TEACHING OF SCIENCE AND TECHNOLOGY IN RURAL AREAS

(UNESCO Sponsored Project No. 179.647.7)

Science and Technology of Rural Transport System

REGIONAL COLLEGE OF EDUCATION, MYSORE (India)

National Council of Educational Research & Training, New Delhi (India)

AUTHORS	:	*D.N.Nagaraj* *Post Graduate Teacher in Technology* *Demonstration School* *Regional College of Education* *Mysore 570 006*
		H.L.Satheesh *Trained Graduate Teacher in Science* *Demonstration School* *Regional College of Education* *Mysore 570 006*
CONSULTANT	:	*Dr.M.S.Murari Rao* *Professor of Technology (Retd)* *Regional College of Education* *Mysore 570 006*
EDITOR	:	*Dr.K.N.Tantry* *Reader in Education* *Regional College of Education* *Mysore 570 006*
ILLUSTRATION	:	*Mr.K.L.Venkatesh* *Arts and Crafts Teacher* *Demonstration School* *Regional College of Education* *Mysore 570 006*

C O N T E N T S

****

CHAPTER I

Introduction

We need to go from one place to another place for various purposes such as going to school, going to a nearby town, going to the field, going to the market and so on. Some may go on foot; some make use of vehicles like cart, cycle or bus.

In figure 1.1, we see people carrying a variety of things from one place to another. In our villages people carry water from wells and tanks. Agricultural implements, seeds and manure are carried to the fields. Agricultural products such as vegetables, fruits and food grains are carried to the town for sale. When the load is less and the distance covered is short, people carry materials on their head or on animals. Villagers carrying vegetables in a basket on their head is a common sight and so is the sight of washer-man carrying clothes on the back of a donkey. However, there is a limit to the load which men or animals can carry. This led to the use of mechanical power.

In day-to-day life, people and materials are to be moved from one place to another. Such a movement of people and materials is known as transportation.

The transportation system has three components, namely,

i) Load (weight)

ii) Road (way)

iii) Vehicle (means)

The type of vehicle used depends on the load and the road. A cycle is not convenient for transporting manure to the fields. It is quite suitable for carrying milk cans or to go to a neighbouring village. When a large number of people are to go to the town, a bus is most suitable provided we have a suitable road. So we can say that the load, the road and the vehicle are interdependent.

Activity 1: Observe the people around you. Make a list of materials carried to the field, to the house and to the market. State how they are transported.

Fig.1.1 Transportation activities in a village

The early man used to travel only on foot carrying his young ones and weapons on his back or head. The distance travelled by him was short and the load to be carried was light. As days passed, poeple had to carry more and heavier materials over longer distances. So they started using animals like horses and donkeys for riding or for carrying goods. Use of animals for transportation helped people to move about and mix with one another more frequently though they faced many hardships and dangers on the way. As people became more civilized need for better transportation facilities were felt. Invention of wheel led to further rapid development. With newer vehicles such as buses, trucks, trains and aeroplanes the places which once seemed far away now appear to be closer. Journeys which took months and years could now be completed in hours or days as a result of the improvement in roads and vehicles.

Need For Transport

Why do people move and carry materials from one place to another? People in villages have to take several products such as paddy, vegetables, sugarcane, fruits and milk to the town for sale. Likewise, they have to bring home materials like sugar, kerosene, clothes, seeds and feeds from the town for their use. These are related to the economic activities of the people. Activities like attending a drama or a festival is of cultural interest. Attending a marriage or taking a patient to a hospital are the social requirements of the people.

Consider the case of a farmer who has an yield of five thousand mangoes. This has to be transported to a nearby town before they get spoiled. The absence of suitable transport will affect the economic interest of the farmer. Dairy owners will have to market their products such as milk every day. Thus there is a need for transporting materials quickly and safely.

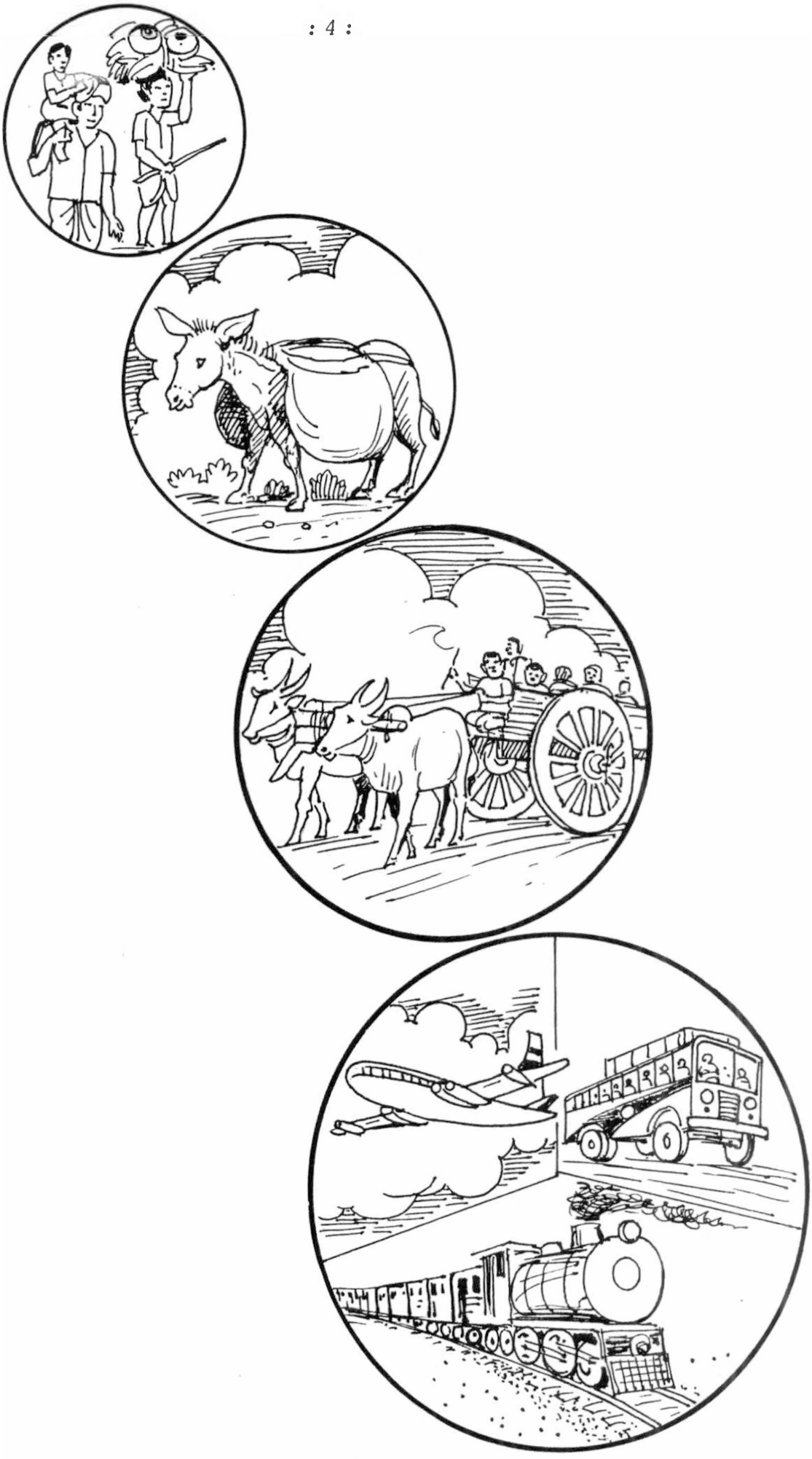


Fig.1.2 Evolution of transportation

Activity 2: Classify the following as social, cultural and economic activities by marking S, C and E respectively against the statements.

1. People carrying milk to the town.
2. People attending a Panchayat meeting.
3. People coming for a village fair.
4. Celebrating a festival to mark the harvest season.
5. Attending a funeral in a village.
6. Transporting sugarcane to a sugar factory.
7. Participating in a community service programme.
8. Getting fertilisers from the town.
9. Approaching the bank for a crop loan.
10. Attending adult education classes.

What are the types of vehicles you would suggest for each of the above cases? Why?

Modes Of Transport

Road transport is the oldest mode of transport. People who had to travel only on foot needed paths or tracks. The beaten tracks/paths were created by frequent use of a particular route which were found safe and easy. These tracks were suitable only for the movement of people and animals as they were narrow.

People living near rivers used floats and boats for transporting across and alona the river. However, this was not safe during floods.

With the development of carts there was a need to develop roads also. Bullock carts were designed for agricultural/passenger transport even on country tracks. Horse carts were generally used for passenger transport on flat roads.

With the invention of automobiles we now have a variety of transport vehicles which move on land, water and through air.

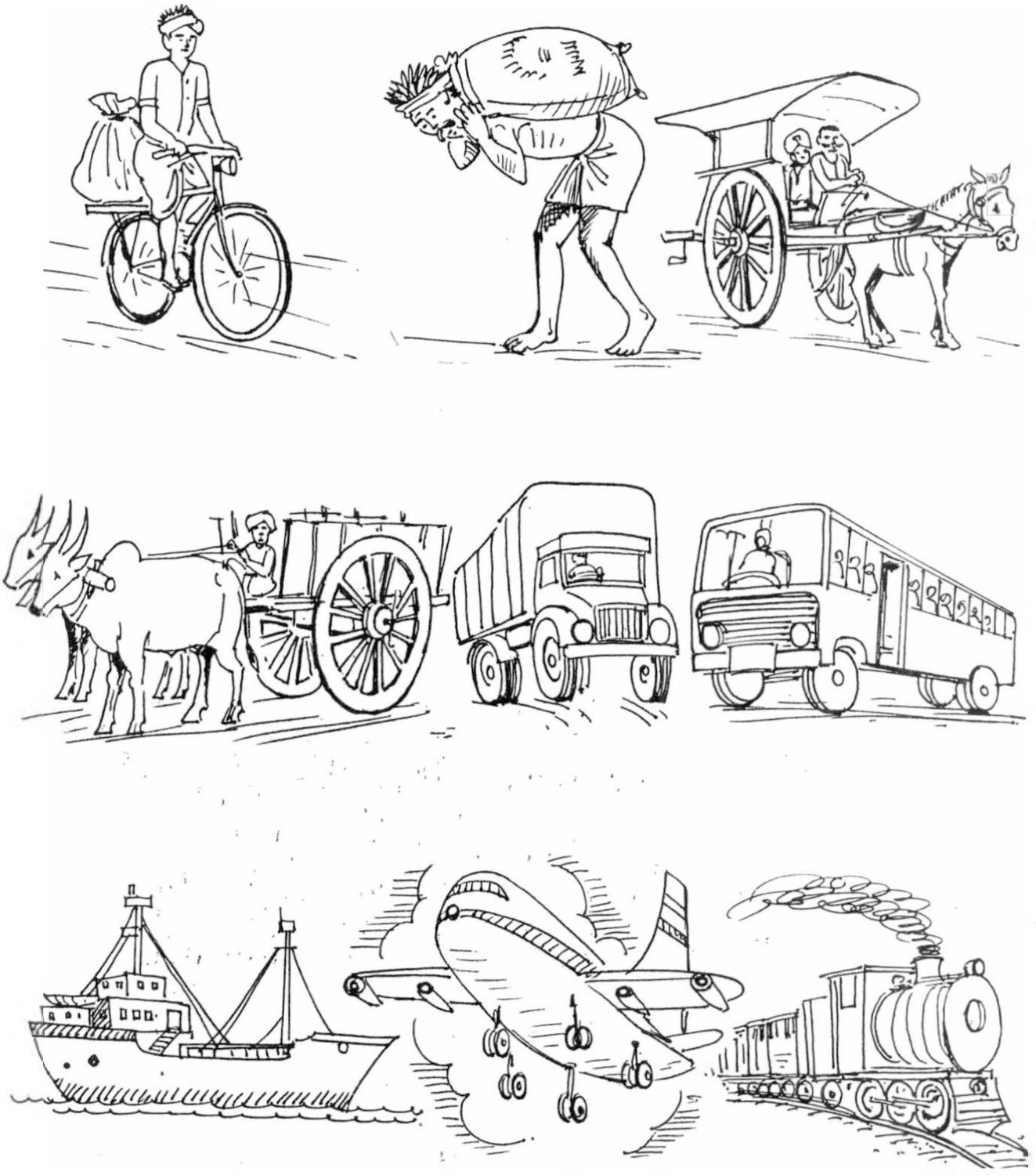


Fig.1.3 Modes of transport

The early modes of transport such as animals and animal drawn carts were slow. Even the load carried on them could not be more than a certain limit. Absence of roads also made the movement of men and materials more hazardous. With the invention of motor vehicles, the speed of transport was greatly increased. Even the passenger comforts and safety were considered in the design of newer vehicles. The journey in a bullock cart is very tiresome due to the jolts, whereas it is more comfortable in a bus or in a train. The mode of transport should be economical to the user. From this point of view generally in a rural set up bullock cart is the most convenient and economical means of transport.

Activity 3: Collect pictures and make a chart of various transport vehicles.

Activity 4: You see a number of transport vehicles in Fig.1.3. Observe them carefully and answer the following questions.

1. *Which of these vehicles are drawn by animals?*
2. *Which of these move on roads?*
3. *Which of these require special track?*
4. *Which of these are run by engine?*
5. *Which of these can move even in country roads?*
6. *Which of these is the fastest vehicle?*
7. *Which of these can move only on water?*
8. *Which of these cannot move on land?*
9. *Which of these are suitable for inter-continental travel?*

In this chapter, you have learnt some facts of transportation in rural areas. Now, you are able to a) define transportation, b) appreciate how transport affects the life and work of the village people, c) appreciate the development of transportation facilities, d) recognise various components of transport system and their interdependence, e) identify the various modes of transport, their cost, speed and efficiency in carrying load, f) appreciate the need for improvement in roads and vehicles.

