19. Properties of a Magnetic Field

Let's recall.

1. Where and how are magnets used in our houses and our surroundings?
2. In which direction does a freely suspended magnet settle?
3. What are the names given to the two ends of a magnet? Why are they named thus?
4. Which metals are used for making magnets?
5. What are the characteristics of magnets?

Magnets are made from alloys of iron, cobalt and nickel. Nipermag, an alloy of iron, nickel, aluminium and titanium is used to make magnets. We have also learnt that alnico is a magnetic alloy of aluminium, nickel and cobalt.

Magnetism

Try this.

Apparatus : Steel bar, bar magnet, iron fillings, thread, etc.

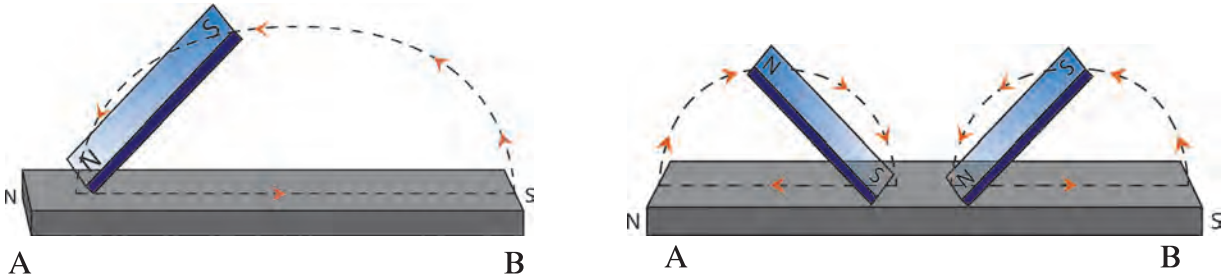
Procedure : Place a steel bar AB, on a table. Take a bar magnet. Place its 'N' pole on the 'A' end of the steel bar and drag it towards the 'B' end. Lift the bar magnet and drag its 'N' pole from the end A to the end B of the steel bar again. Repeat this 15 to 20 times. Now take the steel bar near some iron filings and observe what happens. Hang the bar freely by a thread and observe.

The steel bar will be seen to have developed magnetism. This method of magnetisation is called the single touch method. The magnetism created by this method is of low strength and lasts for a short time.

Procedure : Place a steel bar on a table. Take two bar magnets. Place two opposite poles of the two bar magnets at the centre of the steel bar. Drag these poles apart, one to the 'A' end of the steel bar, and the other to the 'B' end.

Repeat this 15 to 20 times. Now take the steel bar near iron fillings and observe. Hang the steel bar freely and observe.

This method of magnetisation is called the double-touch method. The magnetism generated by this method lasts longer compared to that generated by the single touch method.



19.1 Magnetising a steel bar

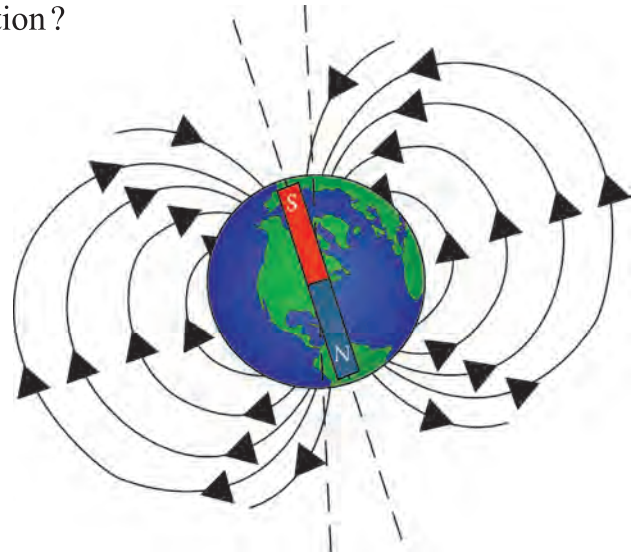
Can you tell ?

Why does a freely suspended magnet always settle in the north-south direction ?

Earth : A gigantic magnet

The scientist William Gilbert gave a scientific explanation, based on experiment, of the observation that a freely suspended magnet always settles in the north-south direction only.

