



CHAPTER – 9

Work, Energy And Power

In the previous chapters we have learnt about the ways of describing the motion of objects, the cause of motion of the objects and the universal gravitation. In this chapter we shall study about "work" which is a natural phenomenon and is closely related to energy and power. The term "work" has different meanings. For example — Mr Tomba is working in a factory; Jahera is a great work of Angahal; the machine is in working order; there are a number of worked out problems in this book; let us work out a plan for the next year etc. However in physics the term 'work' has a special meaning. It represents a physical quantity defined in a special way. When an object moves under an applied force, we say that, in physics, the force has done work on the object. When an apple falls on the earth from a tree, the force of attraction of the earth does work on the apple. When we throw a ball, push a book on a table etc we exert a force and we say that this force does work.

Living beings have to perform several basic activities to survive which are known as "life processes". Besides, we are also performing other activities like playing, singing, reading, writing, jumping, running, cycling and thinking. In performing such activities we need energy. That is why all living beings need food. Similarly, animals too get engaged in certain activities. As for example — they jump, run, fight and run away from enemies, find food etc. We also engage some animals to lift weights, carry loads, pull carts, plough fields etc. All such activities need energy which is obtained from the foods they consumed.

Over and above, the machines that we have come across need food in the form of fuels like petrol, diesel or electricity for their working. Now you know that living beings and machines need energy.

9.1 Work

You know that there is a difference in the way we use the term work in day-to-day life and the way we denote it in science. In order to make this point clear let us consider a few more examples.

Suppose a student is preparing for examination. He spend a lot of time in reading books, drawing diagrams, collecting question papers, discussing problems with his friends, performing experiments etc. In doing so, he spends a lot of energy. In common parlance we use to say he is working very hard. If we go by the scientific definition of work, the hardwork of the student may involve very little work.

In other case suppose, you are trying to push a huge rock or a loaded truck. If the truck or rock does not move inspite of all your effort, for which you get completely exhausted, you have not done any work scientifically since there is no displacement of the objects that you are pushing. Similarly, when you stand still with a load on your head you get tired. In this situation you have exerted yourself and have spent a lot of your energy. According to the way we understand the term 'work' in science, you are not doing any work on the load.

In other activities like climbing up the steps of a staircase, a tall tree, if we apply the scientific definition, these involve a lot of work.

Now, you have learnt that many activities in our day to day life although being considered as work, are not considered as work scientifically. That is why the term work in science is defined in a different way. To understand the way for defining work in science, let us do the following activity.

Activity 9.1.

Out of the activities discussed so far in the above and considered to be work, try to ask the following questions and also try to give the answer.

- (i) What is the work being done on?
- (ii) What happens to the object?
- (iii) Who or what is doing the work?

9.1.1 Scientific definition of work

Let us try to understand the way in which we view '**work**' and we define it from the point of view of science.

A closer look at the above examples reveals that two conditions are essential for work to be done. They are (i) a force should act on an object (ii) the object i.e. point of application of the force must be displaced. If any one of the conditions does not exist, work is not done. For example, when a boy pushes a book on the table we say that the boy has done a work on the book. The work, however, is done by the force exerted by the boy who is the agent.

Activity9.2.

Consider some situations that you have seen in your daily life involving work and try to list them into two groups as (1) involving displacement (2) not involving displacement.

Definition of work

The work done by a force acting on an object is equal to the product of the force and displacement of the object in the direction of force.

9.1.2 Calculation of Work Done by a Constant Force

Let a constant force ' F ' act on an object and the object be displaced through a distance ' s ' along the direction of the force as shown in (Fig.9.1). If W is assumed to be the work done by the force on the object, then from,

Work done = Force $\times$ Displacement, we get
 $W = Fs$(9.1)

Thus work done is equal to the product of magnitude of the applied force by the distance moved in the direction of the force. Hence, work has only magnitude but not direction.

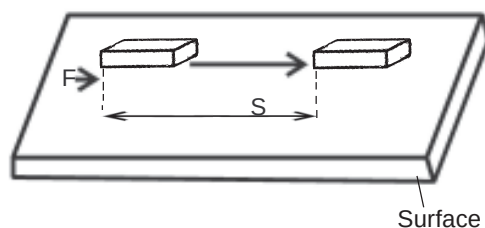


Fig. 9.1

If $F = 1 \text{ N}$ and $s = 1 \text{ m}$ then W will be 1 Nm or joule (J). This is given a separate name 'joule' in honour of the British scientist James Prescott Joule. It is denoted by the letter 'J'. Examine the Fig. (9.1) carefully. What will be the work done when the force 'F' on the object is zero? What will be the work done when the displacement of the object is zero? Thus, it can be referred to the conditions that are to be satisfied to say that a work is done by the force.