In the next chapter you will understand some selected important scientific principles involved in transport system. You will also be able to measure some quantities such as speed, force and moments. You can appreciate their role in daily life.

Test Yourself

I. 1. Define transportation.

2. What are the components of transportation system?

3. Give a brief history of transportation.

4. Discuss the impact of the transport system on the socio-economic life of people.

5. How does the speed and efficiency of the transportation system affect the standard of life?

II. Match the following:

A	*B*
1. Rails	*bullock cart*
2. Highways	*ship*
3. Country roads	*aeroplane*
4. Sea	*trucks*
5. Air	*train*

CHAPTER II

Introduction

In the previous chapter, you learnt the need for transport and its modes. Now let us try to understand some of the scientific terms and principles involved in transport system.

You have seen a number of vehicles. Some vehicles move faster than others. A car can certainly move faster than a cycle or a bullock cart. How do we know this?

Activity 5:

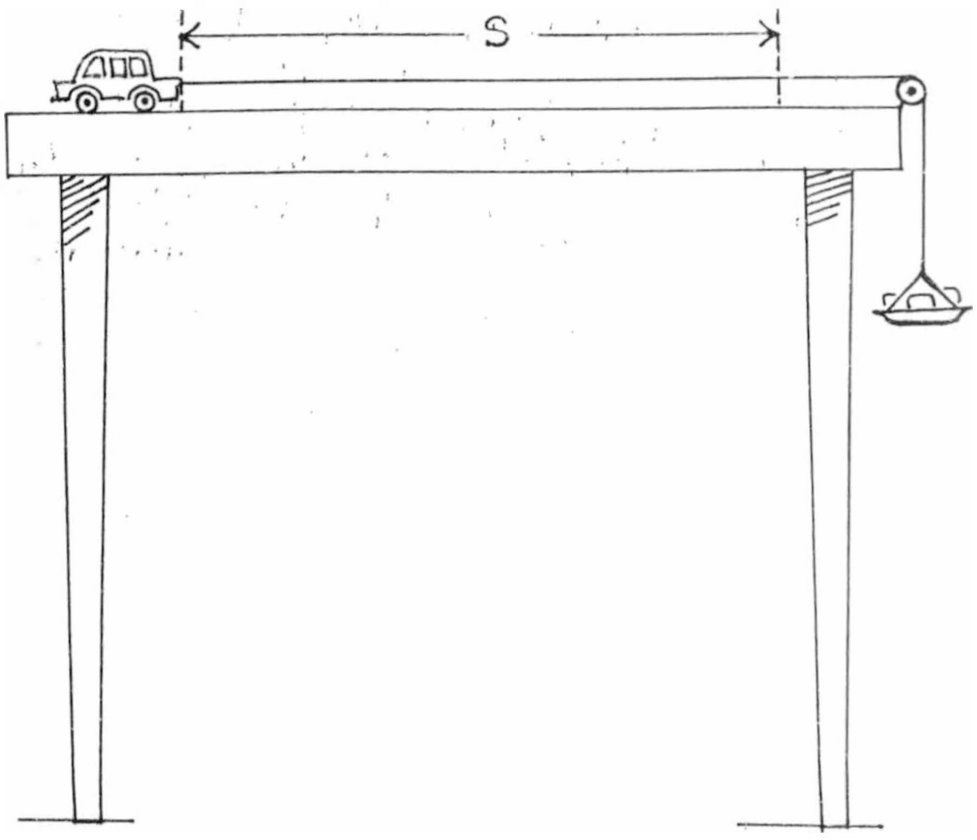


Fig.2.1

1. *Keep a toy car at one end of the table top as shown in Fig.2.1.*
2. *Tie a thread to the car and pass it over a pulley fixed at the other end of the table.*
3. *Attach a pan to the free end of the thread.*
4. *Place weights (you can use stones) into the pan such that the car begins to move.*
5. *Start a stop clock when the car just begins to move.*
6. *Stop the clock when the car just stops. Record the time taken in seconds.*
7. *Use a scale and measure the distance between the initial position of the car and its final position in cm.*
8. *Repeat the experiment three times by increasing the weights in the pan and record the time taken in each case.*
9. *Divide the distance travelled by the time taken in each case. Tabulate your observations as below:*

Trial	*Distance travelled* cm	*Time taken* sec.	$\frac{\text{Distance travelled}}{\text{time taken}}$	*cm/sec*
1.				
2.				
3.				

10. *What will happen to the time taken if the distance is increased in each of the above activities?*

Speed

The speed of a body is the distance covered by it in unit time.

$$\text{Speed} = \frac{\text{Distance covered}}{\text{Time taken}}$$

The distance between Alur and Yalandur is 20 km. Which of the vehicles can cover this distance in less time - a car or a bullock cart? It is the car. Do you know why?

Test Yourself

1. *A runner covers a distance of 100m in 10 sec. What is the speed of the runner?*
2. *Find out from elders the normal speed of a bullock cart, normal speed of a cycle and the safe speed of a car and arrange them in the increasing order of their speed.*

Force

Look at the Fig.2.2. Here you see people engaged in different activities, such as drawing water from a well, pushing the cart, pushing and pulling a saw. You also see a pair of bullocks pulling a plough. In all these activities a push or pull - a force is exerted.

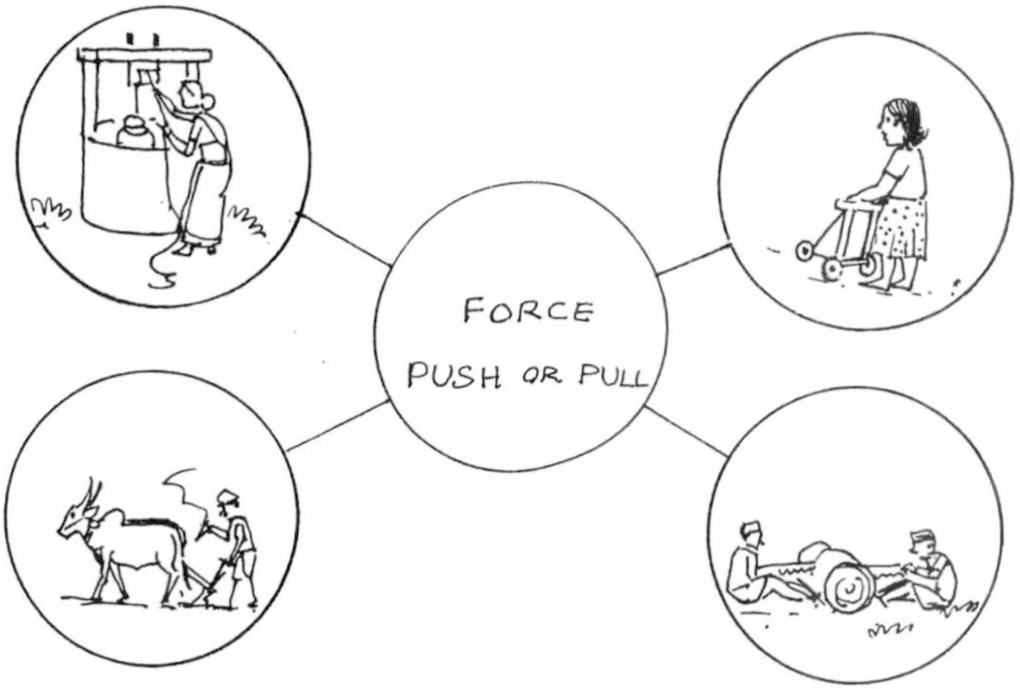


Fig.2.2

Work Sheet: Observe each of the above activities in Fig.2.2 carefully and complete the following table.

Fig.No.	*Activities*	*Push/pull exerted by*	*Push/pull exerted on*
1	*Drawing water from a well*	*the woman*	*the rope*
2			
3			
4			

What can a force do to a body? The general effect of a force on a body is given by Newton's I Law of motion.

I Law of Motion:

Every object continues to remain at rest or of uniform of motion along a straight line unless it is acted upon by an external force.

It is our common experience that a body, say, a plough, kept in a room, remains in its position for any length of time unless a force is exerted on it. Only a force can change the direction or speed of a moving body. In the absence of an external force, a moving body continues to remain in its state of uniform motion along a straight line.

Inertia

The I Law of motion tells that every body as a built-in opposition to being moved if it is at rest or to change its motion if it is moving. This property possessed by all bodies is called inertia. Let us try to understand this with some experiments.

Activity 6:

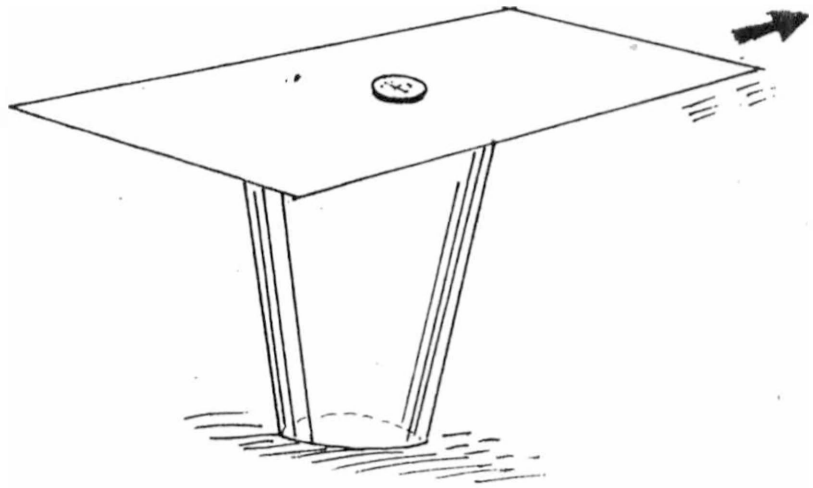


Fig.2.3

1. *Take a tumbler and place a piece of card board on it as shown in Fig.2.3.*
2. *Keep a coin on the card at the centre of the mouth of the tumbler.*
3. *Give a horizontal push to the card board. What happens to the coin? It will fall into the tumbler. Why is it not carried away along with card board? This is due to the inertia of the coin. The coin tends remain in its position.*

Activity 7:

1. *Keep a tumbler filled with water over a wooden box (match box).*
2. *Now knock the box away horizontally with a scale. See what happens and record it. The tumbler stays at rest and does not move with the box.*

Test Yourself

1. *When brakes are applied suddenly to a fast moving bus, the passengers are thrown forward. Why?*

2. *Why is it not safe to jump from a moving vehicle?*

II Law of Motion:

The acceleration produced in a body is directly proportional to the external force acting on it and inversely proportional to the mass of the body.

Force applied on a body = *mass of the body* X *acceleration produced in the body*

$F = ma$

Thus, Newton's II Law of motion enables us to measure force.

Unit of Force: *The S.I. unit of force is 'newton' (N). According to the II Law of Motion* $F = ma$. *If* $m = 1kg$ *and* $a = 1\ m/s^2$ *then* $F = 1$ *newton (N)*

1 newton is the force required to produce an acceleration of $1\ m/s^2$ *in a body of mass 1 kg.*

Test Yourself

1. *How much force is required to give a body of mass 5 kg an acceleration of* $10\ m/s^2$?
2. *Calculate the acceleration produced in a body of 10 kg when a force of 50 N acts on it?*
3. *A force of 100 N produces an acceleration of* $5\ m/s^2$ *in a body. Find the mass of the body.*

Weight

You know that all bodies thrown up will come back to earth. Ripened fruits and flowers of plants fall to earth. This is due to the force of gravity of the earth. Earth pulls all bodies towards its centre. The force with which the earth pulls a body towards its centre is called the weight of the body.

From the II Law of motion

Force = mass X acceleration

$F = ma$

Gravitational force = mass X gravitational acceleration (weight)

$W = mg$

The weight of a body is measured by a spring balance.

Activity 8:

1. *Take a stone, a small brick and a piece of iron.*
2. *Find the mass of each by using a physical balance.*
3. *Calculate the weight of each of these, by taking* $g = 9.81\ m/s^2$.

Object	*Mass in kg (m)*	*Weight in newtons (mg)*
Stone		
Brick		
Iron Piece		

Test Yourself

1. *Take a spring balance from your laboratory and observe the graduations on it. Find out whether you can measure the weight of a body in newtons directly?*
2. *The weight of a body changes from place to place on the surface of the earth. Why?*
3. *The weight of a body is greater near the poles of the earth than at the equator. Why?*
4. *A person whose weight is 600 N on the earth is about 100 N on the moon. Why?*

III Law of Motion:

For every action there is an equal and opposite reaction.

The law says that forces will always exist in pairs as a result of the interaction between two bodies. For example, when you jump forward, your foot pushes the ground backwards and in turn the ground exerts an equal force to you in the opposite direction. During this process you get accelerated. Note that the action and reaction forces do not act on the same body.

If a body A exerts a force on another body B, then the body B also exerts an equal force on A in an opposite direction.

Activity 9:

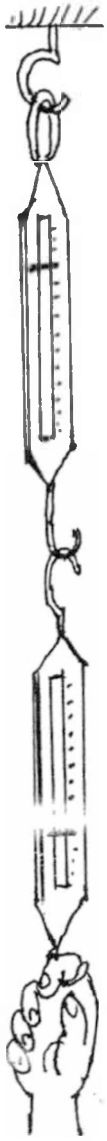


Fig.2.4

1. *Take two identical spring balances A and B.*
2. *Fix one of them (say A) to a hook on a wall.*
3. *Attach the spring balance B to A as shown in Fig.2.4.*
4. *Pull the free end of the spring balance B.*
5. *Note and record the readings of the two balances.*
6. *Increase the pull slightly. What will happen to the readings in the two balances? What do you infer from the experiment?*

Test Yourself

In this Fig.2.5, identify atleast four pairs of action-reaction forces.

