Chapter 11

Simple Machine

Points to study

11.1 Simple and Complex Machines

11.2 Types of Simple Machines

- Inclined plane
- Wheel and Axel
- Lever
- Pulley
- Wedge
- Screw

In our daily life, we perform many activities or see other people doing them such as farming, house construction, sewing, mending of iron utensils, food processing, etc. Some instruments and equipments are used to carry out these activities.

Write the name of some instruments or equipments in the following table 11.1 that are used in order to make these tasks easier.

Table 11.1

S.No.	Activities	Name of the instrument which makes it easier
1.	To shift a heavy stone to another place	Crowbar (sabbal),
2.	To go school from home	Bicycle,
3.	To sew clothes	
4.	To hold a hot object	
5.	To park a motorcycle in a raised house	
6.	To transport construction material in multi-storey buildings	

It is now clear from the above table that to do any work easily, we need certain instruments or equipments. What are these instruments or equipments called?

The instruments or equipments which are used to do any work easily, quickly and properly are known as machines.

11.1 Simple and Complex Machines

Machines can be divided into two types - simple machines and complex machines on the basis of their work capacity, structure and configuration.

Simple Machines: - All the instruments or equipments which use only muscular force to run are called simple machines.

The following are some simple machines: -

I Inclined plane
II Wheel and axel
II Lever
IV Pulley
V Wedge
VI Screw

To run these simple machines no other energy source is required.

Complex Machines: - The machines which use electric motors, chains, gears, etc. besides simple instruments or equipments, are called as **complex machines**. Examples are - cycles, motorcycles, sewing machines, huge factories, etc.

We will only study about simple machines in this chapter. You will study more about complex machines in higher classes.

11.2 Types of Simple Machines

Inclined Plane - Often we observe that an inclined plane is used to load heavy drums in the trucks and to park motorcycles in houses at higher level from the road. A plane that is used to make a difficult task easy is called an inclined plane.

Figure 11.1 (a): To load a drum by an inclined plane

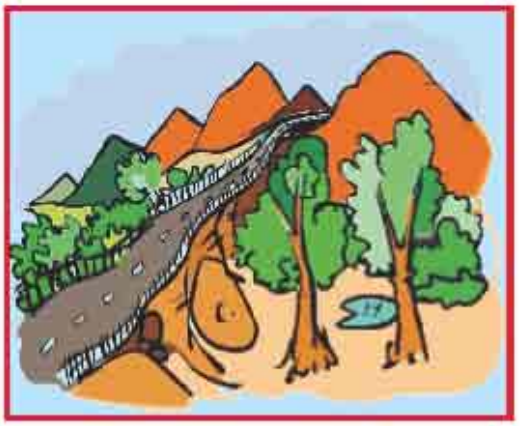


Figure 11.1 (b): winding road up a hill

Apart from this the ladders often found in use at homes and the inclined paths to climb on hills all are examples of inclined planes. Look around yourself and make a list of different inclined planes in use for different purposes.

Wheel and Axel : In daily life for travelling from one place to anther we often use motorcycle, bus, car, train, etc. The use of all these vehicles is incomplete without the wheel. Wheel is a simple machine. Wheel is one of the first inventions by humans. The wheel is often observed as an important part of complex machines. How does the wheel simplify our work?

Let's Find Out

Activity - 1

Take a heavy attaché case without wheels. Slide it on the ground [Fig.11.2 (a)].Take another heavy attaché case with wheels. Slide it on the ground [Fig. 11.2 (b)]. What difference do you feel in both the activities? Why do you need to apply more force in moving the heavy attaché case without wheel ?

Figure 11.2 (a):
Sliding a wheel-less attaché case

Figure 11.2 (b):
Sliding an attaché case with wheels

When we slide an attaché case without wheels on the ground, the ground exerts a greater amount of frictional force on the attaché case. So we can say that a wheel reduces friction.

