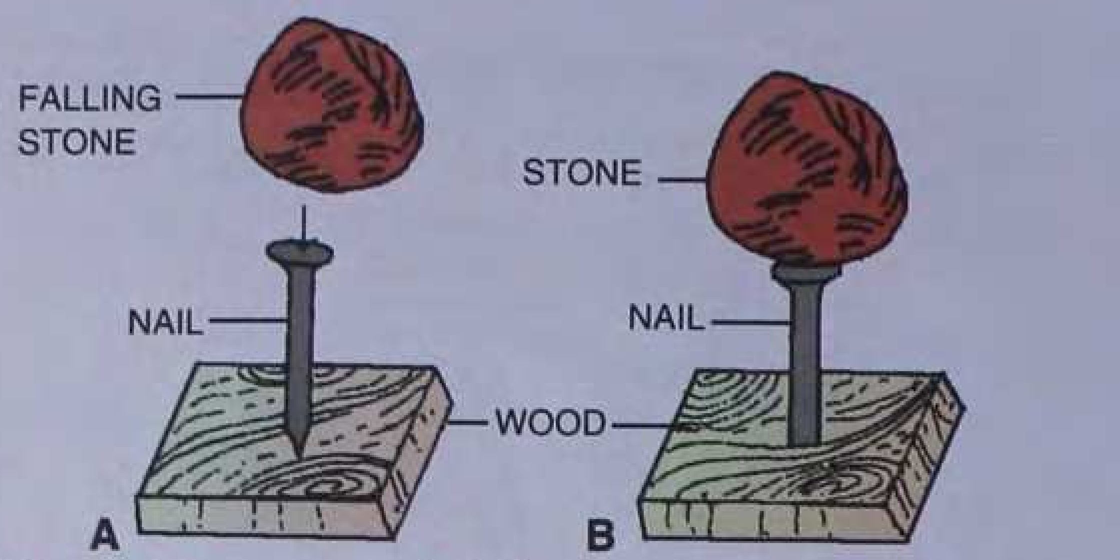


Fig. 5.8 Stone at a height has the potential energy

on a piece of wood, the nail sinks further into the wood.

Elastic Potential Energy is the energy stored when objects are stretched, compressed or bent. When a watch is wound up, energy is put into its spring. The watch works for a few hours with the energy stored in the spring.

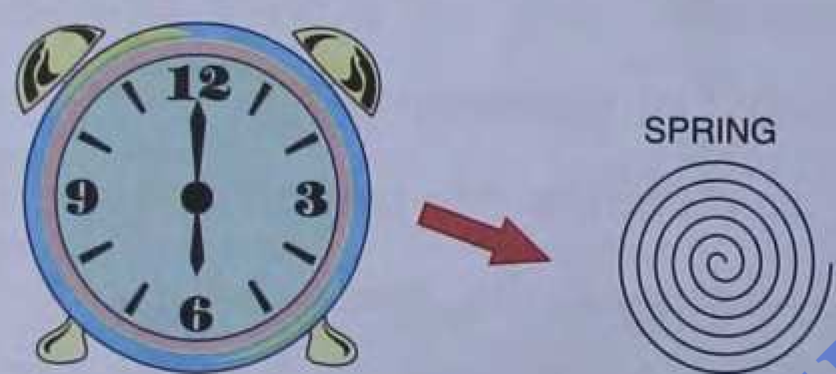


Fig. 5.9 In an alarm clock, energy is stored in its spring which lies in wound up form

Intext Questions

1. What type of energy is stored in squeezing a ball ?
2. What is the difference between joule and kilojoule ?
3. Write a situation where mechanical energy is used.
4. What are the two forms of potential energy ?
5. What is gravitational potential energy ?

OTHER FORMS OF ENERGY

There are some other forms of energy too. They can be classified as **energy in action** and **stored energy**.

Energy in Action

1. **Sound Energy :** Sound energy is produced by the vibrations of an object. When sound produced by a vibrating body reaches our ear membrane, it makes the membrane vibrate and we hear the sound of the vibrating body. Remember, all vibrations may not produce audible sound. A very high amount of vibrations (more than 20,000 vibrations per second) or a very low amount of vibrations (less than 20 vibrations per second) produce such sound that is inaudible to human beings. Since vibrating or moving bodies have kinetic energy so sound too is a kind of energy.