He gave a round shape to a naturally occurring magnetic rock. He suspended this spherical magnet so that it could turn freely and brought the north pole of a bar magnet near it. The south pole of the magnetic sphere was attracted towards it.



19.2 Earth's magnetism

Can you tell ?

1. Which magnetic poles attract each other ?
2. Which pole of a spherical magnet will get attracted towards the south pole of the bar magnet ?

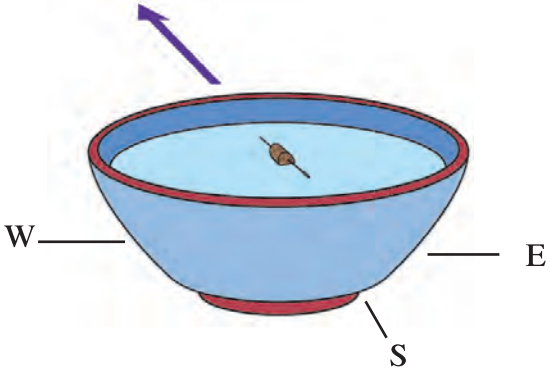
The north pole of a freely suspended magnet settles in the direction of the geographic north pole of the earth. It means that the south pole of some gigantic magnet must be near the geographic north pole of the earth and the north pole of that magnet, near the geographic south pole of the earth. Gilbert inferred from this that the earth itself is a gigantic magnet. However, the south pole of this magnet must be near the geographic north pole of the earth while the magnetic north pole is near the geographic south pole.

Use your brain power !

Which direction will a magnetic needle show on the geographic north pole ?

Magnetic needle

Take a square cardboard and mark the directions on it. Place a pot filled with water at the centre of the cardboard. Take a magnetized needle. Stick it to a small piece of a cardboard by means of a sticking tape. Place the piece of cardboard with the needle, on the surface of water in the pot. In which direction does the magnetized needle point ?



19.3 Magnetic needle

Find out.

In any place, why does the magnetic needle of a compass not settle parallel to the ground but at a an angle to it ?

Magnetic field

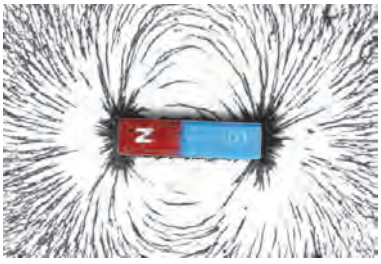
Try this.

Apparatus : A bar magnet, pins, cardboard, iron filings, plastic bottle, bucket, water.

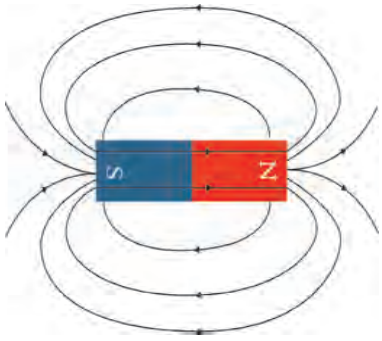
Procedure : Take a bar magnet and some pins. Place them at such a distance from each other that they do not stick to each other. Now slowly move the magnet towards the pins. Observe the pins as they get pulled to the magnet.

The magnet attracts the needles from afar. In other words, a magnet has an effect even at a distance.

Procedure : Take a small cardboard. Place a bar magnet at its centre. Sprinkle iron filings on the cardboard around the magnet. Tap the cardboard gently. Observe the iron filings.



What is the inference from the above experiments? The British researcher Michael Faraday named these lines, going from one end of the bar magnet to the other, 'magnetic lines of force'. The region around a magnet where the magnetic force acts on an object is called a magnetic field. The magnetic field around a magnet can be shown by means of magnetic lines of force. The intensity of the magnetic field at a place can be guaged by the number of lines of force that pass through a unit area at that place, perpendicular to that area. Michael Faraday, imagined that there might be invisible lines of force going from one pole of a magnet to the other, and that magnetic attraction or repulsion might be taking place through the medium of these lines of force. If Faraday's idea is accepted, the intensity of the magnetic field can be obtained from the number of lines of force, as explained above.



19.4 Magnetic field

The intensity of a magnetic field is low where the lines of force are sparse, and the intensity is high where the lines of force are concentrated.

Use your brain power!