In the same manner the wheel of a cycle rotates on a rod like structure which is fixed at the centre of the wheel. This rod like structure is called axel. Wheel and axel are also simple machines.

Lever - From ancient times, lever is one of the simplest machines ever used. In Fig. 11.3 (a), a man is lifting a load with the help of a crowbar (a long, heavy and pointed rod). This crowbar is an example of lever. The man applies force on one end 'E' of the crowbar to lift the heavy stone. This applied force is called effort force and the end 'E' is called effort point. There is a small stone in the middle of the crowbar for support. This support is known as fulcrum (F). The heavy stone on

the other end of the crowbar lifts up due to the force applied by the man on 'E'. The gravitational force is acting on the heavy stone in the downward direction. This force is called as weight (W). The distance 'EF' from fulcrum (F) to effort (E) is known as effort arm (D). The distance 'FW' from fulcrum (F) to weight (W) is known as weight arm (d).

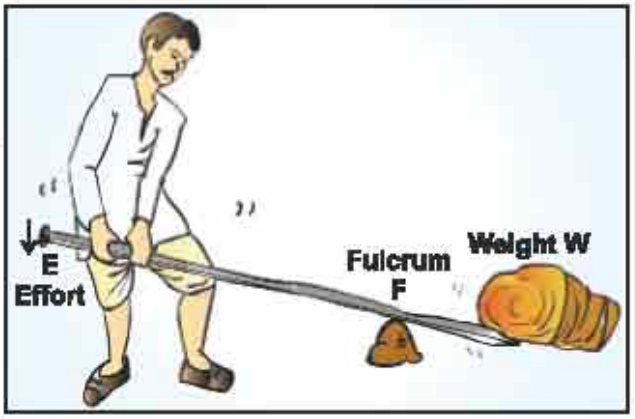


Figure 11.3 (a): Lifting weight with a crowbar

Lifting weight through a lever is easy.

Fig. 11.3 (b): Effort arm and weight arm

On which principle does the lever work?

Let's find out

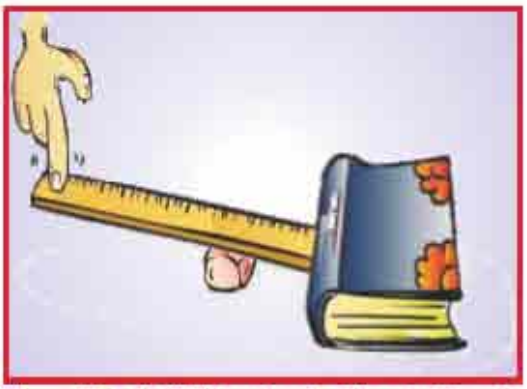


Figure 11.4 (a): Lifting a book with a plastic scale

Figure 11.4 (b): Lifting a load with a bamboo staff

Activity - 2

Keep one or two of your books on the table. Keep an eraser near them. Now put a plastic scale on the eraser as shown in Fig. 11.4 (a) and try to lift the books. Now put the eraser at some distance from the books and repeat the activity. Repeat this activity several times by increasing the distance between books and eraser. What do you experience? You will find that the higher the distance of the eraser from the books, the higher force you have to apply to lift the books.

Activity - 3

Put some load in a carton or box and keep one or two bricks near it. Now place a long and strong bamboo - staff under the carton or box as shown in

Fig. 11.4 (b) and try to lift the carton or box. In this situation the distance between the carton or box and the bricks (weight arm) is less whereas the distance between your hands and the bricks (effort arm) is high and you are able to lift the load easily. Now move the bricks a little away from the carton or box and repeat this activity again. What is your experience this time? You will find that if the bricks are near your hands you have to apply more force to lift the load. Therefore, if the length of the effort arm (distance between your hands and the bricks) is more then you have to apply less effort (force) to lift the load. In other words, when the length of the weight arm (the distance between the bricks and the load) is less then you have to apply less effort (force) to lift the load whereas if the length of the weight arm (the distance between bricks and the load) is more then you have to apply more force to lift the load.