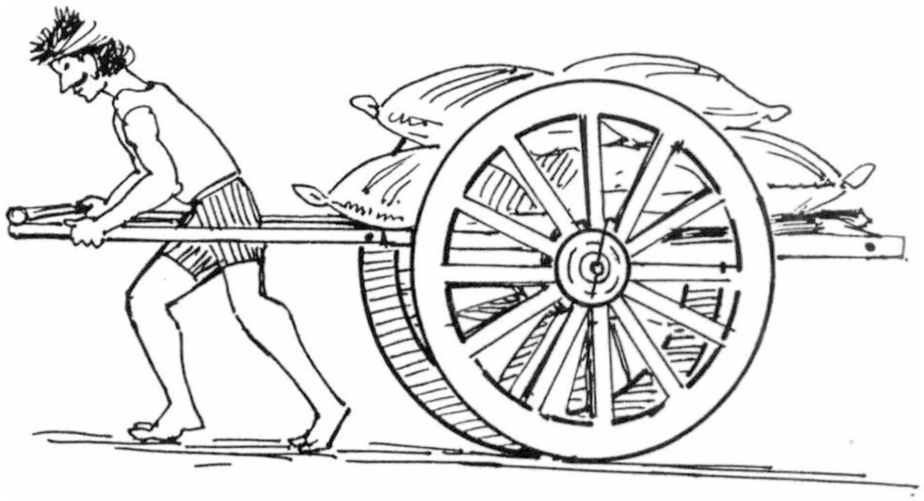


Fig.2.5

Frictional Force

Activity 10:

a) Keep a wooden block on the floor or a table. Now give a gentle push to the block. It will move over a distance and stop. Do you know why? This is because the force which caused the motion must be opposed by another force. This force is called the frictional force.

b) Spread sand uniformly on the table and push the block over it so that it moves. How far does it move now? Why?

c) Rub the two palms of your hands vigorously. How do you feel? What is the source of heat?

d) Take two stones. Strike one stone on the other carefully. You see sparks. What causes the sparks?

Definition of Friction:

A force that arises when one body tends to move or move over the surface of another body and directed opposite to the motion is called frictional force.

When the surface of one body moves over that of another, each body exerts a frictional force on the other. The frictional force on each body is opposite to its direction of motion relative to another.

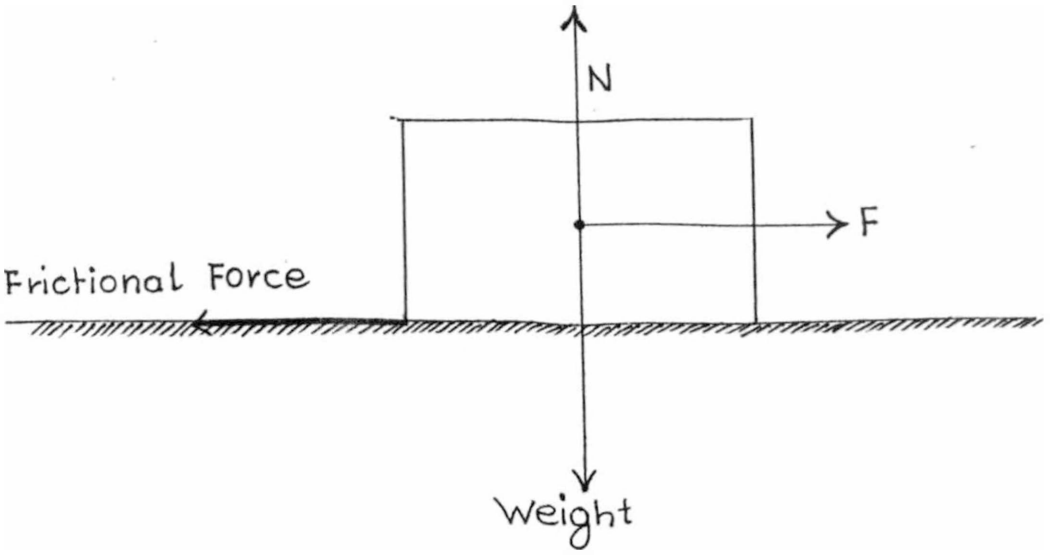


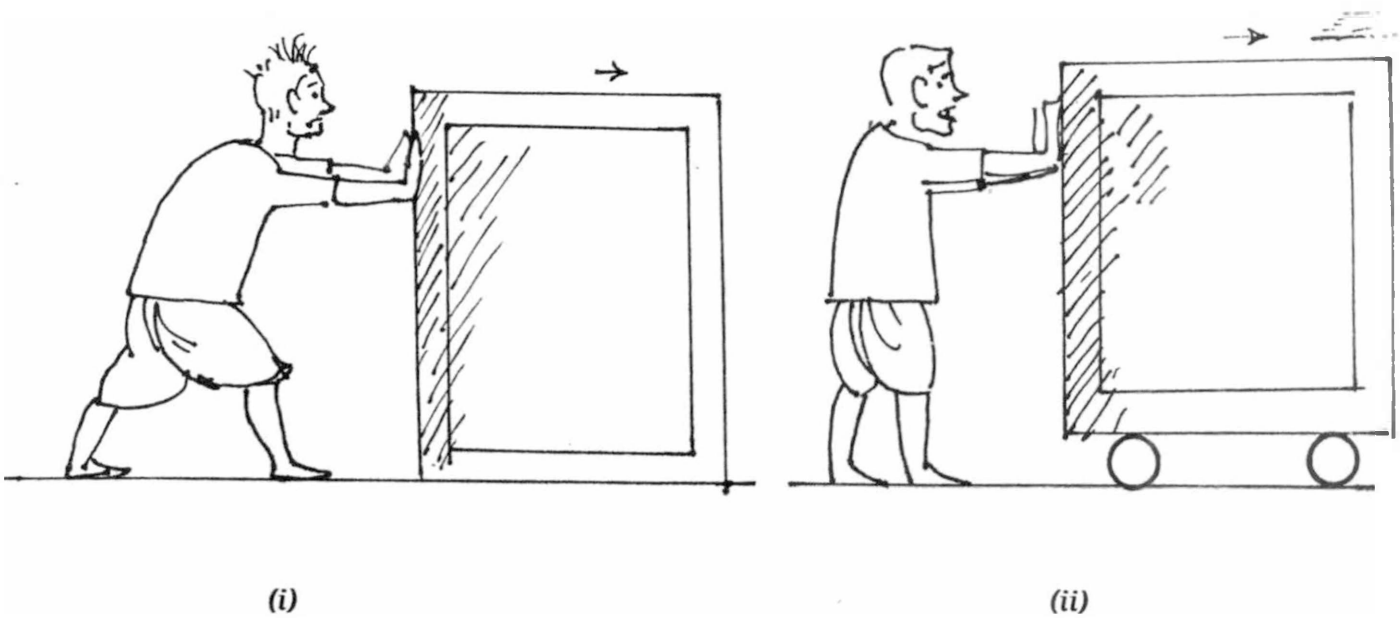
Fig.2.6

Consider a block pulled on the ground as shown in Fig.2.6. Observe in the figure the direction of the applied force and that of the frictional force. They are opposite to each other.

Frictional force can be classified into two types. They are

i) sliding friction

ii) Rolling friction



(i) (ii)

Fig.2.7

The Fig.2.7 illustrates the two types of friction. Observe that the person in fig(i) is struggling to push (slide) a box on the ground. But the person in fig(ii) is doing the same task with ease.

Test Yourself

Explain how the wheels have helped in the improvement of transportation.

Factors on which Friction Depends

Activity 11:

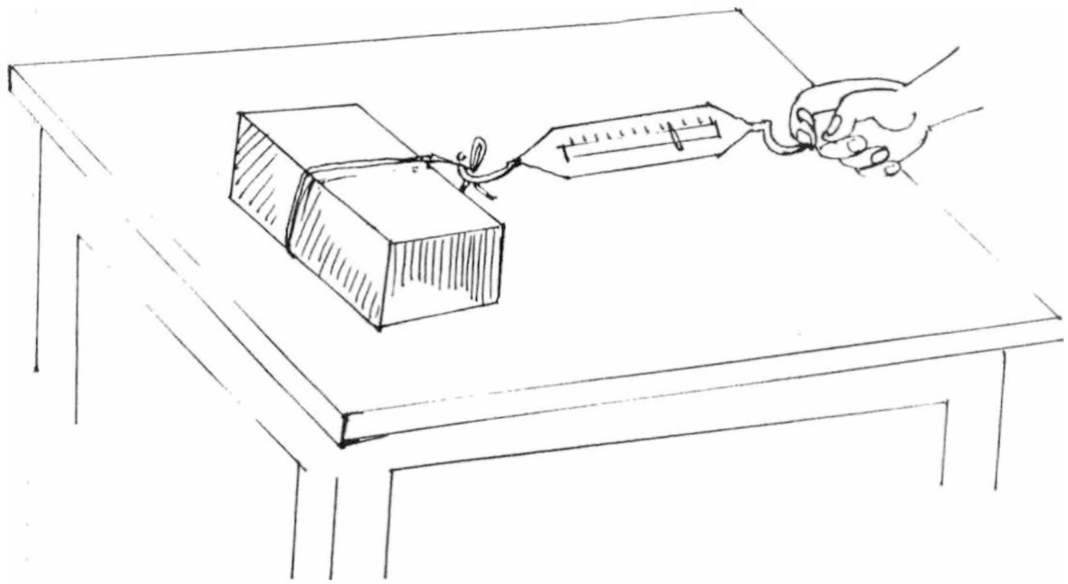


Fig.2.8

1. *Tie a strong thread to a brick and place it on a table.*
2. *Attach a spring balance to the thread tied to the brick as shown in Fig.2.8.*

3. *Now pull the balance by holding the hook at its other end.*

4. *Record the reading in the balance when the brick just begins to move. The reading in the balance is _____.*

5. *Double the weight by keeping another brick over the first one.*

6. *Pull the balance. Record the reading in the balance when the brick again starts moving. The reading is _____.*

7. *Repeat this keeping one more brick. The reading in the spring balance is _____.*

8. *What happened to the frictional force (the reading in the spring balance) as the weight is increased?*

9. *Record your observation as follows.*

Trial	Weight of brick (W)	Frictional Force (F)	F/W
1	One brick		
2	Two bricks		
3	Three bricks		

From this, we can conclude that the heavier a body, the greater is the force of friction.

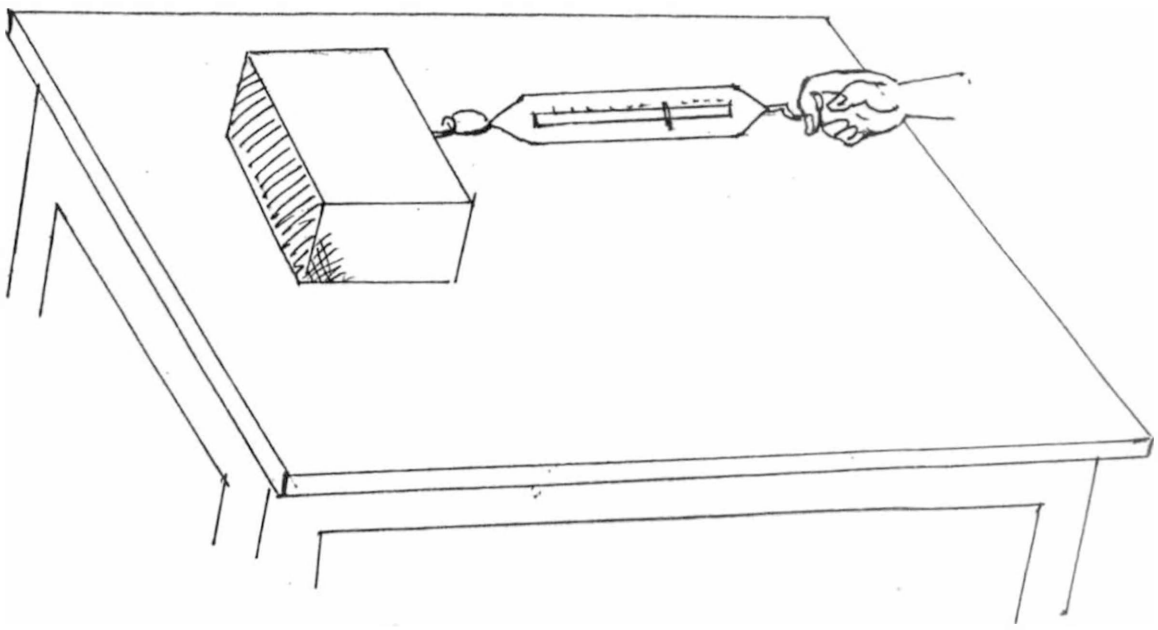


Fig.2.9

Activity 12:

1. *Take a wooden block as shown in Fig.2.9 and repeat the activity and note the value of frictional force.*
2. *Change the surface of the block by glueing a card board to any one surface of the block.*
3. *Keep this surface in contact with the table.*
4. *Pull the balance fixed to it and note value of the frictional force. The reading in the balance is _____.*
5. *Glue a sand paper to the wooden block. Keep this surface in contact with the table. Find the value of the frictional force as before.*
6. *Compare the values of the frictional force noted in the three cases. What are your findings?*

Friction depends on the nature of the rubbing surfaces:

Activity 13:

1. *Take a rectangular block and place it on two cyclindrical pencils.*
2. *Attach spring balance to the block and pull it gently.*
3. *Note the value of friction when the block just begins to move.*
4. *Repeat this experiment with the same block without using pencils.*
5. *Compare the values of the frictional force. What is your observation? In which case was the friction less?*

Rolling friction is much smaller than sliding friction:

Activity 14:

1. *Place a wooden plank on a table.*
2. *Find the value of friction as you did in Activity 8 by using a wooden block and a spring balance. The value of frictional force is _____.*
3. *Smear castor oil on the plank and repeat the experiment. Find the value of friction. What happens to the friction when oil is applied?*

Friction can be considerably reduced by using oil or grease.
Such substances are called 'lubricants'.