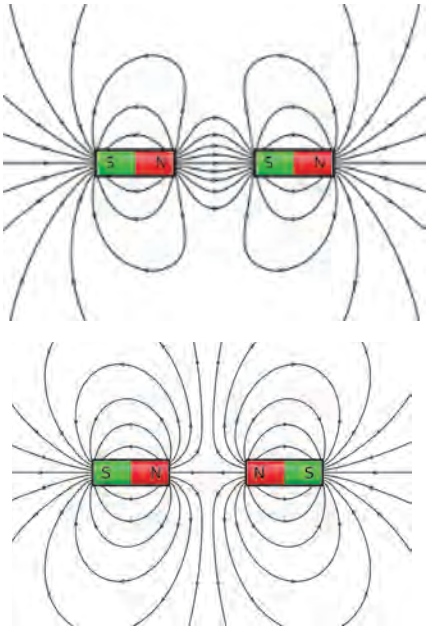
Is magnetic force a vector or a scalar quantity?

Michael Faraday

Properties of magnetic lines of force

While proposing the concept of lines of force, Michael Faraday argued that, if all observed effects are to be explained satisfactorily, then the lines of force must have certain properties.

1. Magnetic lines of force are imaginary connecting lines and Faraday introduced the concept of lines of force in order to explain magnetic attraction and repulsion.
2. Magnetic lines of force always run from the north pole to the south pole. The south pole may be of the same magnet or a different one.
3. Magnetic lines of force are in a state of tension like a stretched spring.
4. Magnetic lines of force repel each other.
5. Magnetic lines of force do not intersect each other.
6. The number of the magnetic lines force at a particular point determines the strength of the magnetic field there.

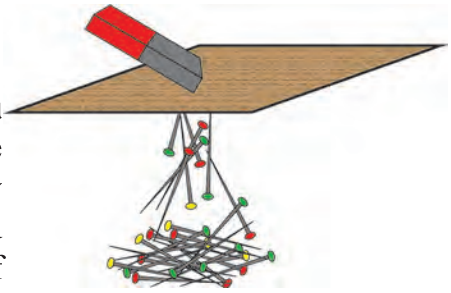


19.5 Properties of magnetic lines of force

You can now see from the figure, how the properties given above help to explain the repulsion between like poles and attraction between opposite poles. According to the third property, the lines of force joining the north and south poles of a magnet, being in a stretched state like a spring, pull the two opposite poles towards each other. By the fourth property they give rise to repulsion between like poles.

Penetrating ability of the magnetic field

Procedure : Spread some pins on a table. Hold a cardboard at a small distance above these pins. Place a bar magnet on the cardboard and observe. Now move the magnet slowly over the cardboard and observe. Repeat this procedure, increasing the layers of cardboard, and observe.



19.6 Penetrating ability of magnetic field

Procedure : Fill water in a plastic bottle. Drop a few pins in the water. Take a bar magnet near the bottle and observe. Move the magnet through a small distance near the bottle and observe.

From the above observations, we see that a magnetic field can pass through a cardboard, a bottle or water. However, in each case, the intensity of the magnetic field is found to decrease.

Procedure : Take water in a big basin. Place a bar magnet on a plastic lid and float it on the surface of the water. Magnetise a needle or pin. Stick this needle firmly to a small piece of thick cardboard by means of a sticking tape.

Place the magnetized needle stuck to the cardboard, in the water near the magnet. Observe the direction in which the needle moves. Repeat this, placing the magnet at difference places around the magnet and observe.

Use your brain power!

1. What is meant by magnetic force ?
2. How does a magnetic force act without direct contact ?
3. What is the difference between gravitational force and magnetic force ?

Can you tell ?

1. What is an electromagnet?
2. How can an electromagnet be made?

Metal detectors

The function of these machines is based on electromagnets. Metal detectors are used in very important places like an airport, bus station, certain temples and buildings. They are used for inspection of persons entering these places. Metal detectors are used to detect very precious articles and also in the food-processing industry to detect any iron/steel objects mixed unknowingly in foodstuff as these would be harmful to health. In geology, these machines are used to detect the presence and quantity of metals.

19.3 Metal detectors

Use your brain power!

1. Why is repulsion the real test for identifying a magnet?
2. How will you find a magnet from among the various articles given to you ?

Exercise

1. Write the appropriate term in the blanks.

(a) The alloys called ..... and ..... are used for making industrial magnets.