Fig. 5.10 Sound energy produced in the form of vibrations

2. **Light Energy :** Light is a form of energy in the presence of which we can see objects. It is also a very good source for starting a chemical reaction. *For example,* in photosynthesis, in exposing photo-graphic plates, *etc*. More importantly, when light travels from an object to our eye we can see the object. Light, under normal circumstances, always travels in a straight line.
3. **Electrical Energy :** When two dry bodies are rubbed together, they produce electrical energy. A comb, when rubbed on dry hair, attracts small bits of paper and makes them

Fig. 5.11 An example of electrical energy

move towards the comb. Electrical energy is of tremendous use in our daily life. We use electricity at home to run our domestic appliances, at offices, in factories, for transportation, *etc*. Today, electricity is a necessity of life. Life will come to a standstill, if electricity fails to exist for quite sometime. Electricity is used to run light, fan T.V., computer, A.C., calling bell, etc. at our house.

4. **Heat Energy :** Most forms of energies get converted into heat energy before they are used. So, it is one of the most important forms of energy. Coal, oil, liquefied petroleum gas (LPG) or domestic gas, *etc*., are burnt before these are used. In steam engines, chemical energy is changed into heat energy which then changes water into steam. Heat energy is also called **thermal energy**.

When you boil water in a container covered with lid, the lid starts bumping if kept loose. Heating increases the rate of movement of particles of water. When water turns into steam, the movement of particles increases further.

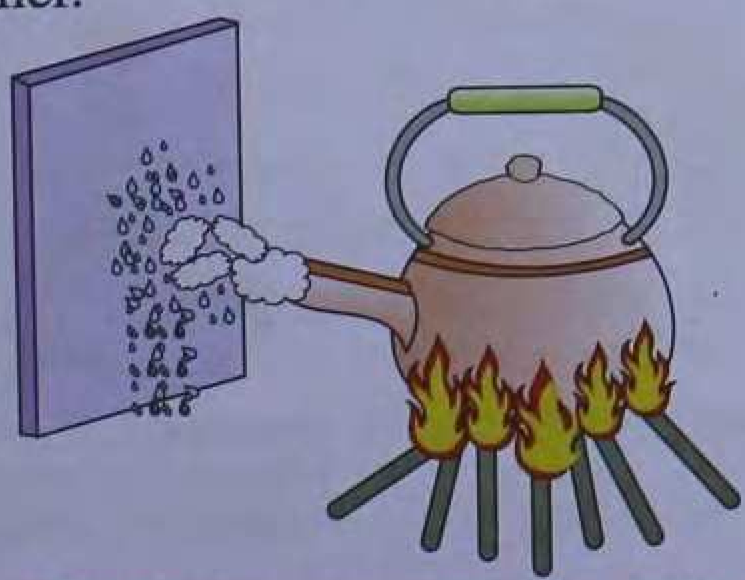


Fig. 5.12 Heat energy produces water vapours

Stored Energy

1. **Chemical Energy :** When we eat food, the body does a process to break the food particles to release energy. The energy stored in the matter is called **chemical energy.** Coal, petrol, diesel, kerosene oil – all have chemical energy stored in them. Petrol has a chemical energy to run the car.

2. **Magnetic Energy :** Magnet can attract iron particles, so it is also a form of energy. In factories, iron scrap is separated from the heap of waste material by using big electromagnets fixed in the cranes (Fig. 5.13). Magnetic energy can work from a distance.

Fig. 5.13

3. **Nuclear Energy :** A large amount of energy is produced when the nucleus of an atom splits or two nuclei of different atoms combine together.

Energy stored inside nucleus of atoms like uranium is nuclear energy. Some elements can change into another element by releasing a lot of energy in the form of heat. This large energy so produced is called **nuclear** or **atomic energy**. This energy is used to generate electricity. Further the radiation emitted from nuclear energy is used in the medical treatment of diseases such as cancer.

Do You Know ?

The energy of sunlight can help in tracing back the energy of moving air. The sun warms the air and this warm air rises and cool air rushes to replace it. These moving air currents are called winds.

TRANSFORMATION OF ENERGY

Energy can be converted from one form to another as per our needs. Water on one side of a dam is stored at a greater height, so it has greater potenitial energy.