Let us consider another example i.e. when the displacement is opposite to the direction of force. If a ball is thrown up, its displacement is in the upward direction whereas the force due to the earth's gravity is in the downward direction. We can say that the angle between the two directions is 180° . In such a situation the work done by the force of gravity i.e. force 'F' is taken as negative. Thus the amount of work done by the force on the object is

$$W = F \times (-s) \text{ or } (-F) \times s.$$

Now, it is clear from the above discussions that work done by a force can be either positive or negative. Let us try to understand the above fact from the following activity.

Activity 9.3.

Suppose, you are lifting a suitcase from ground floor to the first floor of your house or to a greater height. Work is done by the force exerted by you on the suitcase. So it moves upwards. The force you exerted is in the direction of displacement. However there is the force of gravity acting on the suitcase. Using the principle that work done is negative when the force acts opposite to the direction of displacements and positive when the force is in the direction of the displacement, which one of the forces is doing positive work and which one is doing negative work; give reasons.

Example 9.1

A man lifts a luggage of 25 kg from the ground and puts it on a floor 2.0 m above the ground. Calculate the work done by him on the luggage.

Solution:

Mass of the luggage, $m = 25 \text{ kg}$; displacement $s = 2.0 \text{ m}$.

The weight of the luggage $= mg = 25 \text{ kg} \times 9.8 \text{ ms}^{-2}$

Work done by the man, $W = F \times s = mg \times s$

$$\therefore W = 25 \text{ kg} \times 9.8 \text{ ms}^{-2} \times 2 \text{ m} = 490 \text{ kgms}^{-2} = 490 \text{ Nm} \\ = 490 \text{ J.}$$

The work done by the man $= 490 \text{ J}$.

Try to Answer:

1. When do we say that work is done by a force?
2. What is the expression for the work done when a force is acting on an object in the direction of displacement?
3. What is 1 J of work?

4. In ploughing a paddy field, a pair of bullocks exerts a force of 200 N together. If the length of field is 50 m, how much work is done in the process?

9.2 Energy

Life processes are not possible without energy. It is known that the demand of energy is ever increasing. Where do we get energy from? The biggest energy source for us is the Sun. Most of our energy sources are derived from the Sun. We can also get energy from the nucleus of atoms, the interior of the earth and the tides. Can you imagine the other sources of energy?

Activity 9.4.

A few sources of energy are cited above. There are many other sources of energy and try to list them. Discuss among your friends to identify sources of energy due to the Sun and those not due to the Sun.

The word 'energy' is very often used in our daily life by many but in science it carries a definite meaning. Let us discuss some examples.

When a fast moving object like a cricket ball hits a wicket, it is thrown away. Similarly, when objects are raised to a certain height possess capability to perform work, proportional to the heights to which they are raised. In another example water falling from a great height has the capability to rotate turbines connected to an electric generator. You must have seen that when a raised hammer hits a nail placed on a piece of wood, it drives the nail into the wood. We have also observed that when the spring of a toy car is wound and then released, the car starts moving, on the floor. When we press an inflated balloon, we observe that there is change in its original shape which will come back when the pressing force is released or withdrawn. However if we press still hard, the balloon may explode producing a blasting sound. In all the above examples, the objects acquire through different means, the capacity for doing work. Any object having capability to do work is said to possess energy. The objects which do work lose energy whereas the objects on which work is done gain energy.

Let us examine how does an object with energy do work? The object that possesses energy can exert a force on other object. When this is happened, energy is transferred from the former to the latter. The second body may move as it receives energy and therefore do some work. This implies that any object that possesses energy can do work. The energy possessed by a body is measured in terms of its capacity for doing work. The unit of energy is thus the same as that of work done which is in joule (J) in SI-system. Some times, still larger units kilojoule (kJ) or mega joule (MJ) is also used to express the energy possessed by an object ($1\text{kJ} = 1000\text{ J}$; $1\text{ MJ} = 10^6\text{ J}$).