(b) A magnetic field can pass through ..... and ..... .

(c) The intensity of a magnetic field is indicated by the lines of ..... .

(d) The real test of a magnet is ..... .

2. With whom should I pair up?

Group 'A'	Group 'B'
(a) Compass	1. The highest magnetic force
(b) Door of a cupboard	2. Like poles
(c) Repulsion	3. A magnet
(d) Magnetic pole	4. A magnetic needle

3. Write answers to the following questions:

(a) Distinguish between the two methods of making artificial magnets.

(b) Which substances are used for making electromagnets?

(c) Write a note on 'magnetic field'.

(d) Why is a magnetic needle used in a compass?

(e) Explain with the help of a diagram how the intensity and direction of the magnetic field of a bar magnet can be determined.

4. Give detailed information about how the merchants of olden times used a magnet while travelling.

Project :

Obtain information about the function of metal detectors.

♦ ♦ ♦

20. In the World of Stars

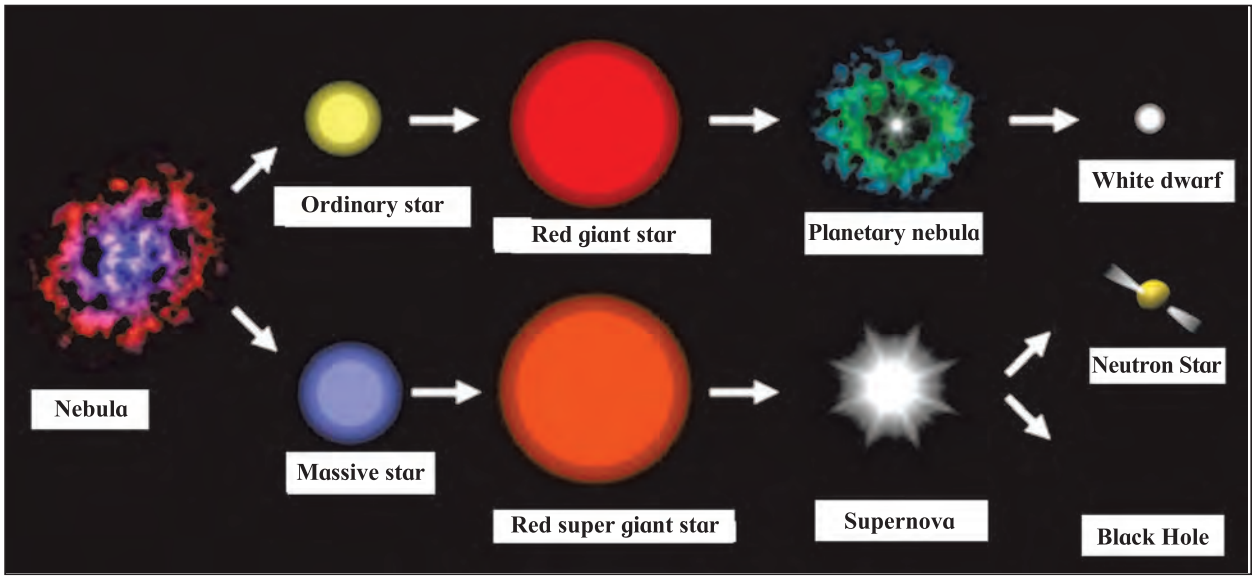
Let's recall.

1. What is a galaxy? What are the various components of a galaxy?
2. What are the different types of stars?

We have already learnt about galaxies and stars as well as the solar system and its different components. Stars are born out of nebulae. Nebulae are clouds made up mainly of hydrogen gas and dust particles. The particles in these clouds are attracted towards one another due to the force of gravity. As a result, the cloud contracts and becomes dense and spherical in shape. At the same time, the pressure of the gas at the core of the cloud increases causing the temperature to rise tremendously and energy generation processes start there. Such a spherical cloud of hydrogen is called a 'star'. Later, processes such as contraction, expansion, rise in temperature, etc. bring about changes in the nature of the star. These changes occur over a very long period of time and constitute the lifecycle of stars. The different forms of the stars at various stages during this lifecycle are identified as different types of stars.

Observe and discuss.

The following figure shows different stages in the lifecycle of stars after their birth from a nebula. Discuss these in the class.