Test Yourself

Can you now see the reason why oil is applied to the axle of the bullock cart?
It is to _____.

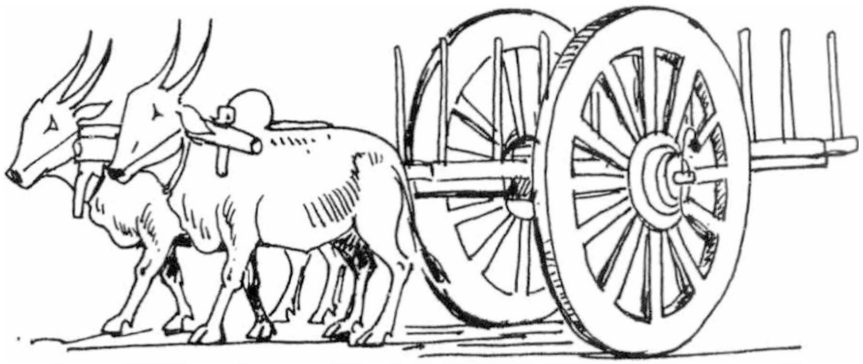


Fig.2.10

Study the Fig.2.10-when the cart is moving, friction exists between some surfaces of the cart. Identify those surfaces.

Friction - bane or boon

Imagine that there was no friction at all! Then we could not have been able to walk, run or climb trees. Things would have slipped out of our hands. It would have been very difficult to stop the moving bodies. Brakes would have been useless in the absence of friction. Without friction sewing of clothes lighting of match stick would have been difficult. Now you will realise how important is friction.

But in machines, friction is mostly unwanted. It wastes a lot of energy usually in the form of heat. You must have noticed machines getting heated up due to friction. Friction changes the shape of bodies and thus causes wearing of surfaces. As a result, the life and efficiency of machines are decreased. Friction is reduced in machines, by using lubricants. Since rolling friction is less than sliding friction, in machines ball bearings are used instead of bush bearings.

In pneumatic type of bullock cart (Fig.2.11) use of ball bearings has considerably made the task easy for bullocks. Thus the efficiency of the cart is increased.

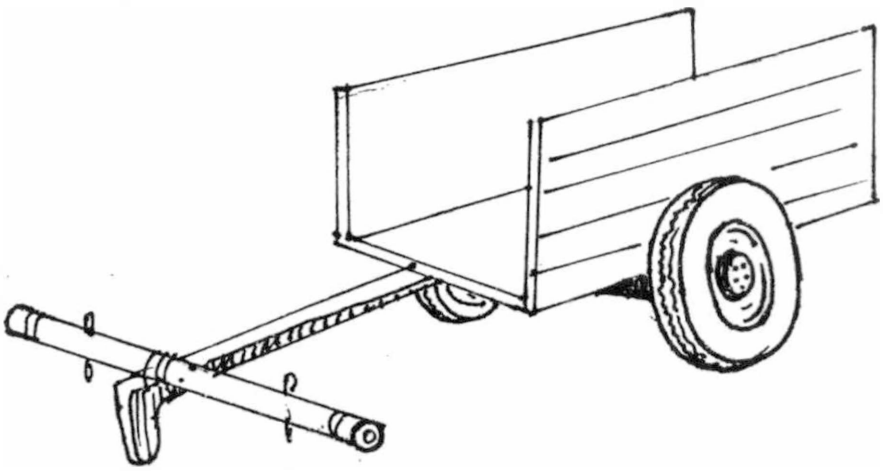


Fig.2.1'

Centre of Gravity:

We have seen that the earth exerts an attractive force on all bodies. In fact, the earth pulls all the parts of a given body towards it. This forms a large number of parallel forces. The resultant of all these forces which is equal to the total force of gravity on the body will act through a point in whatever position the body is placed. This point is called 'Centre of Gravity' of the body.

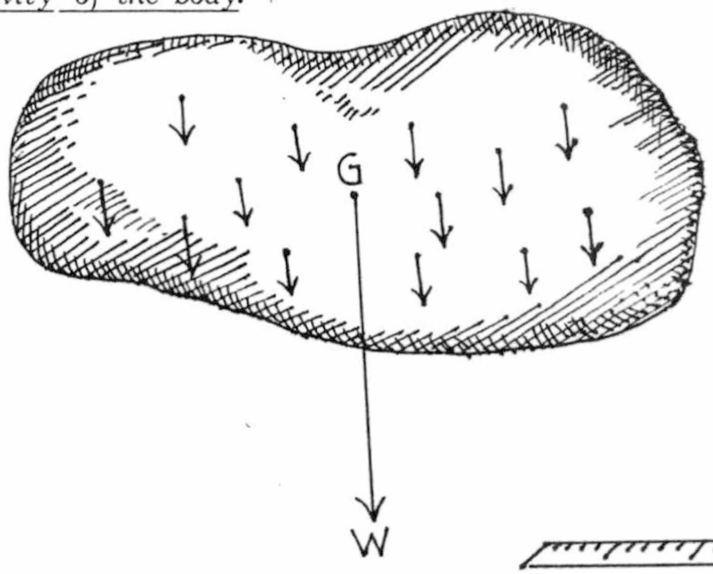
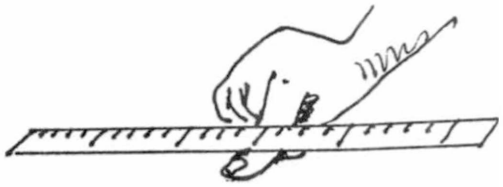


Fig.2.12

Fig.2.13



Activity 15:

1. *Take a scale. Try to balance it over the tip of your finger, as shown in Fig.2.13.*

2. *Now try to balance it on the pencil point. With some experience, you will be able to do it easily. Why will the scale fall if its position is disturbed? This sort of balance is possible only when the finger is exactly below the centre of gravity of the scale.*

Definition of Centre of Gravity:

The centre of gravity of a body is the point of application of the resultant force due to earth's gravitational pull on it.

Test Yourself

1. *Why is it difficult to stand on one foot?*

2. *When will a body tip over?*

3. *Take 5 card board pieces of different shapes such as rectangular, square shaped, circular and irregular shaped. Find the centre of gravity of each by the balancing method.*

In bodies which are made of a single material and have simple geometrical shapes like sphere, cuboid, cylinder, etc., the centre of gravity will be exactly at the centre of the body. Centre of gravity of a body can lie within the material of the body. Fig.2.14 (a),(b),(c). It may also lie outside the material of a body. Fig.2.14(d).

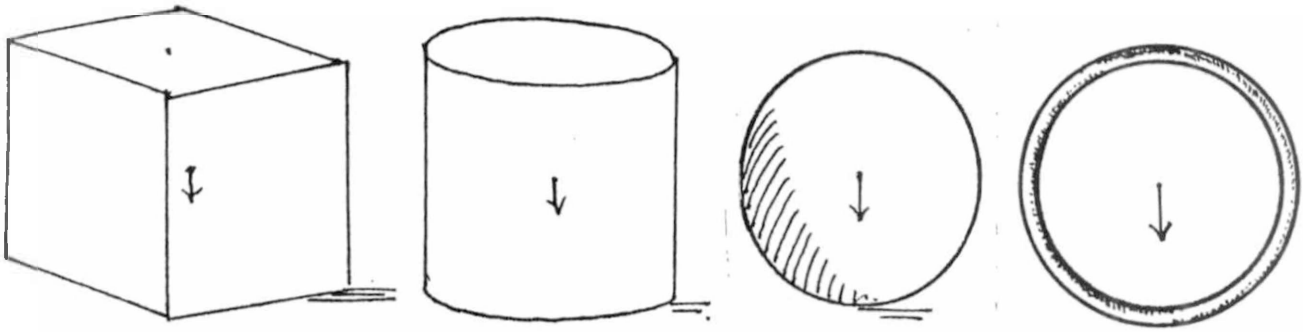


Fig.2.14

(a) (b) (c) (d)

Activity 16:

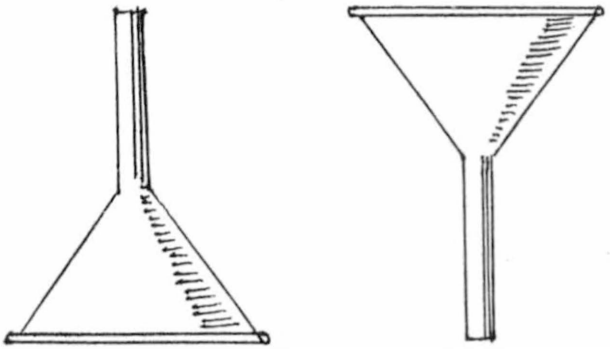


Fig.2.15

1. *Take a funnel. Place it on a table on its mouth as shown in Fig.2.15.*
2. *Tilt the funnel gently. What happens? The funnel restores its original position.*
3. *Try to make the funnel stand on its stem. Do you succeed as easily as in step 1? Why?*
4. *Tilt the funnel ever so slightly. What happens?*

The funnel position is not easily disturbed in position (i) because the vertical line through the centre of gravity of the funnel lies within its base area. We say that the funnel is in 'stable equilibrium'. But in position (ii) the position of the funnel is easily disturbed even by a very small force. This is because the vertical line through the centre of gravity slightly lies outside the stem base when disturbed even slightly. Hence, the funnel is unstable in this position.

While loading a bullock cart the stability of the cart should be taken into consideration in order to avoid tipping of the cart. The centre of gravity of the cart should as be low as possible.

Test Yourself

1. *State whether the following positions of a brick as shown in Fig.2.16 are stable or unstable.*