Actually in every balanced condition, the product of weight and the weight arm is always equal to the product of effort and effort arm.

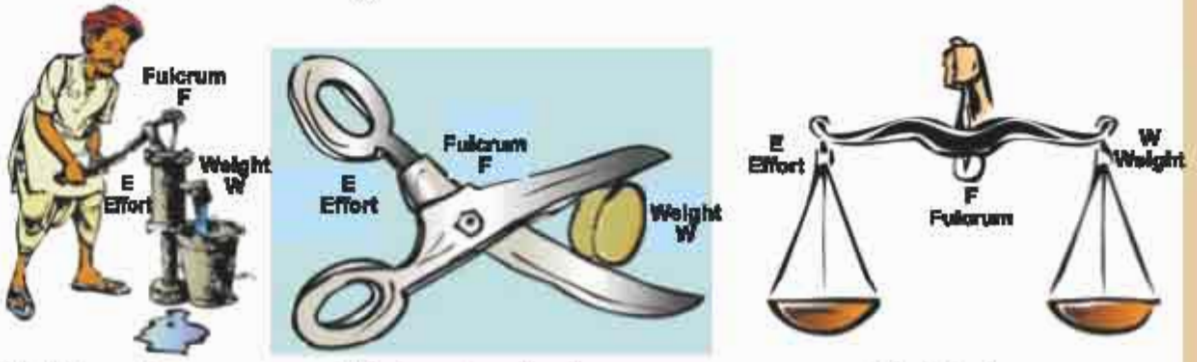
The same can be represented by the following formula which is called the principle of the lever or simply lever's principle -

$$\text{Weight} \times \text{weight arm} = \text{effort} \times \text{effort arm}$$
$$W \times d = E \times D$$

Again look at Fig. 11.3 (a) crowbar (sabbal) is a long metal rod. That's why, the length of the effort arm is large which requires lesser effort for lifting a known weight. Because of this reason it becomes easier to lift or slide heavy objects with the help of a crowbar. Therefore, we can say that with the help of a lever a greater force can be exerted at a point by applying a smaller force at some other point.

A pair of scissors, nut-cracker, knife fitted chopping board (karikatta), pair of tongs, handle of a hand-pump, single wheel barrow, holding weight in hand, physical balance, etc. are examples of levers. Are all these of same type? Let's find out -

On the basis of the positions of effort (E), weight (W) and fulcrum (F) the levers are categorised in three types.



(a) A hand-pump (b) A pair of scissors (c) A balance

Figure 11.5 Examples of first order levers

(1) First Order Levers - Observe a crowbar, a pair of scissors, a pliers, an old common-balance, a hand-pump, etc. Where is fulcrum (F) is situated in all these? Such levers in which the fulcrum (F) is situated somewhere in between the weight (W) and the effort (E) are called first order levers.

Do this also -

As per the figure 11.6 tie up a scale in the centre taking a piece of a spoke of a bicycle wheel. Tie up two plastic spoons at both the ends of the scale. Now take two old small plastic jars and fill them half with sand to make them sufficiently heavy. Keep these jars at a small distance from each other and fit the two ends of the spoke on these jars (as shown in the Fig. 11.6) in such a way that they may rotate freely. In this way you have made your toy see-saw. Keep weights on the two spoons of this lever and exhibit its function. Is it a first order lever? Change the position of fulcrum and lengths of the weight arm and describe the changes you noticed.