20.1 Lifecycle of stars

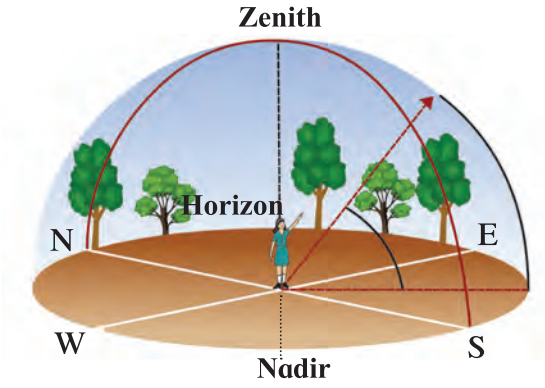
Our solar system is a tiny part of a galaxy called the Milky Way, which is many, many times larger than the solar system. There are lakhs of stars in the Milky Way, some of them being many times bigger than our Sun. Some of them have their own planetary systems. Stars in the Milky Way show a great diversity in colour, brightness, as well as size. Some stars, which appear to be close to one another making a particular figure are together known as a constellation. We shall learn more about constellations in this chapter. But, before that, let us learn a few basic concepts related to sky watching.

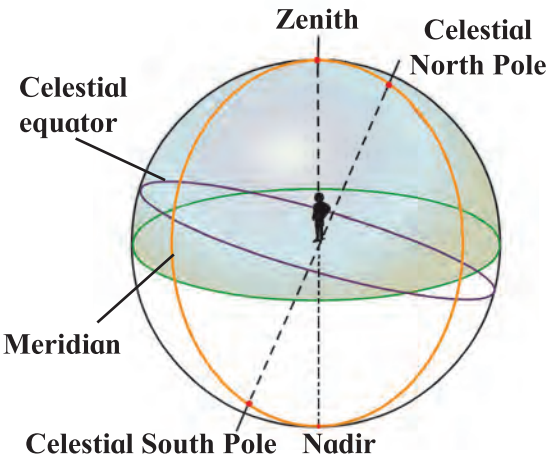
My friend, the internet! www.avkashvedh.com, www. space.com

Sky watching

Try this.

Stand still in an open space and look into the distance. What do you notice about the ground and the sky? Now, still looking into the distance, turn around yourself and observe the ground and the sky as you do so.





20.2 Virtual sphere

Far away, the sky seems to be touching the ground. The line at which they meet is called the **horizon**. While turning around oneself, the horizon will be seen to form a circle and on looking up, the sky will appear to be a sphere based on this circle. The stars and planets moving in the sky appear to be moving on this sphere. This virtual sphere is called the **celestial sphere**. The circular horizon divides this sphere into two halves.

1. Zenith : While standing on the ground, the point on the celestial sphere exactly above our head is called the zenith.

2. Nadir : While standing on the ground, the point on the celestial sphere exactly below our feet is called the nadir.

3. Celestial poles : If we extend the axis of rotation of the earth in the north and south directions it will penetrate the celestial sphere at points called the celestial North Pole and the celestial South Pole, respectively.

4. Meridian : In astronomy, the great circle which passes through both the celestial poles and the observer's zenith and nadir is called a **meridian**.

5. Celestial equator : If we uniformly expand earth's equator in all directions indefinitely, it will penetrate the celestial sphere along a circle. This circle is known as the **celestial equator**. It is in the same plane as the earth's equator.

6. Ecliptic : The earth moves around the sun, but, seen from the earth, the sun appears to move along a circle on the celestial sphere. This circle describing the apparent motion of the sun around the earth is called the **ecliptic.**

Sky and space

Sky : Standing in an open space, if we look at the sky on a cloudless night, we see numerous stars against a dark background. The portion of earth's atmosphere and the portion beyond that which can be seen in the form of a roof by our eyes while standing on the earth is called the sky.

Space : The continuous, empty space between the spheres (planets, stars, etc.) in the sky is called space. It may contain gas and dust particles. Numerous star clusters have formed in space.

The sun, the moon and the stars are seen to rise in the east and set in the west because the earth rotates from the west to the east. If we observe carefully, we will also notice that stars rise and set 4 minutes earlier every day. That is, if a star rises at 8 pm tonight, it will rise at 7:56 pm tomorrow. Against the background of stars, the sun and the moon appear to move from the west to the east, the sun moving through one degree every day and the moon through 12 to 13 degrees. This happens due to the motion of the earth around the sun and that of the soon around the earth.