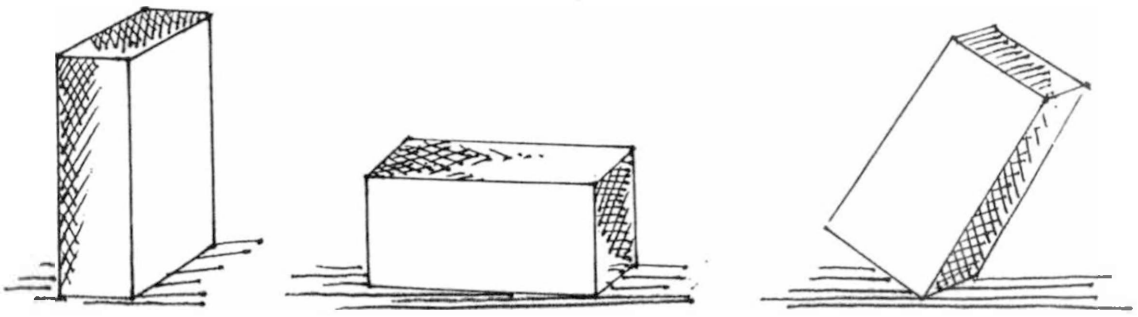


Fig.2.16

2. *State which of the two in Fig.2.17 is more stable.*

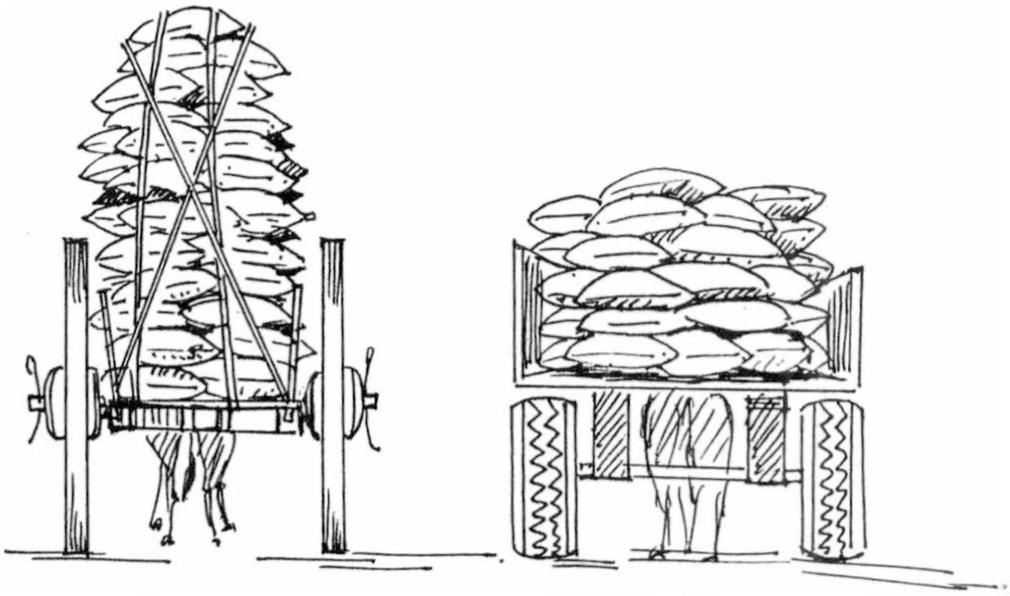


Fig.2.17

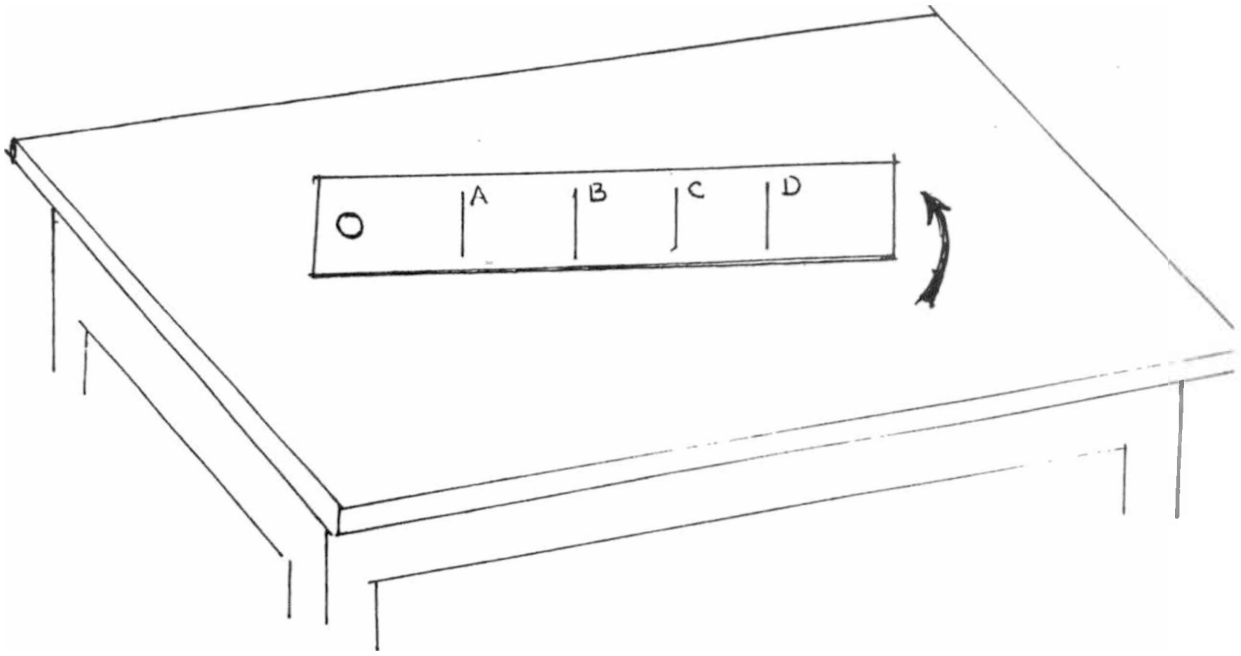


Fig.2.18

Moment of a force

Activity 17:

1. *Take a rectangular card board strip of length 20 cms.*
2. *Fix it to a wooden frame (drawing board) by using a table pin as shown in Fig.2.18.*
3. *Mark points A,B,C and D on the strip at distances of 5 cm, 10 cm, 15 cm and 20 cm respectively from the pin.*
4. *Give a push to the strip. Observe how it moves. It starts rotating.*
5. *Now apply same force at different points A,B,C and D. In which of these points it is easy to move? How can you increase the turning effect rotation? It is clear that the rotating effect of a force depends not only on the magnitude of force applied but also on the point of application of force.*

The combined effect of the magnitude of the force and the perpendicular distance between the axis of rotation and the point of application of force is called moment of force. It is defined as follows:

The moment of a force about a point is the product of the force and the

perpendicular distance of its line of action from the point.

Moment = Force X Perpendicular distance

The Principle of Moments: If a number of force act on a body which is capable of rotation and it remains in equilibrium then the algebraic sum of the moments of all forces about any points will always be zero.

Sum of clockwise moments = sum of anticlockwise moments

Activity 18:

1. *Take a half metre scale.*
2. *Take two bricks and find the weight of each by using a spring balance. Let the weights be* W_1 *and* W_2.
3. *Hang the two bricks, one at each end of the scale as shown in Fig.2.19.*
4. *Carefully adjust the position of the scale on a wedge such that the scale is balanced in a horizontal position.*
5. *Measure the distances of the stones from the wedge. Let it be* d_1 *and* d_2.

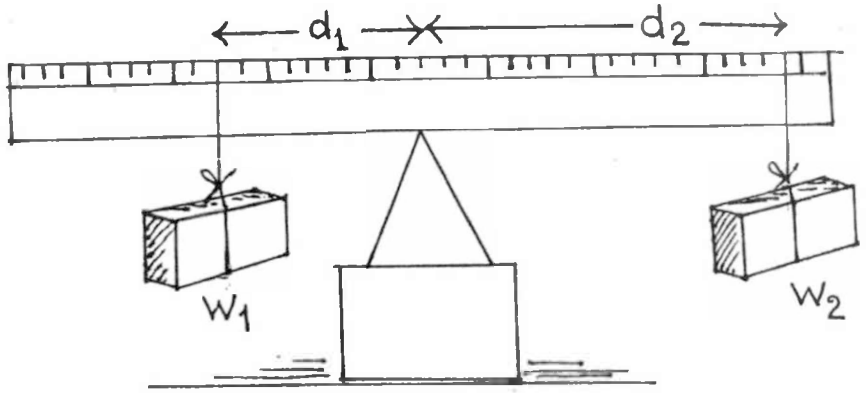


Fig.2.19

6. *Calculate the moment due to* w_1 *given by* $w_1 d_1$.

7. *Calculate the moment due to* W_2 *given by* $W_2 d_2$.

8. *Repeat the experiment by changing the bricks and their positions on the scale.*

9. *Compare the moments in each trial.*

Tabulate the observations:

Trial	W_1 *Kg*	d_1 *m*	W_2 *Kg*	d_2 *m*	$W_1 d_1$	$W_2 d_2$
1						
2						
3						

Do it yourself: *Consider the cart shown in this Fig.2.20.*

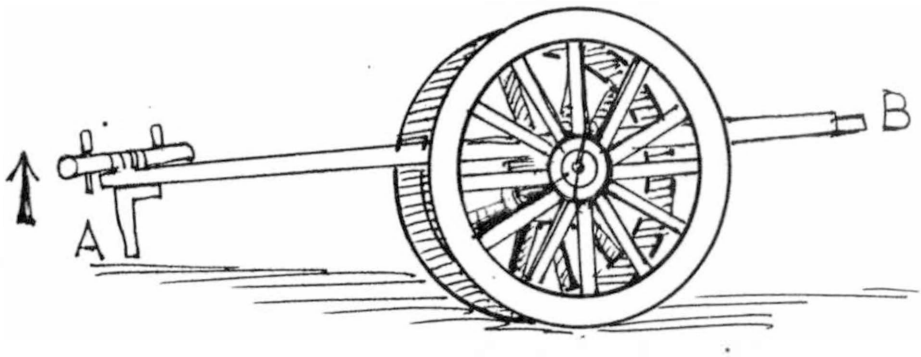


Fig.2.20

It is easy to lift the cart from the front end. Is the principle of moments applied here? What is the distance at which force F is acting from the axle about which the stand can rotate? Can you lift the stand from the back end (end A in the figure).

Conservation of Energy

Energy can neither be created nor destroyed: *However, it is possible to convert one form of energy into another form. When water has to be lifted to a height energy has to be spent for lifting. This energy is stored at a height as potential energy. It is easy for water to flow down the gradient. For eg. Water stored at a height flows by itself through a pipe to a lower level. Now, potential energy is converted into kinetic energy.*

Gradient:

Fig.2.21

The roads we use for transportation are not quite even (flat). There are ups and downs. You must have seen a road that leads to a hill top. Why are these roads curved? A straight road leading almost vertically to the hill top as shown in ***Fig.2.21(a)*** *becomes too steep for the vehicles and it requires more energy at a given instant. In order to make it easy for the vehicles the roads are laid in curves as shown in* ***Fig.2.21(b)*** *thereby decreasing the slope . In this process, the travelling distance becomes more to reach the same height. In other words, the ratio of the vertical distance to the horizontal distance becomes less. This ratio is called the gradient or slope.*

Gradient is an important factor to be considered in the design and construction of roads. Roads with large gradients demand high energy at a given instant. On the other hand, travelling down the gradient in the above case caused tumbling or skidding effect on the vehicles.

Activity 19: Take an inclined plane and fix it at three different positions by varying the height. Calculate the gradient in each case. Keep an object on the inclined plane and see when the object slides easily.

Elevation: The height of a building or the depth of a well has to be measured with a reference point (say) the ground level. This height or depth is known as the 'elevation'. The elevation of a building may be +4 metres and the elevation of the well can be expressed as -10 metres. The elevation of the reference point with reference to itself is zero.

Three villages Lingapura, Chinakuvali, Nandipura are at different levels. Lingapura is at the heightest level 10 mtrs with respect to the level of Chinakuvali. Nandipura is at a level of 5 mtrs with respect to Chinakuvali. Therefore, Chinakuvali is the reference point and elevation can be expressed as

Village	Elevation
1) Lingapura	10 mtrs
2) Chinakuvali	0 mtrs
3) Nandipura	5 mtrs

Now take Lingapura as the reference point and express the elevation of Nandipura and Chinakuvali in a similar table. Elevation of a place is very important in mapping. The map is two dimensional figure therefore it is the elevation which helps us to know the different levels of the places.

Force per Unit area: In order to explain some effects of a force on a body, we have to consider not only the force but also the area on which it acts.

The force per unit one is called pressure (stress)

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

The greater the area over which force acts the less is the pressure, conversly the pressure is more when the area is less.

When you first prick with a pencil if the pencil is sharp it hurts more than when it is blunt. This is because the force applied causes more pressure when it is pointed as the area is less. In a blunt pencil the area is more and hence it does not hurt to the same degree.

Do it yourself:

1. *Spread dry mud uniformly over a rigid table top.*
2. *Take a brick and gently keep it over the mud surface in horizontal position.*
3. *Carefully remove the brick and note its impression on the mud surface.*
4. *Again keep the brick in vertical position on the sand surface and note the impression.*
5. *Hold the brick on one of the edges on the mud surface and again note the impressions.*

In which case is the impression of the brick deeper? Why?

The force per unit area (stress) is to be considered while constructing the roads. The load of the vehicles act on the wheels. The area of contact between the wheels and the ground is less. Therefore the pressure (stress) is high. The soil of the road must withstand this force and if the soil is weak it has to be reinforced by putting harder materials (stones)

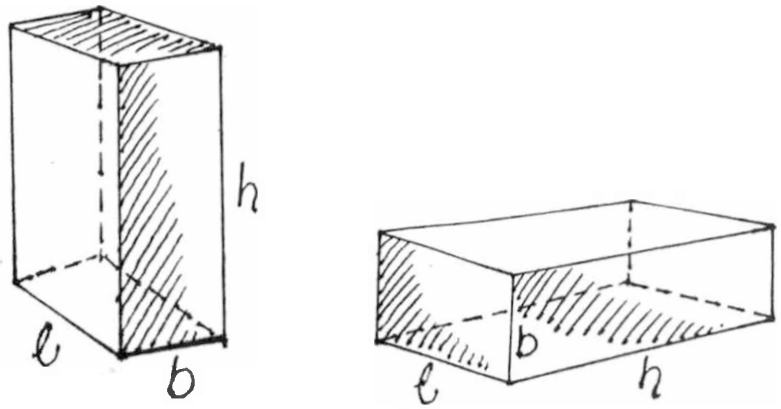


Fig.2.22

Activity 20

1. *Take a brick and find its weight (force)using a spring balance.*
2. *Measure its length breadth and height using a scale*
3. *Place the brick in two positions as shown in Fig. 2.22*
4. *Calculate the area over which the weight is acting in position(i)&(ii)*
5. *Find the force per unit area in each case and compare them*

Do it yourself

Find out from the farmers the approximate weight of the bullock-cart when it is empty. Assume the area of contact between the wheels and the ground to be 50 cm^2. Calculate the force per unit area (stress) on the ground.

Suppose the bullock-cart is loaded with 15 Quintals of rice what will be the change in the stress.

Compression: What happens to a bundle of hay when you sit on it? The hay bundle reduces in size. This is due to the weight (force) of your body. When you sit on a sponge (cushion)seat, the seat gets compressed . Likewise there are many instances in our daily life where compression acts. Some times if the force is large the material under it may even break or get crushed. Therefore compression force is some times referred to as crushing force also.

Do it yourself: List out 5 examples from your daily life where compression/ crushing force acts.

Activity 21: Dip your hand in water, when you take out your hand, some water is seen clinging to your hand. The hand gets wet. Why does the water stick to the hand? There must be a force of attraction between hand and water. You know hand and water are made of different kinds of particles (molecules).

The force that makes water stick to the hand is called an adhesive force. "The force of attraction between different kinds of particles (molecules) is called adhesive force". Re call how you would fix a stamp on a cover. We use glue for this. Here glue is an adhesive.

When you take out your hand from water, some droplets of water fall down. The droplets of water are formed by the sticking together of a large number of water particles. This is due to another kind of force that exists between particles of the same kind. This force is called cohesive force.

You know that the tyres of the bullock cart are made of iron flats. Have you seen how the blacksmith joins the ends of the iron flat? He heats them red hot and keeps the two ends one over the other and strikes with a hammer. The cohesive force holds the two ends together and the joint is made strong.

Test Yourself

1. Distinguish between cohesion and adhesion.

2. Give two illustrations each for adhesive force and cohesive force.

Erosion

You might have observed the depressions caused on the ground by the rain water falling down the roof. Here, when the rain water flows down the roof it hits the ground. When the water flows it carries the soil along with it. This phenomenon is known as erosion.

Fig. 2.23. *Topographical features of a village*

Activity 23: Pour water from a mug over a heap of soil. Observe the depressions on the soil. What happens when water is poured from a higher level?

Erosion of roads and fields is a natural phenomenon caused by the flow of wind or water. The erosion is more when the soil is loose and not compact. You can see the effect of erosion on roads of your village on a rainy day.