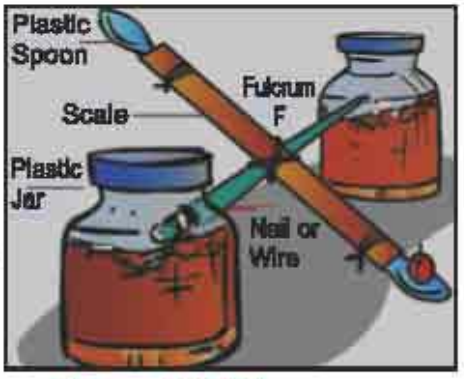
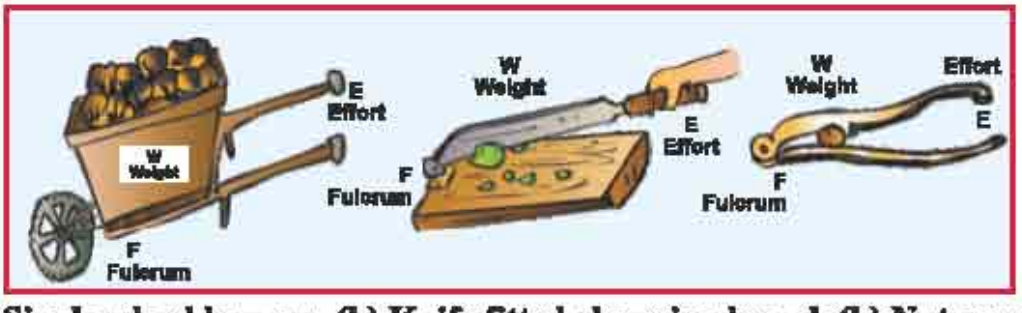


Figure 11.6 Toy see-saw

(2) Second Order Levers - Observe a nut-cracker, knife fitted chopping board (karikatta), fruit cutter and single wheel-barrow (fig. 11.7) Such levers in which weight (W) is situated between fulcrum (F) and effort (E) are called second order lever.



(a) Single wheel barrow (b) Knife fitted chopping board (b) Nut cracker

Figure 11.7 Examples of second order lever

(3) Third Order levers - The levers in which effort (E) is situated in between weight (W) and fulcrum (F) are called third order levers. A pair of tongs, holding weight in a hand, etc. are examples of third order levers.