Constellations

A group of stars occupying a small portion of the celestial sphere is called a **constellation**. Some of these stars appear to form certain figures of animals, humans or objects. These figures have been named after certain events or beliefs of the times when the constellations were identified. In this way, western observers have divided the celestial sphere into 88 constellations. Similarly, ancient western astronomers put forward the idea of 12 zodiac signs, whereas Indian astronomers suggested the 27 *nakshatras*.

Zodiac sign : The ecliptic has been imagined to be divided into 12 equal parts. Thus each part subtends 30 degrees at the centre of the celestial sphere. Each of these parts is called a *raashi* or zodiac sign. They are named Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricorn, Aquarius and Pisces.

Nakshatra : The moon completes one revolution around the earth in approximately 27.3 days. The portion traversed by the moon in one day is called a *nakshatra*. So if we divide 360 degrees into 27 equal parts, each part is about 13 degrees and 20 minutes. A *nakshatra* is known from the brightest star that it contains. This brightest star is called the *yogatara*. Which *nakshatra* we can see during a sky watch depends upon the position of the earth along its orbit.

Always remember –

1. The place for sky watching should be away from the city and, as far as possible, it should be a new moon night.
2. Binoculars or telescopes should be used for sky watching.
3. Identifying the Pole Star in the north makes the sky watch easier. Hence, the Pole Star should be used as a reference point for sky watch.
4. As the stars in the west set early, sky watching should begin with stars in the west.
5. As in geographical maps, the east and west are shown to the right and left respectively in a sky map.
6. On a sky map, the north and south are towards the bottom and top of the map respectively. This is because the sky map is to be held overhead. Hold the sky map in such way that the direction we face is at the bottom side.

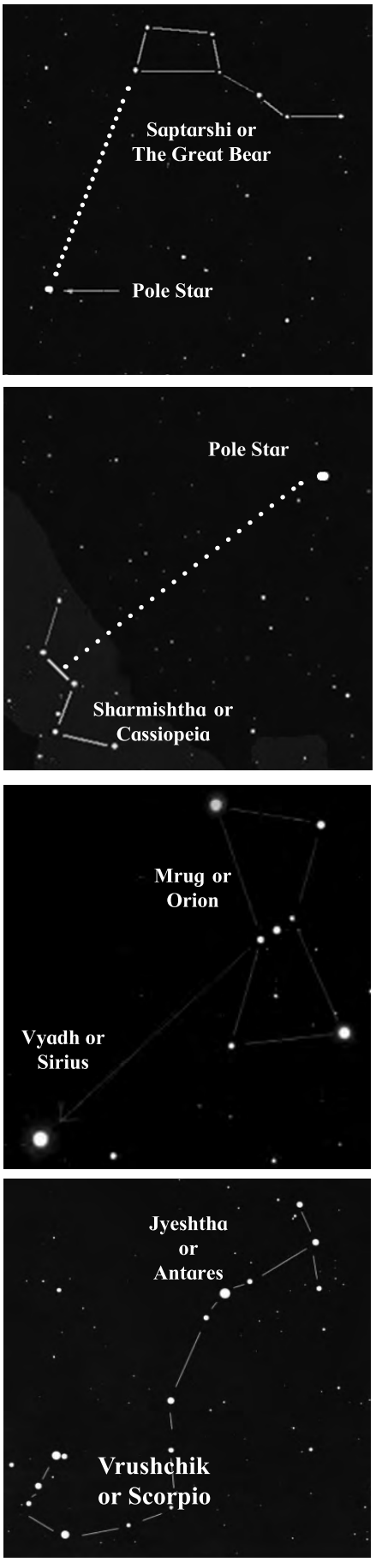
Find out.

Using a Marathi calendar, collect information about the 27 *nakshatras* and divide them into the following three categories:

Monsoon *nakshatras*	
Winter *nakshatras*	
Summer *nakshatras*	

Use your brain power !

One zodiac sign = ….. *nakshatras*.