Topography

The ground surface of a given place may be plane or uneven with hills and valleys. The pictorial representation of all such factors is called topography of the place. It helps us to identify the direction of water flow. It also helps us to determine the gradient of the roads to be made. It also helps in identifying an appropriate route for the construction of roads for transportation.

Activity 24: In the given Fig. 2.23 locate the following:

a) hills b) tank c) bund d) irrigated land
e) dry bunds f) canals g) roads

Now you have learnt a few principles of science behind the construction and working of vehicles and ways of transportation. You will appreciate that these principles are applied in the technology of rural transportation. You will also identify the various practices adopted for transportation in rural areas.

In the next chapter, you will learn about bullock cart as a typical transport vehicle in rural areas. You will also learn about the roads in rural areas. You will understand the scientific method of constructing metal roads. You will also appreciate the need for the maintenance of roads and their effect on transportation system.

Test Yourself

Answer the following questions.

1. *What is meant by 'speed' of a body?*
2. *One body is moving with a speed of 15 m/s and another body is moving at a speed of 40 km/hour. Which of these is moving at a greater speed?*
3. *Give three examples each for 'push' and 'pull' from your daily life.*
4. *Give two examples from your daily life for inertia of bodies.*
5. *A force of 10 N acts on a body of mass 0.5 kg. Calculate the acceleration produced?*
6. *'Greater the mass of a body, greater will be its inertia'. Explain this statement.*
7. *'Friction is both a boon and a bane'. Explain this statement with two examples.*
8. *Use of wheels has helped us to reduce friction. How?*
9. *How do lubricants help in reducing friction?*
10. *State the principle of moments. Give two examples from your village situation to illustrate the principle of moments.*
11. *Illustrate the law of conservation of energy by giving an example.*
12. *Define the following terms:*
    Erosion, Gradient, Elevation
    Why should we consider these factors in the design and construction of roads.

CHAPTER III

In this chapter, you will study the bullock-cart as one example of the mode of transport in rural areas. You know bullock carts are the most widely used transport in our village.

Observe Fig.3.1 carefully. You will find the essential parts of a bullock cart. Names of the parts are also given here. Match the parts of the bullock cart with suitable names by indicating an arrow against each.

You have seen an assembly of these parts in a bullock cart. Identify these parts from (diagram 1) in Chapter I. You will recognise each of these parts has definite functions. List the functions of each part.

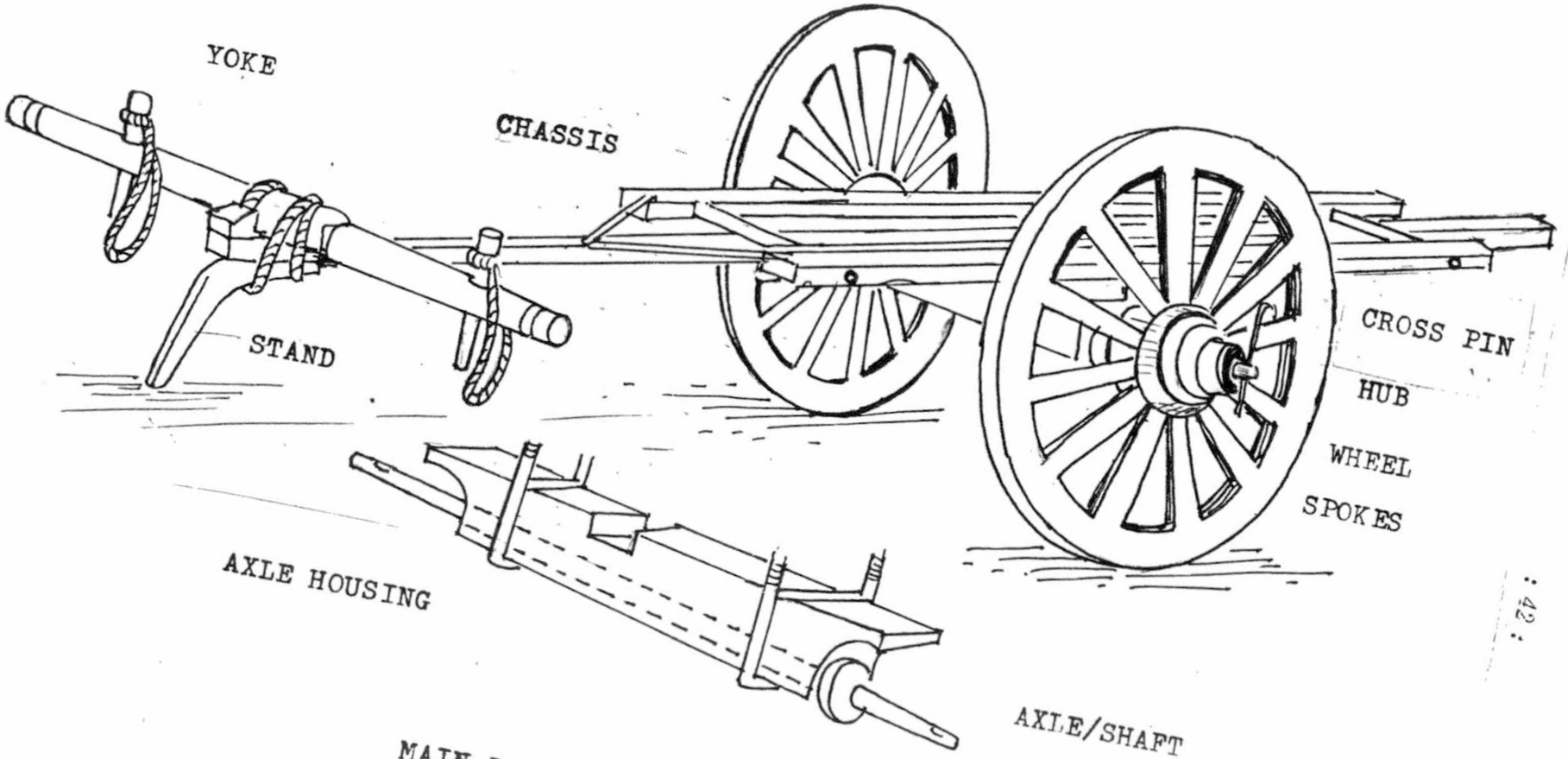
Activity: *Measure the following dimensions on a bullock cart in your village.*

1. *a) Diameter of the wheel and distance covered by the wheel in one rotation*
   b) Number of spokes on the wheel
   c) Diameter of the hub
   d) Width of the wheel rim
2. *The length/width of the chassis. Calculate the area over which you can load.*
3. *The length of the central beam carrying yoke.*
4. *The distance between the axle centre and the front end.*
5. *The height of the front stand.*
6. *The length of the yoke.*
7. *The height of the chassis from the ground*

Work Sheet:

i) Reproduce a free hand sketch of the assembled view of the bullock cart and label its parts.

ii) Draw the individual sketches of each component of a bullock cart. Measure the dimensions from a cart.



MAIN PARTS OF A BULLOCK CART

Fig.3.1

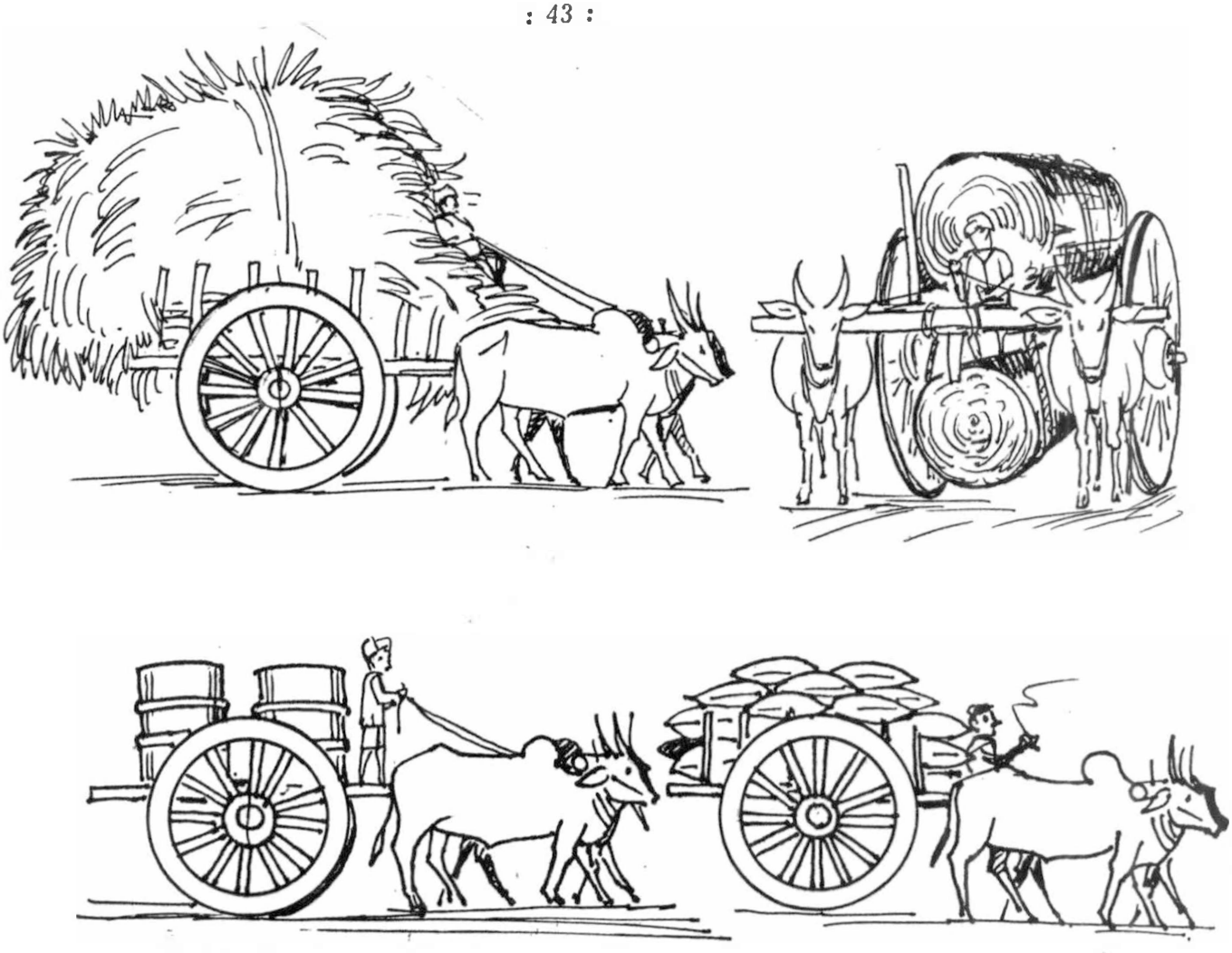


Fig.3.2

The above illustrations show some of the various materials that are carried on a bullock cart. (The concept container-service of modern days has originated from these practices.)

It is wise to remember the following factors while loading.

a) Pulling capacity of the animal

b) Strength of the axle

c) The conditions of the roads

Overloading and bad roads may result in the breaking of the axle. In this picture, you see a cart with a broken axle. Observe the broken end of the axle, the cross sectional area is much less and when a heavy load acts on this area the force per unit area (stress) is too large. The material cannot withstand this stress. Therefore, it breaks. Fig.3.3 illustrates the case of a bullock cart whose axle is broken.

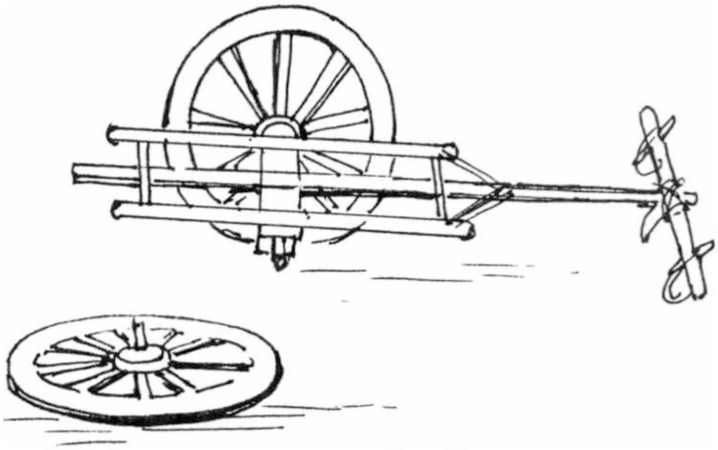


Fig.3.3

Observe the loading of a slab stone into the cart. In Fig.3.4, note the position of the cart. Can you identify that the principle of lever is used here. The front side of the wheels are given support with stones. What would happen if we do not provide this stone? You will recognise that the wheels would roll in the absence of stones under them.