By opening the gates of the dam, the water is allowed to flow to the other side of the dam. Thus, its potential energy changes to kinetic energy, *i.e.,* flowing water has kinetic energy. This flowing water is made to run through the pipes to turn big wheels. These wheels turn engines called generators which generate electricity. When electricity is passed through an electric bell, an electric bulb and an electric kettle, sound energy, light energy and heat energy will be produced respectively. Thus, we conclude that energy can be transformed from one form to another as per our requirement and the form of energy attained can also be identified.

As such, the quantity of energy in this universe remains constant. Therefore, the total sum of mass and energy in this universe is a conserved quantity. This is known as the **law of conservation of mass and energy.**

Examples of Transformation of Energy

1. Photosynthesis	Light energy to chemical energy
2. Table fan	Electrical to mechanical energy
3. Tubes and bulbs	Electrical to light energy
4. Door bell	Electrical to sound energy
5. Electrical motor	Electrical to mechanical energy
6. Dry cell	Chemical to electrical energy
7. Heater	Electrical to heat energy
8. Loudspeaker	Electrical to sound energy
9. Microphone	Sound to electrical energy
10. Electromagnet	Electrical to magnetic energy
11. Washing machine	Electrical to mechanical energy
12. Mixer grinder	Electrical to mechanical energy
13. Generator	Mechanical to electrical energy
14. Solar cell	Light to electrical energy
15. Burning of wood, coal and candle	Chemical to heat energy
16. Windmill	Mechanical to electrical energy
17. Photo voltaic cell	Light to electrical energy
18. Steam engine	Heat to mechanical energy
19. Biogas	Chemical to heat energy
20. Automobile engine	Chemical to mechanical energy
21. Cooking gas (LPG)	Chemical to heat energy
22. Television	Electrical energy to sound and light energy
23. Car	Chemical energy into thermal and mechanical energy.
24. Campfires	Chemical energy into thermal energy.

(a) Photosynthesis (light energy → chemical energy of food)

(b) Bursting of fireworks (chemical energy → heat, light and sound energy)

(c) Electric bulb (electrical energy → light energy)

(d) Loudspeaker (electrical energy → sound energy)

(e) Table fan (electrical energy → kinetic energy)

(f) Physical exercise (chemical energy of food → muscular energy)

Fig. 5.14 Various modes of transformation of energy

> **Knowledge bank**
>
> Scientists are trying to use solar energy instead of conventional fuels. Solar energy is available to us in huge quantities, whereas the quantity of fuels is limited. Besides, the use of solar energy does not cause any pollution.

SOURCES OF ENERGY

We get energy from various sources. The main sources of energy are solar energy, flowing water, wind, biomass, fossil fuels, sea waves, nucleus of atom, *etc*.

Sources of energy : Conventional sources — You know that living things get energy from food. Plants are the main food for human beings as well as animals. Hence, **plants are an important source of energy**. Energy is stored in plants in the form of chemical energy.

Wood, obtained from plants, has been used down the ages as a fuel. The chemical energy stored in wood is released in the form of light and heat on burning. Coal and petroleum store solar energy in the form of chemical energy.

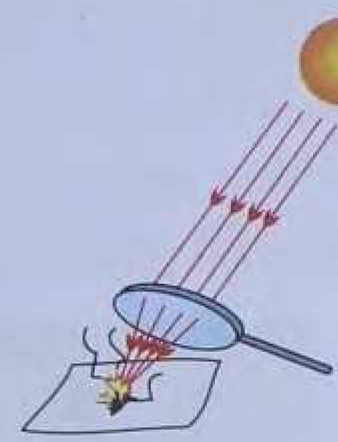
We have been using all these sources of energy as fuel since a long time ago. That is why, they are known as **conventional sources of energy**.

> The deposits of these fuels found inside the earth are limited. Their use is increasing day by day. Hence, there is the danger that they will run out. It will be wise to use alternative sources of energy to supplement the use of conventional sources.

Sources of energy : Non-conventional

1. **Solar energy** — We get heat and light from the sun. In fact, it is the main never-ending source of energy. It can be used to produce energy. We can make use of **solar energy** for our daily needs by using devices such as the solar heater, the solar electric cell, solar cooker, etc.