20.3 Some constellations

Getting to know some constellations

1. During summer nights one can see a particular arrangement of seven stars. We call them Saptarshi. In the month of February, this constellation rises around 8 pm in the north-east. It is on the meridian in the month of April and in the month of October, it sets around 8 pm. As the name suggests, Saptarshi is a group of seven bright stars. It is in the shape of a quadrangle with a tail made up of three stars. It thus resembles a kite and can be easily recognized. If we extend one side of the quadrangle, it reaches the Pole Star or Polaris as shown in figure 20.3. Different countries have different names for this constellation. In English it is called the Great Bear.

2. The constellations of Saptarshi and Sharmishtha or Cassiopeia are useful in locating the Pole Star. Sharmishtha is made up of five bright stars which are distributed along the figure of the letter M. The perpendicular bisector of the line joining the third and fourth stars in Sharmishta goes towards the Pole Star. (See figure.) The Pole Star has Saptarshi on one side and Sharmishtha on the other. As Sharmishtha sets, Saptarshi rises. Thus, we can always use either one or the other as a reference point on any given night.

3. Mrug *nakshatra* or Orion has very bright stars. On winter nights, they can be easily identified. It has seven-eight stars of which four are at the corners of a quadrangle. The line passing through the three middle stars of the constellation, when extended, meets a very bright star. This is Vyadh or Sirius. During the month of December, Mruga *nakshatra* rises at 8 pm on the eastern horizon. It is on the meridian during February and in June, it sets around 8 pm.

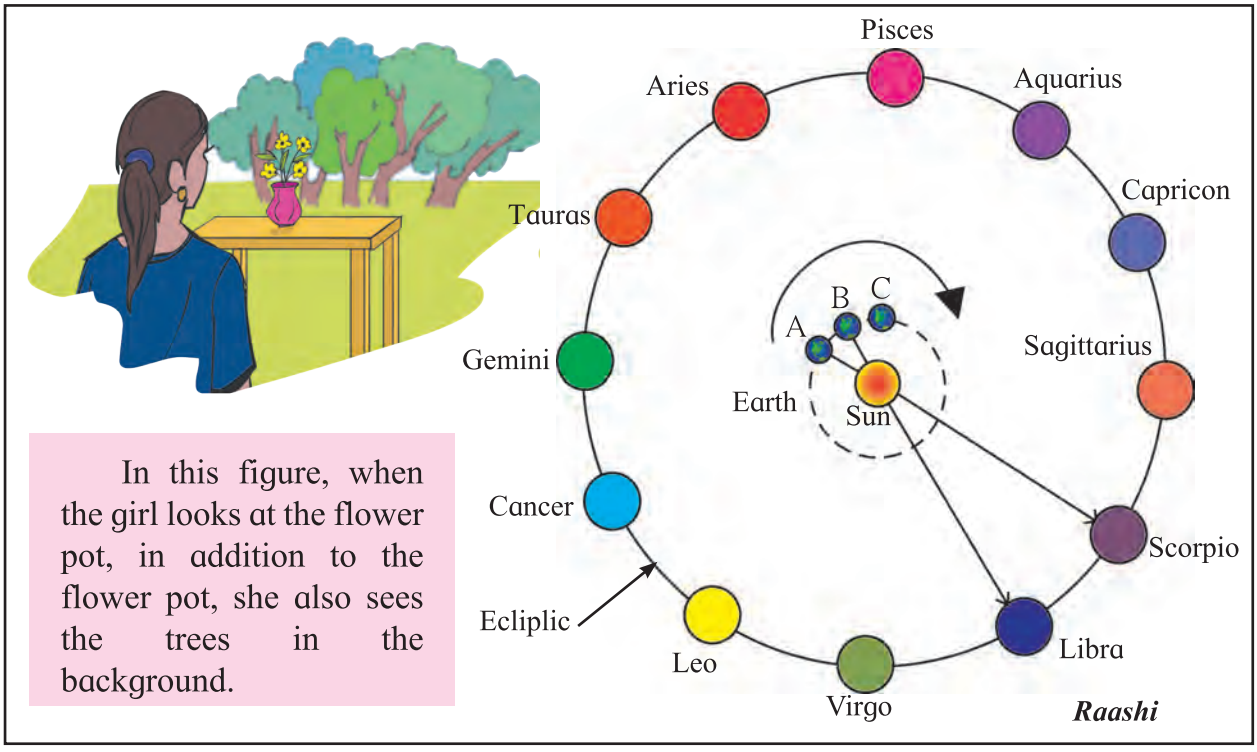
4. Vrushchik or Scorpio is a constellation with 10 to 12 stars. Jyeshtha or Antares is the brightest among them. This constellation is below the equator, in the sky of the southern hemisphere. In the third week of April, it can be seen in the eastern sky a few hours after sunset.