(a) A pair of tongs (b) Holding weight in a hand

Figure 11.8 Examples of third order levers

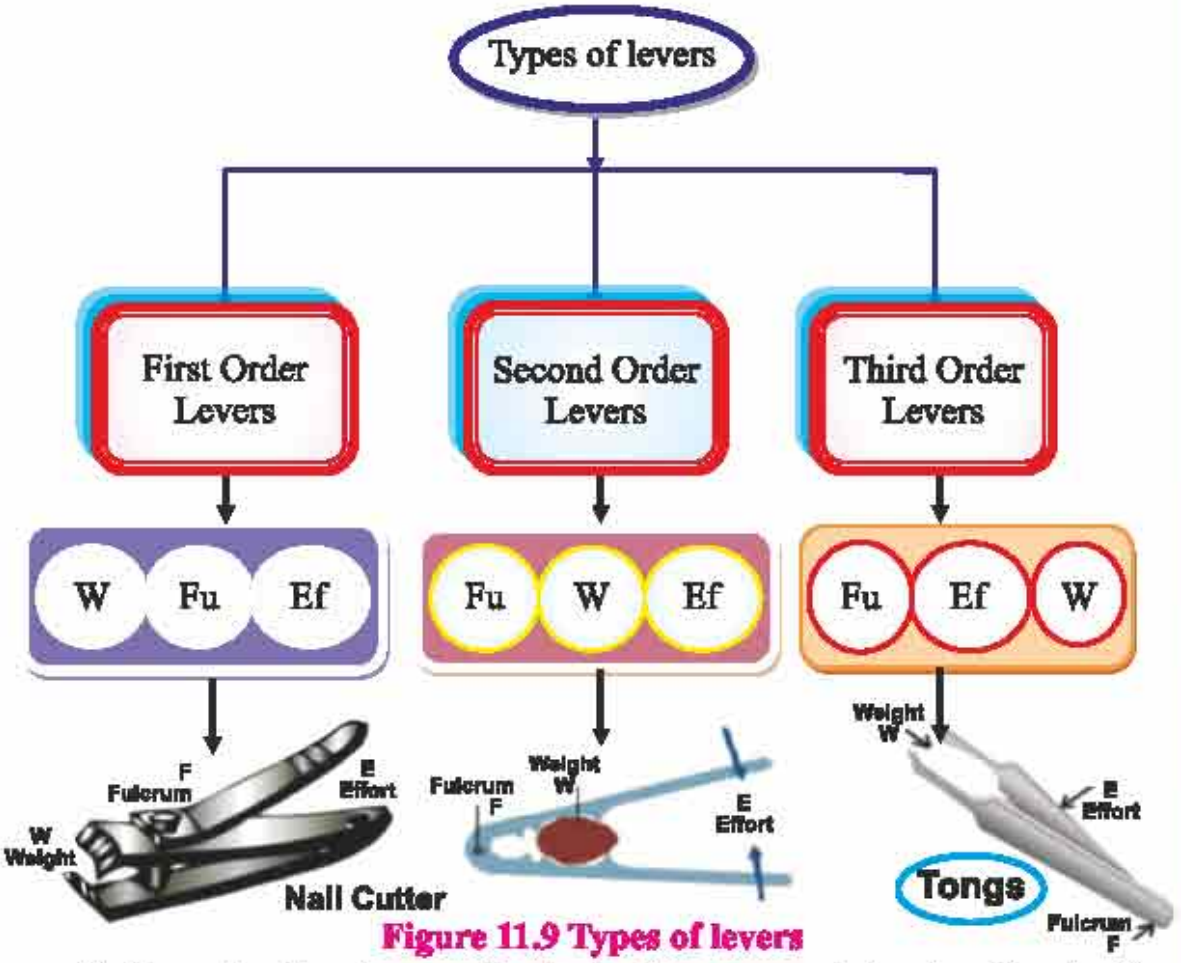


Figure 11.9 Types of levers

Pulley : A pulley is a small wheel with a grooved rim. A pulley is often made up of craft iron of which the central part is joined with arms through the hole of pulley. These arms are 4 or 6 six in number. This wheel (pulley) rotates around an axel which passes through the centre of gravity of the pulley and also this axel is perpendicular to the plane of the pulley.

(a) Pulley (b) Pulling a bucket without the help of pulley (c) Pulling a bucket with the help of pulley

Figure 11.10 Use of a pulley

You must have observed that it is difficult to pull a bucket full of water from a well and it brings tiredness quickly. It is so because the direction of the force applied by the person pulling the bucket is opposite to the gravitational force. With the help of a pulley a bucket full of water can be pulled out of the well easily. Why it is easier to pull objects with the help of pulleys? In order to pull straight up the objects, we need to apply a force in a direction opposite to the gravitational force whereas by the use of pulley the direction of the force get changed because of which the act of pulling the rope down is easier then pulling it straight up.

Pulleys are used in factories, cranes, to lift heavy items in houses, to run the curtains on the stage, etc. and for similar works.

Wedge : Visit a farmer's or a wood-cutter's workplace and inspect axe and chheni and find out what figure they possess? There are two mutually inclined planes giving a sharp and common edge at front end and a broader and plane shape at back end. This type of figure is called as wedge figure. Chheni and axe cut through wood easily because of their wedge like structure. Wedges are simple machines because they help us in doing our work in an easier way.