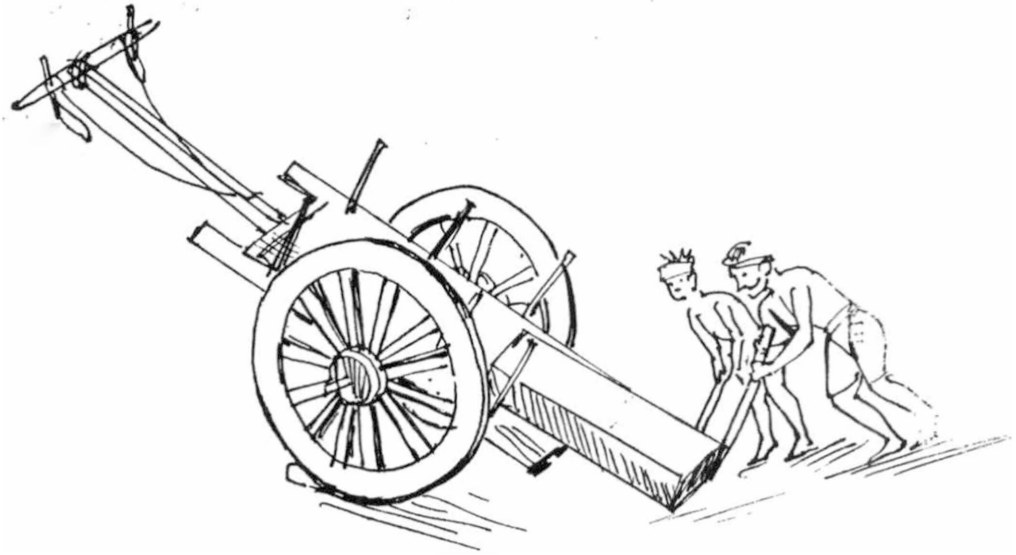


Fig.3.4

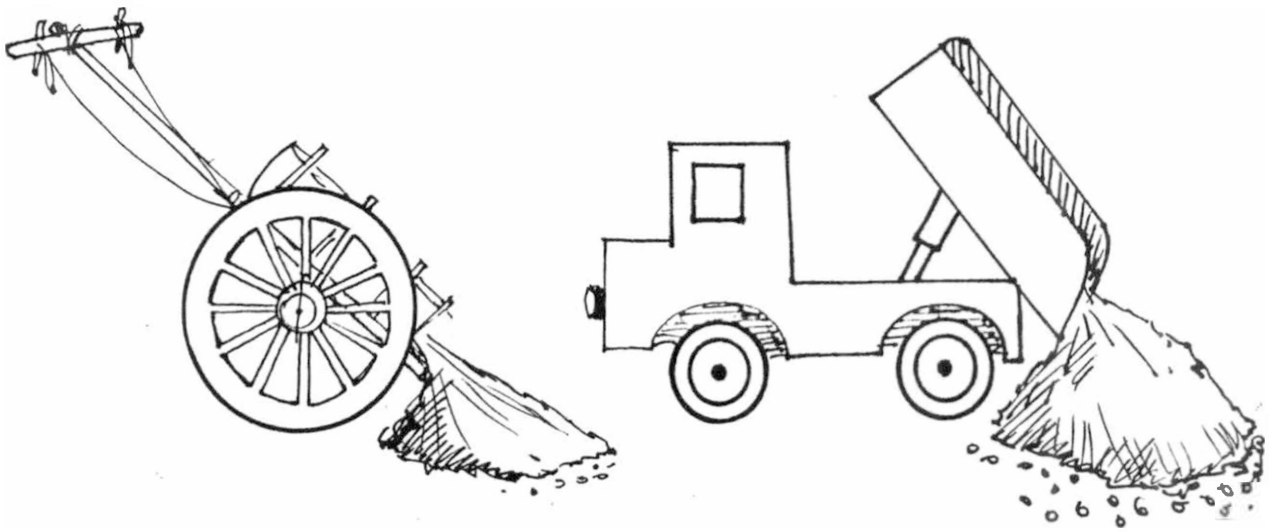


Fig.3.5

Have you noticed how materials such as sand, manure are unloaded from the cart. Usually the stand of the cart is lifted up and the cart assumes the shape of an inclined plane as shown in Fig.3.5 The entire material inside the cart is unloaded. This technique is used in modern vehicles like tippers/dumpers.

Power Transmissions in Bullockcarts

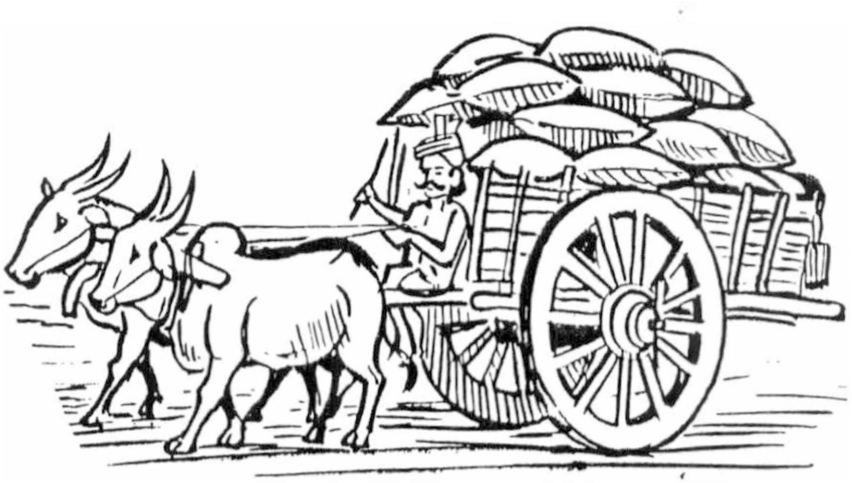


Fig.3.6

The power forbullock cart is provided by the bullocks. This is known as inputs. The amount of load carried depends on it. There is a limit for the animal power. Therefore, load to be transmitted on a bullock cart depends on the bullocks. The capacity of an animal to pull the cart depends on its age, health and nutritional factors. But still beyond a limit, the load becomes too heavy for bullocks. Therefore, the efficiency which is the ratio of input to the output cannot be improved beyond a certain limit.

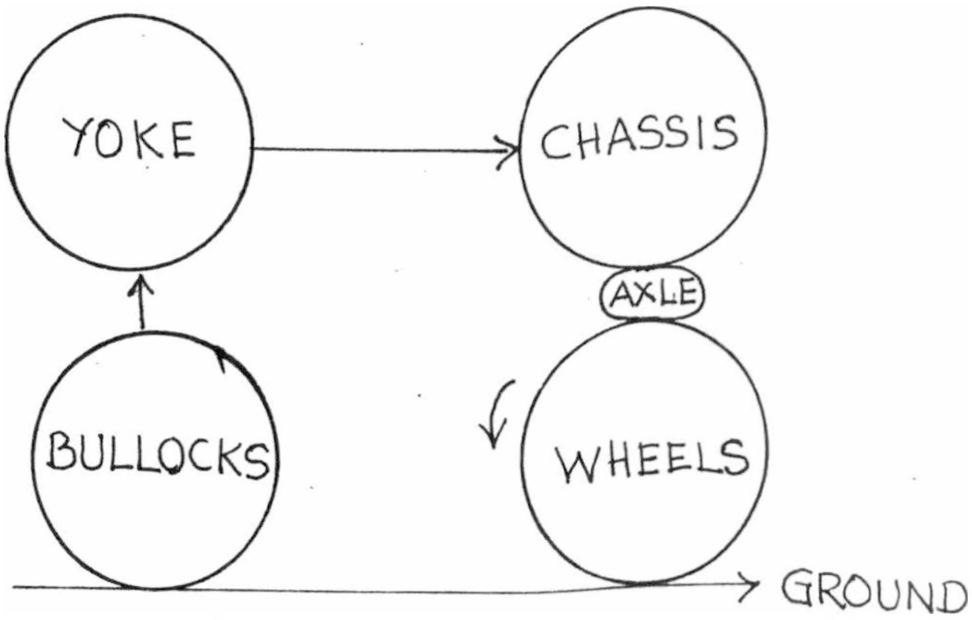


Fig.3.7

Fig.3. 7 gives a flow diagram. Observe and determine the source of power and the direction of transmission of power. The arrow indicates the direction of the power transmission.

Test Yourself

From the flow diagram shown above rearrange the power transmission sequence in proper order.

GROUND → ***AXLE*** → ***YOKE*** → ***BULLOCKS*** → ***CHASSIS*** → ***WHEELS***

Source of energy losses: The total energy supplied by the bullocks is not completely utilized for pulling the cart. Losses occur at various points of the cart. Some of these losses are avoidable to some extent. Others are not.

1. Bullocks are tied to yokes with ropes. Since the ropes are to be loose some amount of energy is wasted. But we cannot tie the rope tightly around the animal as it would lead to the bruising of the skin of the animal. This can be seen on some bullocks in our villages. Is this avoidable?
2. The yoke is tied to the chassis by ropes and here again some allowance is made in ropes so that the bullocks can easily steer the cart while turning. Hence this loss is to be allowed.
3. The axle and the inner surface of the hub of the wheel rub each other. What is the nature of this loss? Is this loss avoidable? To what extent?
4. When the wheels roll on the ground, the surface of the wheel (metal) comes in contact with the road surface. There is a relative motion between them and they press each other. What type of loss of energy is this? Is this avoidable? If so how?

Now consider the following situations in the transportation by using bullock carts.

i) Loaded cart is moving up a gradient. What force is dragging the cart and the animal backwards?

ii) Loaded cart is moving down the gradient. What additional force is acting in the direction of motion of the animal? What is its effect on the animals?

iii) The cart wheel is caught in a wet and muddy soil. The bullocks find it difficult to pull the cart out of this. What is the reason for this? How can we get the cart out of this spot?

Discuss the situations with the farmers in your village and find out from them what measures they normally adopt to overcome the problems in the above situations.

The yoke is constantly pressing the neck of the animal. What is the effect of this on the animal? Some times the skin in this area swells up and becomes rough. How can we prevent this cruelty to the animals?

The weight of the cart when it is empty is called the deadload-(Tare) of the cart. This is important because the bullocks have to pull this load all along. This is not a useful load but it is unavoidable. The materials which constitute the various parts of the cart do have some weight.

If we reduce the deadload of the cart, the efficiency of the cart naturally increases. The input required for pulling will decrease. But while decreasing the dead weight of the cart, we should remember the safety of the cart.

The useful load carried on a cart is called payload. If we can carry more payload on the cart naturally the cost of transportation would decrease. However, the payload cannot be increased beyond a certain limit considering the capacity of bullocks and space available for loading. The area available on the chassis is limited and the only way to increase the loading is to pile the load on the cart. Piling of the load to a greater height will pose problems of stability while driving the cart.

DEAD LOAD *(Weight of the Cart)*	+	***PAY LOAD*** *(Weight of the materials)*	=	***TOTAL LOAD PULLED BY BULLOCKS***

Roads for Transport:

...oads form an integral part of the ...ciency of the transport can only be improved when the road conditions are also improved.

Roads can be classified as highways, link roads and country roads.

Fig.3.8

In Fig.3.8 , you see a truck moving on a highway connecting two important cities. A village situated above 4 km from this highway is connected by a link road/ approach road. You notice that a cyclist is on his way to

his village. There are farm roads which lead to the fields from the village. You can see the farmer driving a bullock cart to the fields.

Now answer these questions:

1. Are all the roads of same type?
2. Which of the road is widest?
3. Which road is a metal road?
4. Which road can be constructed easily?
5. On which road is the traffic movement more?

We have observed earlier that tracks guide us for selecting the route. Man and animals select the route of least obstruction, discomfort, energy/power input when they travel on foot. But the width of the track in this case is much less when compared to the roads needed for the transportation of vehicles like bullock-cart. The roads must be wide enough to permit the movement of vehicles from one or both directions. Good roads enhance the speed, efficiency and safety in transportation.

Breakdowns and accidents are few on good roads. This will have a considerable effect on the life of the vehicles. The travelling time is much less on a good road. It requires less effort for pulling the (comparatively) vehicles on an even road than on a bumpy road.

What makes a road good? How can a good road be identified?

Imagine a road like this. The road is below the level of the surrounding lands. How good will this be for transport in rainy season? You know that water flows from the surrounding land on the road and erodes the soil on the road.

Hence a good road should be on a higher level compared to its surrounding land. It should consist of drainages to keep away the flow of water on the road.

Suppose the road surface is soft when there is transport with heavy load on it. The soil gets crushed and ruts are formed. The road surface becomes uneven.

To overcome this, good roads are constructed with hard and strong materials like broken stones, gravel and sand. Further, the materials are made hard and compact. Thus the road surface is made free from hollows, ruts and pot holes on it.

The road construction is done on a scientific basis. Let us see how metal roads are constructed.

The ground (soil) on which the road is constructed is known as subgrade. The subsoil is dug to a definite shape in which hard materials are filled to provide the bearing strength i.e. to take the load without crushing or changing the shape and transmit the load to the soil below.

The strength of the soil to withstand the crushing force of the vehicles on it is known as bearing capacity of the soil. This capacity depends on the type and nature of the soil. The bearing capacity can be improved by ramming and compacting the soil. Bearing capacity is measured in tonnes/meter^2.

The following table indicates the bearing capacity of the soil of different types.

Soil material	Bearing capacity
Hard clay	44 ton/m^2
Medium clay	22 ton/m^2
Sand gravel	22 ton/m^2
Silt/sand	16 ton/m^2
Soft clay	11 ton/m^2

The nature of the soil is found out by inspection and its bearing capacity is read from the table. The ground is dug in the shape as shown in Fig.3.9 . This digging helps to remove the roots and such other organic materials. Note the slope provided towards sides of the road. This slope ensures water flow away from the road. This stage is known as "formation".