1. Why is the Pole Star important for sky watch?
2. What is the relation between the Pole Star and the constellations Saptarshi and Sharmishtha ?

Try this.

With the help of your friends, draw a big circle on the ground as shown in figure 20.4. Ask twelve of your friends to stand at equal distances along the circle, each holding a placard with the name of one zodiac sign in proper order.

Make one friend stand as the sun at the centre of the circle. Now, move along a smaller circle around the sun, as if you are the earth, facing the sun all the time. What do you notice as you move along this circular orbit? Ask your friends to take turns to do the same. Discuss what everybody sees.



In this figure, when the girl looks at the flower pot, in addition to the flower pot, she also sees the trees in the background.

20.4 Diagram of the experiment

The observer looking at the sun sees not only the sun but also a constellation behind the sun. The constellation cannot be seen in bright sunlight, but it is indeed present behind the sun. As the earth changes its position, a different constellation or zodiac sign or *raashi* appears behind the sun. This is what we express when we say that the sun enters a particular zodiac sign or *raashi*. For example, on Makar Sankranti we say that the sun enters Makar *raashi* (Capricorn zodiac sign).

When the earth is at A, for an observer on the earth, the sun appears to be in the Scorpio zodiac sign. When the earth moves from A to B, the observer will say that the sun has entered Libra. In reality, the sun does not move, but we perceive it as moving due to the motion of the earth around it. This motion of the sun is called its **apparent motion** and its path is called the **apparent path**. The rising of the sun in the east and its setting in the west is also an apparent motion. You might have heard some elders saying that a particular *nakshatra* is in the rising and now prevails. It means that, at that time, if you look at the sun from the earth, that particular *nakshatra* is behind the sun.

National Institutions

IUCAA (Inter University Centre for Astronomy and Astrophysics) in Pune carries out fundamental research in astronomy.

In India, planetariums named after Pandit Jawaharlal Nehru have been established at New Delhi, Bangaluru, Allahabad, Mumbai and at New English School in Pune. They present a virtual projection of various stars and constellations as if it were a sky watch. Do visit these places during a school tour or whenever possible.

Layout of a planetarium

Website : www.taralaya.org

Always remember –

Science has proved that the constituents of the solar system e.g. planets, satellites and comets as also distant stars and constellations do not have any influence on human life. Man stepped on the moon in the twentieth century. He will conquer Mars in the twenty-first century. Hence, in this age of science, holding on to beliefs which have been proved to be wrong through numerous scientific tests, is an unnecessary waste of one's time, energy and money. It is necessary to consider all these issues with a scientific frame of mind.

Books, my friends !

'*Aakashashi Jadale Naate*', '*Chhand Aakashadarshanachaa*', '*Vedh Nakshatrancha*', and '*Taarakanchya Vishvat*' are a few books which you may read to get more information on constellations and sky watching.

Exercise

1. Write the proper words in the blanks.
(meridian, horizon, twelve, nine, apparent, celestial, ecliptic)

(a) When seen from a great distance, the sky seems to be touching the ground along a circle. This circle is called the ..... .

(b) The ..... is used while defining the zodiac signs.

(c) Classified according to seasons, one season will have ..... *nakshatras*.

(d) The rising of the sun in the east and its setting in the west is the ..... motion of the sun.

2. A star rises at 8 pm tonight. At what time will it rise after a month? Why?

3. What is meant by 'The sun enters a *nakshatra*'? It is said that in the rainy season the sun enters the Mrug *nakshatra*. What does it mean?

4. Answer the following questions.

(a) What is a constellation?

(b) What points should be considered before a sky watch?

(c) Is it wrong to say that the planets, stars and *nakshatras* affect human life? Why?

5. Write a paragraph on the birth and lifecycle of stars using figure 20.1

Project : Visit a planetarium, collect information and present it in your school on Science day.

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