9.2.1 Different Forms of Energy

We get energy in different forms. The various forms include mechanical energy (kinetic energy and potential energy), heat energy, chemical energy, electrical energy, light energy, sound energy.

9.2.2 Kinetic Energy

Activity 9.5

Take a heavy but small iron ball and drop it from different heights on mud starting from a lowest height. The ball will create a depression on mud. Increase the height from where the ball is dropped and observe the depth of the depression. Compare the depths and find out the shallowest and deepest.

Discuss and analyse the observations.

Activity 9.6

Set up the experimental arrangement as shown in Fig.9.2. Place a wooden block B of known mass slightly at the left side of pegs D and C whose distance apart is less than the dimension of block A so that, in any case, A can not go beyond CD but the block B can pass through. Keep a heavy metal block on A and place a known mass on the pan so that A will move when the metal block is removed from A.

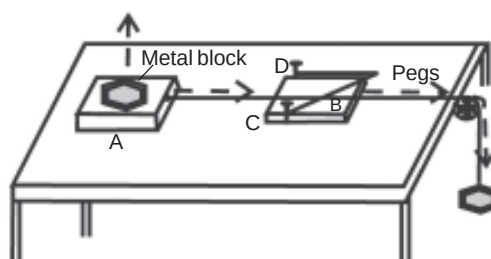


Fig. 9.2

Remove the metal block and note down the displacement of B. This means that work is done on block B as it gains energy.

From where does this energy come?

Repeat the activity by increasing the mass on the pan. Check in which case the displacement of B is larger.

In this activity you know that the moving block A does work and it possesses energy.

You can understand from the above that a moving object can do work. An object moving faster can do more work than an object of identical mass moving relatively slow. We have seen already in our daily life that blowing wind can rotate the blades of a windmill, a moving bullet fired from a gun can pierce a target; moving water can rotate a turbine etc. These observations show that objects in motion possess energy which enables them to do work. We call this energy as kinetic energy. In short, the energy possessed by an object due to its motion is called *kinetic energy*. By definition we say that 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.

Let us try to express how much kinetic energy is possessed by a moving object, in the form of an equation. Let us consider an object of mass ' m ' moving with a uniform velocity ' u '. Let it now be displaced through a distance s when a constant force ' F ' acts on it in the direction of displacement.

From Eq. (9.1), work done W is $(F \times s)$ and this work done will cause a change in its velocity since the force is the cause of acceleration. Let ' a ' be the acceleration produced, changing the velocity from ' u ' to ' v '.

From $v^2 - u^2 = 2as$, we get

$$s = \frac{v^2 - u^2}{2a} \dots\dots\dots(9.2)$$

We also know that the force $F = ma$. After putting 's' in Eq. (9.1) we can write the work done by the force F as

$$\begin{aligned} W &= ma \times \frac{v^2 - u^2}{2a} \\ &= \frac{1}{2} m(v^2 - u^2) \dots\dots\dots (9.3) \end{aligned}$$

If the object were starting from stationary position then

$$u = 0 \quad \text{and} \quad W = = \frac{1}{2} mv^2 \dots\dots\dots(9.4)$$

Thus the kinetic energy possessed by a body of mass 'm' moving with a uniform velocity 'v' at any instant of time is

$$E_k = \frac{1}{2} mv^2 \dots\dots\dots(9.5)$$

Example 9.2

Suppose a car of mass 2500 kg was moving at a uniform velocity 18 km h⁻¹. What is the work to be done by its engine to increase its velocity to 36 km/h.

Solution:

Mass of the car, $m = 2500$ kg

$$\begin{aligned} \text{Its initial velocity, } u &= 18 \text{ kmh}^{-1} = \frac{18 \times 1000}{260 \times 60} \text{ ms}^{-1} \\ &= 5 \text{ ms}^{-1} \end{aligned}$$

$$\text{Similarly, the final velocity } v = 36 \text{ kmh}^{-1} = \frac{36 \times 1000}{60 \times 60} = 10 \text{ ms}^{-1}$$