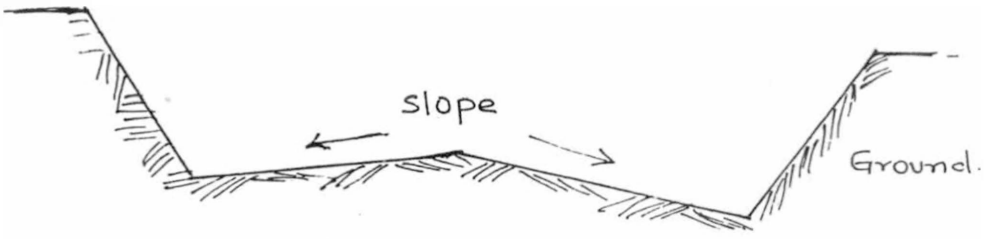


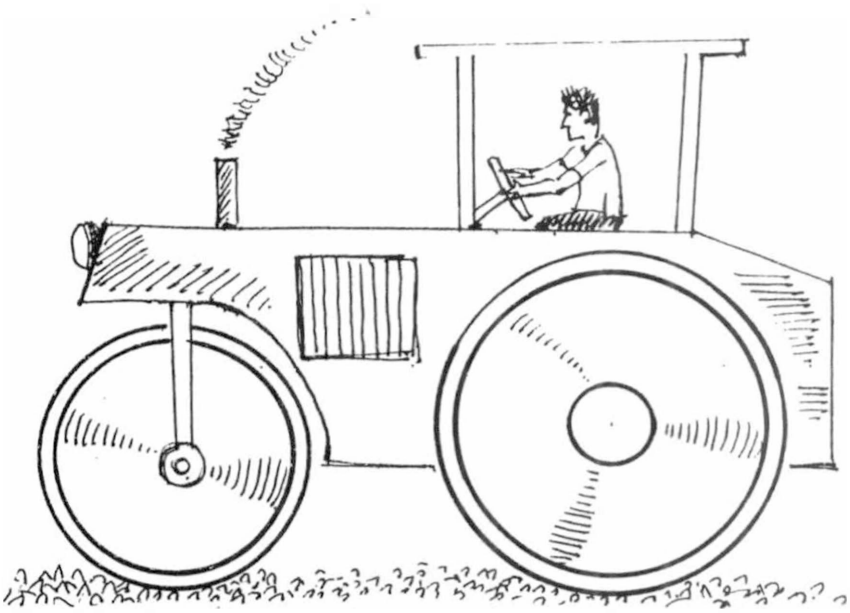
Fig.3.9

On the formation two layers of broken stone (size 7 cm) is spread to a thickness of 12 cm. This is known as sub-base. Over the sub-base one layer of broken stone (size 2.5 cm) is spread to a thickness of 5 cms. This is known as base-course.

On the top of the base course a mixture of sand and binding soil (clay) is spread to form what is known as 'wearing course'.

The materials are to be rammed at each stage mentioned above. Rams as shown in Fig.3.10 are used for compacting the soil. Road rollers are used in urban areas. This process sets the soil by cohesion.

Fig.3.10



Road Roller

Find out the following from Fig.3.11

1. *Subsoil/Subgrade*
2. *Formation*
3. *Base course*
4. *Sub base*
5. *Wearing course*

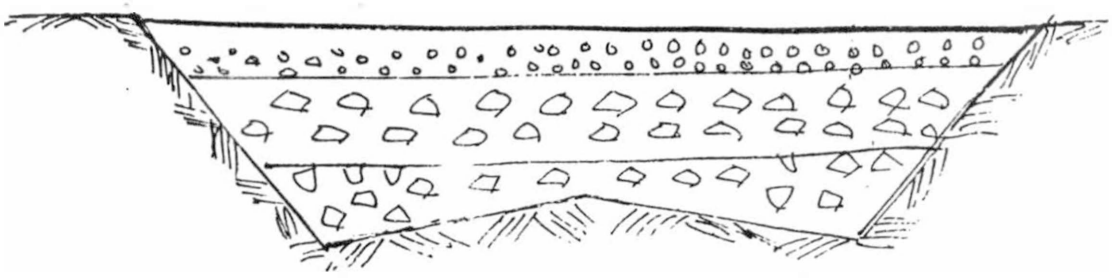


Fig.3.11

Once the road is constructed, it is essential to maintain the road in useable condition.

Drainages are to be provided on either side to drain water from the roads.

Blockages like weeds in the drainages should be cleared from time to time.

The roads must be free from obstacles like tree branches and shrubs on either side.

The ditches and pit holes must be repaired immediately by filling with soil and compacting.

Do it yourself:

Observe the road from your village to the highway and find out whether,

1. *the road has drainages on both sides.*
2. *the drainages are free from obstructing materials like plant weeds, silt,*
3. *any ditches or pot holes found on the road surface.*
4. *the road surface is a higher level than the surrounding land.*
5. *the top soil is eroded.*

Now consider a problem situation in Fig.3.12

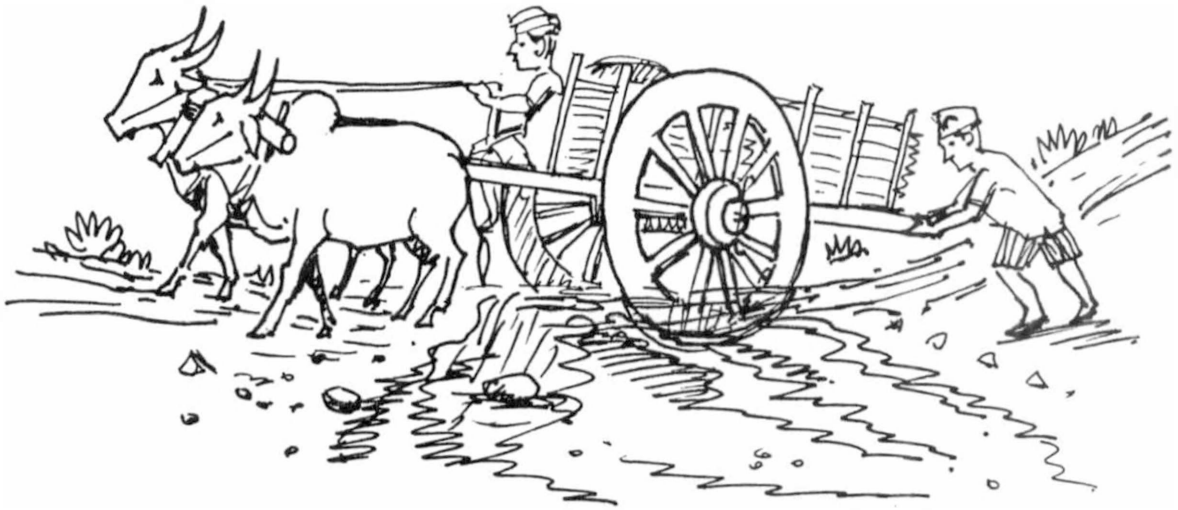


Fig.3.12

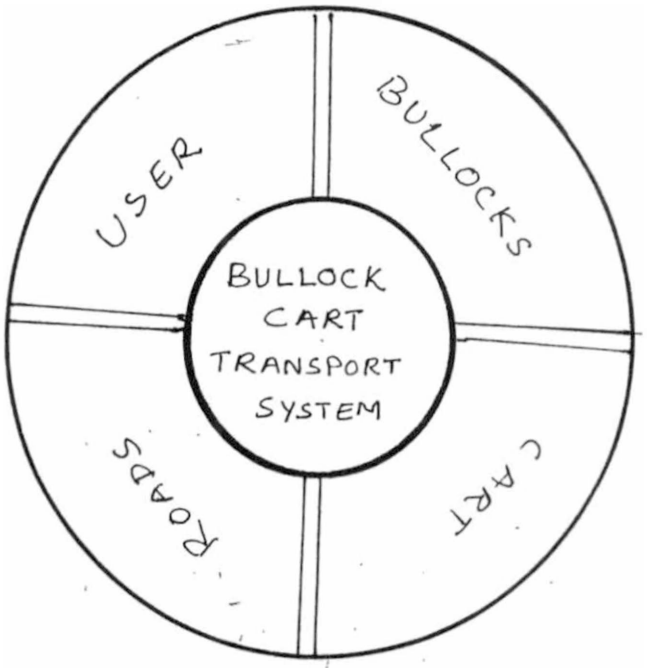
An irrigation sub-channel cuts across the approach road of a village, and the channel is full of slit with low bearing capacity. Imagine that a bullock cart is transporting on this road. It may be difficult for bullock cart transportation under the present conditions.

The various ways of overcoming it are

1. *building a permanent structure across the channel.*
2. *providing concrete slabs in the channel.*
3. *providing a temporary bridge with bamboos.*
4. *seeking the help of people to push the cart.*

Discuss the advantages of each of the above solutions and state under what conditions each of them are best suited.

Systems Approach: *Bullock-cart transportation is having some definite components and functions, it therefore, can be called as a system. In this system, we have subsystems. Performance of bullock cart transportation as a whole depends on these sub-systems.*



1. *The bullocks provide input energy/power to the system.*
2. *The supply of power from the bullocks is limited and bullocks get tired after some time.*
3. *Energy losses occur in the bullock cart transport. We can minimise/ reduce the losses.*
4. *The iron tyre of the cart has adverse effect on the roads.*
5. *Methods are to be adopted to maintain roads in good condition so that the efficiency of the system is high.*
6. *There is considerable effect of rain water, weather and environment on roads.*

The condition of the cart, roads, the bullocks and the farsightedness/ wisdom of the user collectively contribute to the efficient working of the bullock cart transport system.

How does the failure of any one sub-system affect the other sub-system? What impact it will have on the transportation system?

Now you have some broad ideas about the design and the construction of the bullock cart. Improvements are necessary to obtain some specific advantages. Suppose, we intend,

A. to increase the pay load within the broad set up: This can be achieved by decreasing the dead load. We can reduce the dead weight of the cart by using lighter material for the body. However, this can affect considerably the strength and safety of the cart. So, use materials that are light in weight but possessing the needed strength.

B. to improve the efficiency: To achieve this, the frictional losses are to be reduced. This requires a change in the design of wheels as bearings are to be fitted on the wheels.

C. to maintain road in good condition without ruts: The iron tyres damage the road. The tyre width is less and therefore, force per unit area of the road surface is more. We can increase the width of the tyres and hence the soil may not bear the pressure.
The cart with a wider wheel poses problems when it is to be (steered) turned to left/right.

D. to increase the safety of the articles carried: Bullock carts often damage articles/materials carried on it. One way to minimise this is to by providing springs to absorb the shocks.

E. *to enhance the passenger comforts:* The passenger comforts are poor in bullock carts. People have to couch/squat while travelling on it. Moreover, the hard surface of the seat is inconvenient. We can provide cushions for the cart. But they should be removable while loading the cart with materials like manure, sand and brick.

F. *to replace the tyres with pneumatic ones:* The diameter of the pneumatic tyres are so small . They are not convenient in farm roads and ruts. The tyres cannot be taken off the ruts easily.

You have seen that improvements are possible but they may pose some other problems. The problems are to be carefully considered while giving a new design for the cart.

Test Yourself

1. What are the reasons for considering bullock cart as an effective mode of transport in rural areas?
2. Why should the road be constructed at a higher level than the surrounding ground?
3. What is the purpose of providing drainages on the sides of road. What are the reasons for the blockage of these drainages?
4. How does the efficiency of transportation system affect when one of its sub-system fails?
5. List out the improvements that are possible on bullock carts. State the problems which occur while bringing the improvisations?

Activity 26:

1. *Compare the load that can be carried on a bullock cart (the number of bags of ragi/paddy) with that which can be carried on a cycle.*
Express it as a ratio: $\frac{\text{20 bags of ragi}}{\text{2 bags of ragi}}$ *(say)*

2. *Find out from the users of the cart in your village the number of people (adults) that can be carried comfortably on a bullock-cart. How does it compare with the passenger capacity of a cycle?*

3. *You have seen people driving bullock carts and cycles. In your opinion, which of these require a high degree of skill?*

4. *Considering the above modes of transport, which can be manueovered easily in emergency?*

5. *If agricultural implements like yoke, plough are to be carried to the field, which of the above transport is suited for this purpose?*

6. *In the above example, which of the two transport modes requires more force to be exerted (effort) by the driver?*

7. *Measure the width of the bullock-cart and estimate the road width required for the bullock cart transportation. How does it compare with the width of the road needed for a cyclist?*

8. *Find out from the user the approximate cost of the bullock cart and the average life span of a bullock cart. Compare it with the cost of a cycle and its average life.*

	Cycle	Bullock cart
Load		
Cost		
Life		

9. Identify the type of activities where a bullock cart can be used for transportation. List out the situations where a bicycle would be more advantageous for transportation in comparison to a bullock cart.

10. A cycle requires more maintenance than a bullock cart. Do you agree?

Activity 27:

1. Count the number of the traffic vehicles which pass over your village in an hour. Classify them into high speed vehicles, medium speed vehicles and slow vehicles.

2. Measure the width of a lane in your village. Compare it with the width of the main road.

3. Shoulders are provided on either side of the road to permit vehicles to move in opposite directions. Measure the width of these shoulders.

4. Sometimes, heavy vehicles like trucks cannot enter your village for want of a good approach road. In such a situation, it is a practice to take the materials to be transported in bullock carts till the highway and then load it to the truck. This is known as transshipment.
How does this affect the cost of transportation?

5. On a sandy/market day, you find trucks come to collect the materials from three or four villages to transport them to the city. Such a spot is known as a pick up spot.
How are these pick up spots decided by the people who transport their materials?

Conclusion

In this module, you have learnt some aspects of transportation in rural areas. You also realised the needs and modes of transportation. You have identified the significance of transportation in social, cultural and economic activities in rural areas. You agree that there is an impact of transportation on the socio-economic life of people.

You have also learnt some of the principles of science like friction, levers, moments, centre of gravity. You have correlated these principles with the various practices adopted in transportation in rural areas.

You have been able to recognise the role of bullock cart in rural transportation. You have studied the basic constructional details of a bullock cart and the need for improving the same.

The role of roads in transportation and its relationship with the vehicles and transportation cost has been recognised by you.

The transportation system of any country is an indication of its economic prosperity. The needs and modes of transportation are changing in pace with the rapid developments in science and technology. There is a need for more and more efficient vehicles both energy and cost-wise.

Meeting the transportation demands is a challenge. As this is true for a country, it is also true for a village.

Therefore, it is envisaged that from now onwards, you will develop an insight towards the improvements of the transportation system in your area.

****