Try this : Take a convex lens. Hold it over a piece of paper in sunlight. Now, adjust the position of the lens so that you see only a tiny spot of sunlight on the paper. Hold the lens and the paper in this position for some time. In a minute or two, you will see that the paper begins to burn at the place where sunlight passing through the lens is focused on it. What does this tell us ?



Sunlight contains heat energy. The lens causes the sunlight to focus at one point. That is why, the paper begins to burn there.

The blowing of wind and water cycle are also caused due to solar energy. Solar cells, solar cookers, solar furnaces, all work because of solar energy.

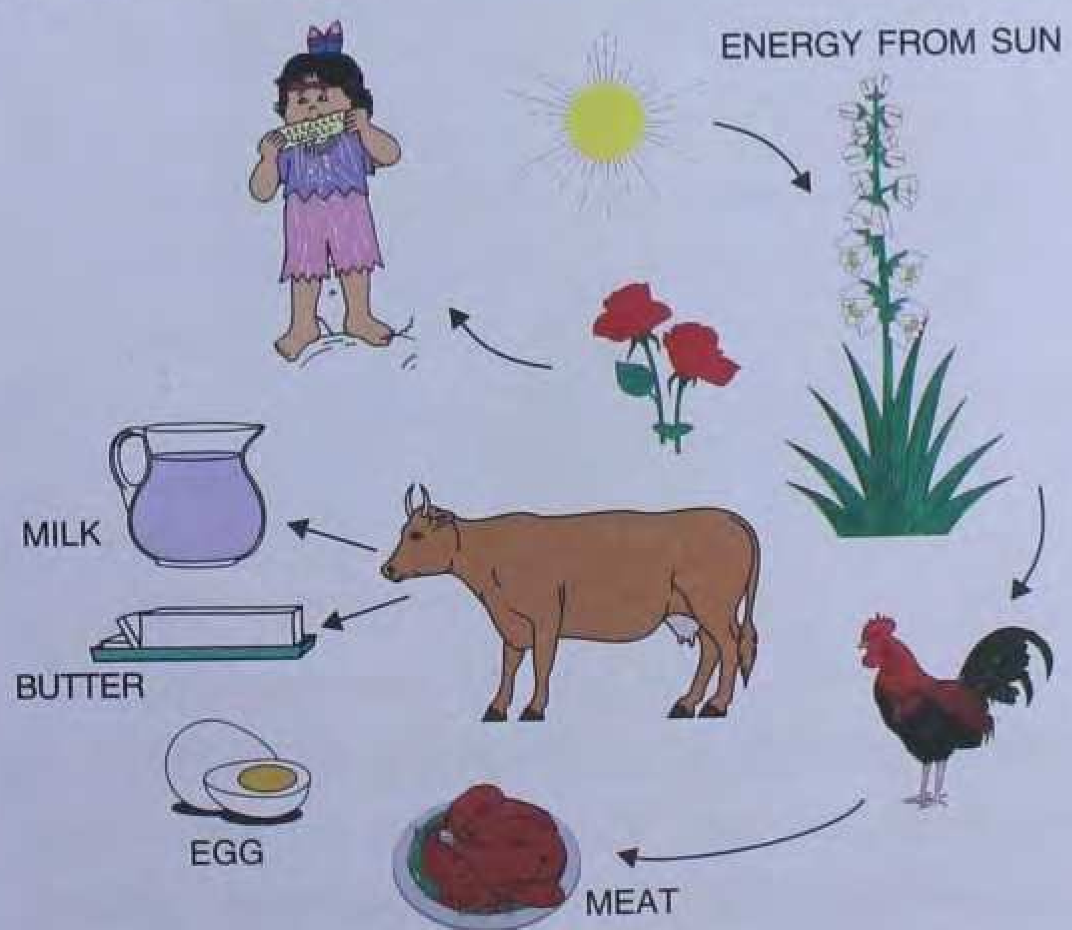


Fig. 5.15 Sun is the ultimate source of energy

2. **Energy from flowing water :** Flowing water is an important source of energy. Water collected in dams is made to flow through the special channels thereby changing potential energy into kinetic energy. This water with kinetic energy is allowed to fall on the plates of turbines which convert it into electrical energy. This electricity produced by water is called **hydro-electricity**.

Fig. 5.16 Energy from flowing water

3. **Energy from wind :** Strong winds are also a good source of energy.