Thus the initial kinetic energy

$$E_{ki} = \frac{1}{2} mu^2 = \frac{1}{2} \times 2500 \times 5^2 \text{ J.}$$

And the final kinetic energy

$$E_{kf} = \frac{1}{2} mv^2 = \frac{1}{2} \times 2500 \times 10^2 \text{ J.}$$

Therefore the require work to be done

$$\begin{aligned} &= E_{kf} - E_{ki} = \frac{1}{2} \times 2500 \times 10^2 - \frac{1}{2} \times 2500 \times 5^2 = \frac{1}{2} 2500 (100 - 25) \\ &= \frac{1}{2} \times 2500 \times 75 = 1250 \times 75 = 93750 \text{ J.} \end{aligned}$$

Try to answer:

1. What is kinetic energy of an object?

9.2.3 Potential Energy

Let us perform some experiment to understand the nature of potential energy possessed by an object.

Activity 9.6

Stretch a rubber band using your hands. Release the band at one of its ends. What happens? The band will regain its original length, because it had acquired energy in its stretched position. How is this energy acquired by stretching?

Activity 9.7

Wind the spring of a toy car with the help of its key to a certain number of rotation and then place it on the floor. Did it move? From where did it acquire energy for the motion? Does the energy acquired depend on the number of windings? Try to test it.

Activity 9.8

Take the spring from a ballpen and compress it. Now release the spring slowly. What happens? How did the spring acquire energy when compressed? Would the spring acquire energy when it is stretched?

Activity 9.9

Lift a marble to a height 'h' and then release on a hard floor. It will certainly fall. After striking the floor, see what happens? It begins to jump to a height vertically. Measure the height attained by it. Repeat by lifting the same marble to a height higher than 'h'. Measure the height through which it jumps from the same floor. Think and discuss.

In the above activities, the energy gets stored due to work done on the objects. You supply energy when you stretch a rubber band or in compressing the spring. The energy supplied in each case is the potential energy since the energy is not used to cause change in velocity or speed of the object.

Similarly, you are doing work while winding the spring of the toy car. The energy supplied while winding the spring is stored as potential energy present in it by virtue of its configuration.

Activity 9.10

Prepare a bow using a bamboo stick as shown in Fig.9.3. and place an arrow made of light and straight stick as shown in the Fig.9.3. Now stretch the string with the arrow in position and then release the arrow. See the motion of the arrow flying off the bow and notice change in the shape of the bow in the two cases i.e. while stretching and on releasing. The potential energy stored in the bow due to the change in configuration is thus used in imparting kinetic energy to the arrow.

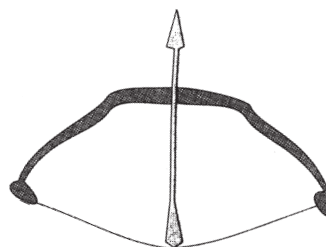


Fig.9.3. Bow and arrow

9.2.4 Potential Energy of an object at a height

The potential energy of an object increases when it is raised from a lower level to a higher level because of work done on it against the gravity while it is being raised. The energy possessed by such an object is called the *gravitational potential energy*. The gravitational potential energy of an object at a point above the ground is defined as the work done by the agent on the object in raising it against the gravity of the earth.

Let us try to obtain an expression of potential energy in the above situation.

Consider an object, say a stone, of mass ' m ' raised through a height ' h ' from the ground. The minimum force required to raise is equal to its weight ' mg '. The object gains energy equal to the work done on it. Let the work done be W .

Thus, work done, $W = \text{force} \times \text{displacement}$

$$= mg \times h$$

$$= mgh = \text{energy gained by the object, since the work is done on it.}$$

This is the potential energy of the object at a height ' h ' above the ground.

$$\text{That is, } E_p = mgh \dots\dots\dots(9.6)$$

If ' m ' is in kg; g is in ms^{-2} and ' h ' is in ' m ' then E_p is in ' J ' (joule). It is to be noted that workdone against the gravity is independent of the path but depends only on the initial and final positions of the object. Fig.9.4 shows a case where a block is raised from position A on the ground to a position B above by following two different paths to a height ' h '.

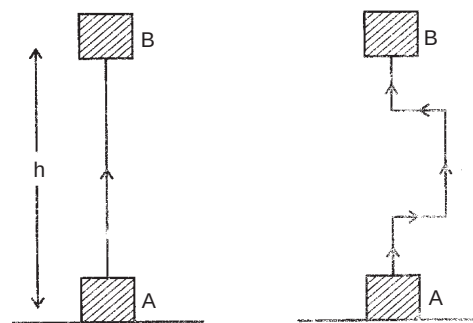


Fig.9.4

Example 9.3

Find the potential energy possessed by an object of mass 15 kg when it is raised to a height of 10 m above the ground. Given $g = 9.8 \text{ ms}^{-2}$.