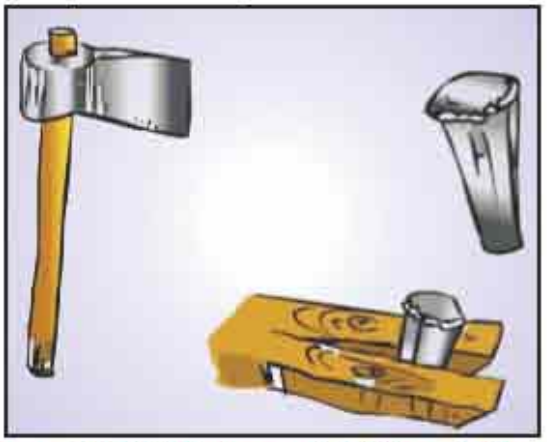


Figure 11.11 Wedges of different figures

Screw : It is a simple tool which is used to join (fasten) two parts. It is called a screw. Take a screw and observe it carefully. It is made of a cylindrical rod of metal by cutting spring like threads over it. It has a head which can be rotated to fasten it. Generally, in order to fasten a screw one needs to rotate it in clockwise direction whereas to unfasten a screw we need to rotate it in anticlockwise direction.

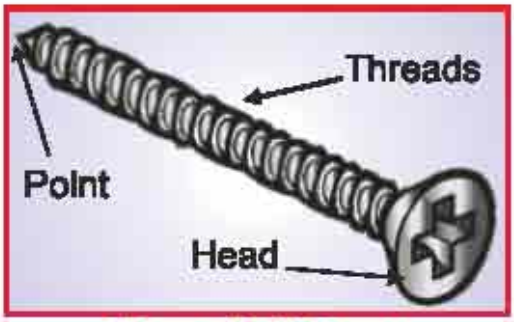


Figure 11.12 Screw

Do and observe -

Till this point, you have learnt that how, we carry out our works easily with the use of machines. If such machines are not carefully and regularly maintained and serviced, they lose their ability and do not carry out their work properly. Visit your nearby factory or manufacturing unit and check how the maintenance and servicing are done there. Make a list of such methods and solutions.

What have you learnt

1. Machine is a source or tool which carries out work easily and quickly.
2. There are two types of machines - (1) Simple machines, (2) complex machines
3. Crowbar (sabbal) works as a lever, it is a long strong rod which can be rotated all around.
4. The external force applied at one end of a lever to lift or slide heavy objects is called effort.
5. The support around which a lever is rotated is called fulcrum.
6. The weight of the object which is to be lifted on placed or moved acts at any point of the lever.
7. Levers are classified into three categories on the basis of the different positions of fulcrum, effort and weight.
8. Pulley, inclined plane, wheel and axel, wedge, etc. all are examples of simple machines.

Exercises

I. Tick the correct answer from the following -

1) The positions of effort, fulcrum and weight in a pair of tongs are -
   a) Effort, fulcrum, weight b) Fulcrum, weight, effort
   c) Weight, effort, fulcrum d) Weight, fulcrum, effort ( )
2) While working with the help of machines -
   a) More energy is required b) More force is required
   c) Work is done easily and efficiently d) Work is done with difficulty ( )
3) Which of the following is a complex machine?
   a) Screw b) Wedge
   c) Sewing machine d) Wheel ( )
4) Wheels are used to move heavy objects because -
   a) They lessen gravitational force b) They lessen frictional force
   c) They lessen magnetic force d) They increase frictional force ( )

II. Fill in the blanks -

1) To ..... a screw, it should be rotated clockwise.
2) The use of wheel and axel decreases ..... force.
3) Machines should be properly ..... to increase their life and efficiency.
4) By the use of pulley, the ..... of force gets changed.

III. Short answer questions -

1) Draw a well labelled diagram of pulley and describe its structure.
2) Write the equation of the lever principle.
3) What is a machine? How many types of machines are there?
4) Screw and wedge are also simple machines. Explain how?
5) Classify these objects into the levers of first, second and third order - a pair of tongs, crowbar, hand-pump, nut-cracker, a pair of scissors, a common balance, to hold a weight in hand, single-wheeled barrow and pincer.

IV. Long answer questions -

1) Explain through two equipments or instruments that with the help of machines we can do work easily and efficiently.
2) What are levers? State the differences between its different types with the help of examples.

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