Fig. 5.17 A windmill runs on wind energy

The kinetic energy of the moving air (called wind) is called wind energy.

- Wind energy is used for pumping out underground water, grinding of grains such as wheat, grams, maize, etc. by using wind mills.
- Wind energy also helps in the movements of gliders, parachutes and aeroplanes.
- A windmill can be used for running a water pump, for grinding grains and to generate electricity.
- Sailing boats also use wind as the source of energy.

4. **Energy from biomass :** Biomass is actually a mixture of dried leaves, cow dung or any other non-used product of plant or animal origin. The biomass is converted into biogas in biogas plants. Biogas is a clean and cheap fuel and is almost free from smoke and air pollution. It is actually a mixture of methane (65%), carbon dioxide and hydrogen. It can be widely used in villages. This is a form of chemical energy.

Fig. 5.18 Biogas plant

5. **Energy from fossil fuels :** Coal, petrol, kerosene and diesel possess chemical energy. On burning, the chemical energy stored in them can be converted into heat, light and sound energy. The chemical energy in fossil gives large amount of heat energy.

Example : Non-renewable resources — fossil fuels (coal, petroleum) natural gas (L.P.G. and C.N.G.), etc.

Renewable sources — Solar energy, tidal energy, hydroelectric energy, wind energy, geothermal energy and energy obtained from wood.

6. **Energy from sea waves :** Sea waves are also an important source of energy. They constantly hit the sea shore. Methods have been developed by which the energy of sea waves can be used to turn a turbine to produce electrical energy.

ENERGY CHAINS

If we have to do work, we need food. Our food is just like petrol to a car. Food supplies energy to us just as petrol supplies energy to the car.

Let us think of ourselves first. We get our energy from the food we eat. We eat plant and animal parts or their products as food. Animals too get their energy from plants. Therefore, all the energy we get from our food is present in the plants. Where did the plants get it from ?

Plants are dependent on sunlight for photosynthesis. So, we can say that we are solely dependent upon one source for all our energy – the Sun.

There are two sources from where we get energy, one is renewable sources like sun, wind, water, etc. which will never end and the other important source is the non-renewable sources like coal, fossil fuel, *etc*. The non-renewable sources will be consumed in the coming years and we are going to face the shortage of electricity, petrol, diesel, etc. since they are produced from these sources.

Hence, we should be very careful in using such energy and should not waste it in any form.

Knowledge bank

Our survival on the earth depends on the things that our environment provides us. Important among these are air, water, soil, food, fuels, materials for clothes and materials for building houses. These are known as natural resources. Natural resources must be conserved otherwise they will disappear.

HOW TO SAVE ENERGY ?

1. Use solar cooker to save cooking gas.
2. Electrical energy is used to purify water. So, do not waste water.
3. Switch off fans, lights and other electrical appliances, when not in use.
4. Save petrol, diesel wherever possible. Do not drive vehicles unnecessarily.
5. Heaters, air-conditioners and desert coolers should be used only when necessary.
6. Use compact fluorescent lights (CFL) and LED lights. They consume less electricity and last upto 10 times longer than the ordinary bulbs.
7. Refrigrator accounts for 11 percent of a household's total energy consumption. Today's energy efficient refrigrators use 50 percent less energy than old models.
8. Using a microwave oven instead of a conventional oven can save 50 percent of cooking energy costs.
9. Iron clothes in bulk once a week.
10. Unplug any battery chargers or power adapters when not in use.
11. Use laptop computers since they use up to 90 percent less energy than a standard computer.
12. Implement paper-reducing strategies, such as double-sided printing, reusing paper and using e-mail instead of sending memos or faxing documents to save energy and conserve other resources.

13. Make sure that bulb, lamps, lenses, etc. are regularly cleaned. By removing the grease, dust and other dirt, you can increase the output of your lights.

WORK AND ENERGY

Work and energy are very common terms used in our day-to-day life. You get tired after your whole day activities and you are unable to do any more work. So, we say that you do not have any more energy left in your body to do more work. Thus, energy and ability to do work are related to each other. Without using energy, we cannot perform any work.

In figure 5.19, a force of 1 N is applied and the box is displaced by 1 m. Then, 1 joule of work is said to be done.