Solution:

Mass of the object, $m = 15 \text{ kg}$; displacement or height raised $h = 10 \text{ m}$.

$$\begin{aligned} \text{Potential energy} &= mgh = 15 \text{ kg} \times 9.8 \text{ ms}^{-2} \times 10 \text{ m} \\ &= 1470 \text{ J.} \end{aligned}$$

Thus the potential energy = 1470 J.

9.2.5 Interconvertibility of Various Forms of Energy

Can we convert energy from one form into another? We have observed in nature a number of instances of conversion of energy from one form to another or others. You can get some idea about the conversion of energy of one form into another form from the following activities:

Activity 9.11

Discuss the following questions with your friends and try to answer:

1. How do green plants produce food to keep them alive?
2. From where do they get the required energy?
3. What kinds of energy conversions are there in the water cycle in nature?
4. What makes the air move from one place to another place?

Activity 9.12

You have seen a number of gadgets used in our daily life. Such gadgets involve the conversion of energy from one form to another for their working. Prepare a list of such gadgets and their activities. Identify them based on the kind of energy conversion that takes place for working them.

9.2.6 Law of Conservation of Energy

You must have learnt that, from the above activities, energy can be transformed from one form to another. At the same time you may ask a question — "What about the total quantity of the different forms of energy"? For the answer to this question, you should remember that — "Whenever energy gets transformed, the total energy remains unchanged". This is the universal law of conservation of energy. According to this law, energy can never be created nor destroyed but total energy before and after the transformation remains the same. It means that when all forms of energy are taken into account, the sum total of energy in the universe is constant. This principle is also valid for an isolated system i.e. any system where no force acts from any agent.

Let us consider a simple example with a ball falling from a height. Its gravitational potential energy decreases as it falls. It may appear that its energy has been lost. But the ball comes into motion and hence it acquires kinetic energy which was zero at the beginning.

Suppose the mass of the ball is 'm' and it is made to fall from a height 'h' above the ground where it is at rest. The total energy of the ball at the start is 'mgh'. As it falls, its potential energy will change into kinetic energy. If 'v' is its velocity at any instant when it falls through a distance 'x' from the starting point, then its potential energy is $mg(h - x)$ and $v^2 - u^2 = 2gx$.

But $u = 0$, then $v^2 = 2gx$(9.6)

Thus its kinetic energy at that point is $\frac{1}{2} mv^2 = \frac{1}{2} m2gx = mgx$(9.7)

Therefore its total energy at the instant is $mg(h - x) + mgx = mgh$, which is the total energy at the beginning of fall.

Further, if 'v' is the velocity of the ball when it just touches the ground i.e. after falling through the height h then from above its potential energy is zero (since $x = h$) and $v'^2 = 2gh$ for which its kinetic energy becomes $\frac{1}{2} mv'^2 = \frac{1}{2} m \cdot 2gh = mgh$

Thus total energy at the ground = potential energy at the ground + its kinetic energy

at the ground = $mgh + 0 = mgh$, which is also the total mechanical energy at the beginning of fall.

From the above you have seen that during the falling of the ball, the decrease in potential energy at any point of its path, appears as an equal amount of increase in its kinetic energy. Thus there is a continuous transformation of gravitational potential energy into the kinetic energy.

Let us discuss some more examples on transformation of energy. (i) When we switch on an electric torch the electrical energy derived from the chemical energy stored in the cells (batteries) is converted into heat energy as the filament of the bulb gets heated and heat energy is then transformed into light energy. (2) When a person pushes an object, the energy of the object increases. As the total energy is constant, the person must lose the same amount of energy. That is why when we push a block on a floor, we feel tired. Here, we do work on the block and hence lose our own energy.

Think it over! If the transformation of energy were not happened in the nature, life could not have been possible. Do you agree with this?

9.3 Rate of Doing Work

Activity 9.13

Consider two persons i.e. you and your friend having the same body weight, have to climb to the top of a small hillock of height 10 m (say). Let us say that you take 20 s while your friend takes 25 s, to arrive at the top following the same path.

What is the work done by each? Work done is the same since both have the same body weight. But you take less time than your friend.

Who has done more work in 1s?

You will know that you are doing more work in 1s. In this way all the machines consume or transfer energy at different rates. Agents that transfer energy do work at different rates. Thus a more powerful vehicle could complete a journey in a shorter time than a less powerful one. Thus we classify machines like motor-bikes and trucks of more or less power based on the speed of doing work. In fact, power measures the speed of work done i.e. how fast or slow work is done by.

Power is defined as the rate of doing work or the rate of transfer of energy. If an agent does 'w' amount of work in time 't', then its power is given by the relation: (Power = work/time)

$$\text{or } p = \frac{w}{t} \dots\dots\dots(9.8)$$

The unit of power in SI-unit is watt [in honour of James Watt (1736 – 1819)] having the symbol 'W'. Thus 1 W is the power of an agent which works at the rate of 1 joule per second i.e. $1W = 1Js^{-1}$

We use larger rates of energy transfer or power in kilowatt (kW) or megawatt (MW)

1 kilowatt = 1000 watt = $1000 Js^{-1}$

1 megawatt = 1000000 watt = $1000000 Js^{-1}$

In practice an agent may be doing work at different rates for different intervals of time. In such situation, average power is useful. The average power of an agent is obtained by dividing the total power consumed by the total time taken.

9.3.1 Commercial Unit of Energy

Since the unit joule (J) used for measurement of energy is too small, it is inconvenient to express large quantity of energy. As a result a bigger unit called kilowatt hour is used. The symbol for kilowatt hour is (kWh).

Suppose a machine uses 1000 J of energy every second. If this machine is continuously used for 1 hour, it will consume $1 \text{ kW} \times 1 \text{ hour}$

$$\begin{aligned}\text{So, 1 kilowatt hour} &= 1 \text{ kWh} = 1 \text{ kW} \times 1 \text{ hour} \\ &= 1000 \text{ W} \times 3600 \text{ s.} \\ &= 3.6 \times 10^6 \text{ J.}\end{aligned}$$

The unit used for measuring energy consumed in household, industries and commercial establishments are usually expressed in (kWh). Now-a-days unit of electrical energy used during a period, say, of one month, is expressed in kilowatt hour. Here, 1 unit of energy means 1 kWh.

Example 9.4

A man of mass 50 kg runs up a staircase of 20 steps in 15s. If the height of each step is 10 cm, find (i) work done by the man (2) power of the man.

Solution:

$$\text{Weight of the man} = m \times g = 50 \text{ kg} \times 9.8 \text{ ms}^{-2} = 490 \text{ N.}$$

$$\text{Height of the staircase} = 20 \times 10 \text{ cm} = 200 \text{ cm} = 2 \text{ m.}$$

$$\text{Time taken to complete the task} = 15 \text{ s.}$$

$$\text{(i) Work done by the man} = mg \times h$$

$$\Rightarrow w = 490 \text{ N} \times 2 \text{ m}$$

$$\text{Thus } w = 980 \text{ J.}$$

$$\text{(ii) Power of the man, } p = \frac{w}{t}$$

$$= \frac{980 \text{ J}}{15 \text{ s}} = 65.33 \text{ Js}^{-1} = 65.33 \text{ w.}$$

Example 9.5

An electric bulb of 100 W and a fan of 40 W are used for 10 hours per day in summer. Calculate the energy consumed by them in 30 days.

Solution:

$$\text{Power of the bulb} = 100 \text{ W}$$

$$\text{And } \text{Power of the fan} = 40 \text{ W}$$

$$\begin{aligned}\text{Total power of the bulb and the fan} &= 100 \text{ W} + 40 \text{ W} = 140 \text{ W.} \\ &= 0.14 \text{ kW.}\end{aligned}$$

Time for using them in 30 days = $10 \times 30 = 300$ hours.

Thus, energy consumed in 30 days = Power in kW $\times$ time in hour
 $= 0.14 \text{ kW} \times 300 \text{ hours}$
 $= 42 \text{ kWh}$
 $= 42 \text{ units of energy.}$

Therefore the energy consumed by the bulb and fan together is 42 units.

Activity 9.14

Make a careful observation at the electric energy meter installed in your house for the following:

Take the reading of the meter for each day at 7 am.