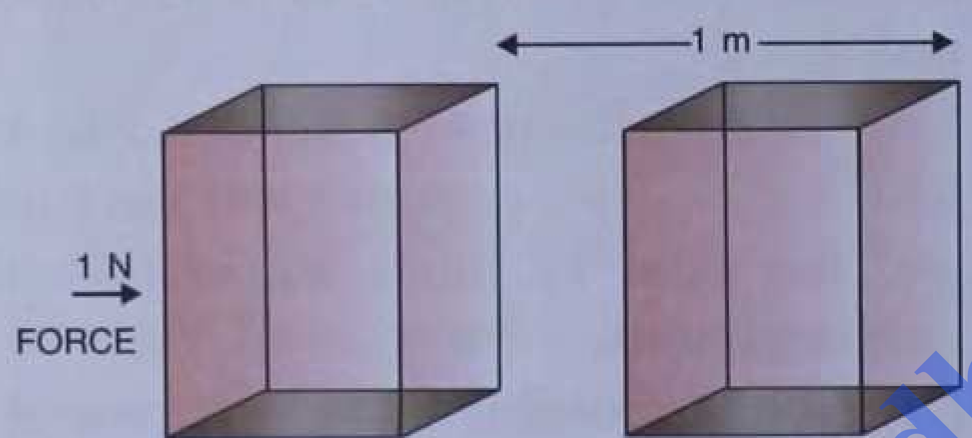


Fig. 5.19 1 joule work is done

Intext Questions

1. Name the various forms of energy.
2. From where does nuclear energy generate and what is its use ?
3. What can we generate from the flowing water ?
4. How can you prove that all kinds of energies come from the Sun ?

Example 1 : Calculate the work done by a machine to displace a load of 520 N through a distance of 5200 cm.

Solution :

Given F = 520 N

Distance moved in the direction of force

= 5200 cm = 52 m

Work = Force × Distance moved in the direction of force

= 520 N × 52 m

= 27040 Joule

Example 2 : The mass of a body is 20 kg. It is moving with a velocity of 10 m/s. What is its kinetic energy ?

Solution :

Mass (m) = 20 kg, velocity (v) = 10 m/s

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

$$= \frac{1}{2} \times 20 \times (10)^2 \text{ J}$$

$$= 10 \times 100 \text{ J} = 1000 \text{ J}$$

When mass (m) is in kg and velocity (v) is in m/s; K.E. is in joule (J).

Example 3 : A bullet of mass 40 gms has a K.E. of 200 J. What is its velocity ?

Solution :

Given K.E. = 200 J,

$$\text{mass } m = 40 \text{ gm} = \frac{40}{1000} \text{ kg}$$

$$\text{Since, } K.E. = \frac{1}{2} mv^2$$

$$\therefore \quad v^2 = \frac{2 \times K.E.}{m}$$

$$v^2 = \frac{2 \times 200}{\frac{40}{1000}}$$

$$v^2 = 2 \times 200 \times \frac{1000}{40} = 10000$$

$$\therefore \quad v = \sqrt{10000} \text{ m/s} = 100 \text{ m/s}$$

When K.E. is in J and mass in kg, velocity is in m/s.

Example 4 : What is the potential energy of a stone of mass 10 kg. Which is lifted to a height of 8 m, if $g = 10\ m/s^2$.

Solution :

Given $m = 10$ kg, $g = 10\ m/s^2$, $h = 8$ m

$$\begin{aligned} P.E. &= mgh \\ &= 10\ kg \times 10\ m/s^2 \times 8\ m \\ &= 100\ N \times 8\ m \\ &= 800\ Joule \end{aligned}$$

TEST YOURSELF

A. Short Answer Questions

1. State whether the following statements are ***true*** or ***false*** :
   (a) We work when we push a wall.
   (b) Squeezing of rubber ball is a kind of work.
   (c) Stored-up energy is called kinetic energy.
   (d) Unit of energy is joule.
   (e) Coal and petroleum are stored forms of chemical energy.

2. Fill in the blanks :
   (a) An electric fan converts electrical energy into .... energy.
   (b) Cooking gas converts .... energy into heat energy.
   (c) Energy possessed by a compressed spring is .... energy.
   (d) The ability to do work is called ....
   (e) The energy possessed by a body due to its position is called .... energy.
   (f) The energy possessed by a body due to its motion is called .... energy.
   (g) Green plants convert .... energy into chemical energy.
   (h) The source of energy in a solar heater is the Sun's .... energy.
   (i) An object falling freely from the roof of a multistorey building has .... and .... energy halfway down the building.