How many units are consumed during one day? Continue the observation for one week and make a tabulation.

Draw an inference from the data and estimate the units of electrical energy that may be consumed in a month.

Try to compare your estimated value of units with the details given in the monthly electricity bill submitted by the Electricity Department.

Points to remember

- (i). Work is said to be done by the force when a force acts on an object and the object moves in the direction of the force.
- (ii). Work done on an object by a force would be zero if the displacement of the object is zero.
- (iii). Work done on an object by the applied force is measured by the product of the magnitude of the force and distance moved by the object in the direction of the applied force.
- (iv). The unit of work done is joule.
 $1 \text{ joule} = 1 \text{ newton} \times 1 \text{ metre.}$
- (v). The capacity of an object to do work is called energy of the object. Energy and work have the same unit i.e. joule (J).
- (vi). The energy possessed by moving object is called its kinetic energy. At any instant, if a body of mass 'm' is moving with a velocity 'v' then its kinetic is $\frac{1}{2}mv^2$.
- (vii). The energy possessed by a body due to its change in position or shape is called the potential energy of the body. The gravitational potential energy of a body of mass 'm', raised through a height 'h' from the earth's surface is given by 'mgh'.
- (viii). Work done by external applied force on a body is equal to the increase in its energy.

- (ix). The sum of the kinetic energy and potential energy of body is called its mechanical energy.
- (x). Different forms of energy exist in the nature.
- (xi). Energy can be transformed from one form into other form or forms. But the total energy before and after transformation remains constant.
- (xii). Power of an agent performing work is defined as the rate of doing work. The SI unit of power is watt, $1 \text{ W} = 1 \text{ J/s}$.
- (xiii). The energy used by a machine or work done by a machine at the rate of 1 kW in one hour is called 1 kWh.

EXERCISES

1. Calculate the work done by a student in lifting a packet of books of mass 5 kg from the ground and keeping it on a shelf 1.5 m high.
(Take $g = 10 \text{ m/s}^2$). (75 J).
2. A player kicks a ball of mass 500 g placed at the centre of a football ground. The ball leaves his feet with a speed of 4 ms^{-1} . Find the work done by the player on the ball. Does it equal to the kinetic energy of the ball as it leaves?
(4 J; yes)
3. A ball of mass 2 kg is thrown upwards vertically with a speed of 4.9 ms^{-1} . (a) Find the potential energy when it reaches the highest point. (b) Calculate the maximum height it reaches.
(a) 24.01 J. (b) 1.225 m
4. A ball is thrown at a certain angle to the ground. It moves along a curve path and falls back on the ground. The initial and final positions of the path lie on the same horizontal line. What is the work done by the force of gravity on the ball?
(zero)
5. How much time an agent will take to perform 400 J of work at the rate of 20 W?
(20s)
6. Tomba does 200 J of work in 10 second and his brother Pishak does 100 J of work in 4 second. (a) Who is delivering more power? (b) Find the ratio of the powers of Tomba to that of Pishak.
(a) Pishak (b) 4:5.
7. In a certain household 500 units of energy is consumed during one month. Express it in terms of joule.
(1.8×10^9)
8. Read the situations given below carefully and reason out whether work is done or not in the light of scientific term of work.
 - (a) Kamala is swimming in a pond along a straight path.
 - (b) Tomba is standing with a load having the same weight as his weight on his head.
 - (c) Chaoba pushes a huge stone with all his strength but the rock does not move.
 - (d) A horse is carrying a load on its back and moves on a horizontal surface.

9. *The work done by the weight of a 1 kg mass while it is raised through a height of 1 m is*
(A) 9.8 J (B) – 9.8 J
(C) Zero (D) $\frac{1}{9.8}$ J. (B)
10. *When a body slides down an inclined plane, it has*
(A) only kinetic energy.
(B) only potential energy.
(C) neither kinetic nor potential energy.
(D) both kinetic and potential energies. (D)
11. *A stone of mass 2 kg falls from a height of 1 m. Its kinetic energy when it reaches the ground is*
(A) 19.6 J. (B) 10 J.
(C) 9.8 J. (D) Zero. (A)
12. *Two bodies of unequal masses are dropped from a certain height above the ground. At any point of their path, they have equal*
(A) momenta. (B) potential energy.
(C) acceleration. (D) kinetic energy. (C)