3. Match the following columns :

Column A	*Column B*
(a) running water	(i) heat energy
(b) L.P.G.	(ii) vibrations
(c) work	(iii) atoms
(d) sound energy	(iv) kinetic energy
(e) nuclear energy	(v) Nm

4. Tick the correct answer :
   (a) What will happen to the kinetic energy of a body (when the weight remains the same) if :
   (i) its velocity is doubled.
   (ii) its velocity is halved ?
   (b) What will happen to the potential energy of a body (when the height is kept the same) if :
   (i) its mass is doubled.
   (ii) its mass is halved ?
   (c) The ultimate source of energy is
   (i) sun (ii) coal
   (iii) petroleum (iv) wind
   (d) Energy chain consists of
   (i) fossil fuels (ii) solar energy
   (iii) wind energy (iv) all of the above
   (e) The S.I. unit of work is :
   (i) second (ii) metre
   (iii) joule (iv) newton
   (f) If *two* teams play tug-of-war and both pull with equal forces, then

(i) no work is done

(ii) work is said to be done

(iii) double work is done

(iv) none of these

(g) Which is not a renewable source of fuel?

(i) geothermal (ii) wood

(iii) coal (iv) solar

(h) According to law of conservation of energy, energy changes from one form to another form, but the total energy of that system

(i) increase (ii) decrease

(iii) alternates (iv) remains the same

5. Answer the following questions :

(a) What do you mean by the term work ?

(b) What is the S.I. unit of work ?

(c) When do we say that the work is done?

(d) State the factors on which the work done on the body depends.

(e) State how the work is related to energy?

(f) When we climb stairs, do we do any work ? What energy change is taking place here ?

(g) What is meant by the term energy ?

(h) Define the following :

(i) Kinetic energy

(ii) Potential energy

(i) Give *one* relevant example for each of the following transformations of energy :

(i) Electrical energy to heat energy.

(ii) Electrical energy to mechanical energy.

(iii) Electrical energy to light energy.

(iv) Chemical energy to heat energy.

(v) Chemical energy to light energy.

(j) Give *one* example each of work done by the following forms of energy.

(i) mechanical energy

(ii) heat energy

(iii) electrical energy

(iv) chemical energy

B. Long Answer Questions :

1. Give reasons for the following :

(a) No work is done if a man is pushing against a wall.

(b) Hammer drives a nail into wood only when lifted and then struck.

(c) A horse and a dog are running with the same speed. One of them has more kinetic energy.

(d) A teacher moving around in the class is doing work but a child standing and reading a book is not doing any work.

2. Why do we need energy in our day-to-day life?

3. How does a battery operated toy cause movement of the toy ?

4. Explain with the help of an example, how is magnetism a form of energy ?

5. How can you prove that light is a form of energy ?

6. The Sun is the ultimate source of energy. Comment on this statement.

7. What are the factors on which the amount of kinetic energy and potential energy depend ?

8. Give *five* methods to save energy.

RECAPITULATION

- In the language of Physics, work is said to be done if there is displacement of a body on the application of force.
- The S.I. unit of work is joule (J).
- Work is calculated as the product of force (F) applied and the displacement(S) produced thereby. The other unit of work is kgf × m where 1 kgf × 1 m = 9·8 joule.
- The energy of a body is its ability or capacity to do work.
- Energy exists in nature in many forms.
- The energy possessed by a body by virtue of its position is called potential energy. $PE = mgh$.
- The energy possessed by a body by virtue of its motion is called kinetic energy $KE = \frac{1}{2} mv^2$.
- Mechanical energy is equal to the sum of potential energy and kinetic energy.
- Solar energy runs solar cells, solar heaters, solar cookers, solar furnaces, *etc*.
- Some of the renewable sources of energy are the sun, wind, water, *etc*.
- Some of the non-renewable sources of energy are coal, petrol, diesel, kerosene, *etc*. They cause pollution.

Project Work

1. Make a list of 20 objects you see around yourself and note down the energy transformation in them.
2. Make a list of 10 objects which use electrical energy. For each object (or appliance) note down which energy is produced from electricity.