

Chapter-12

Celestial bodies and Indian Calendar

12.1 Celestial Bodies :

In your earlier classes you have studied that riddles and puzzles, have witnessed the beautiful scenes of the moons and the stars. Even you can see this mesmerising view at night. You can see numerous stars - some very bright and others not so. A few of them twinkle while others do not. Some stars appear near to each

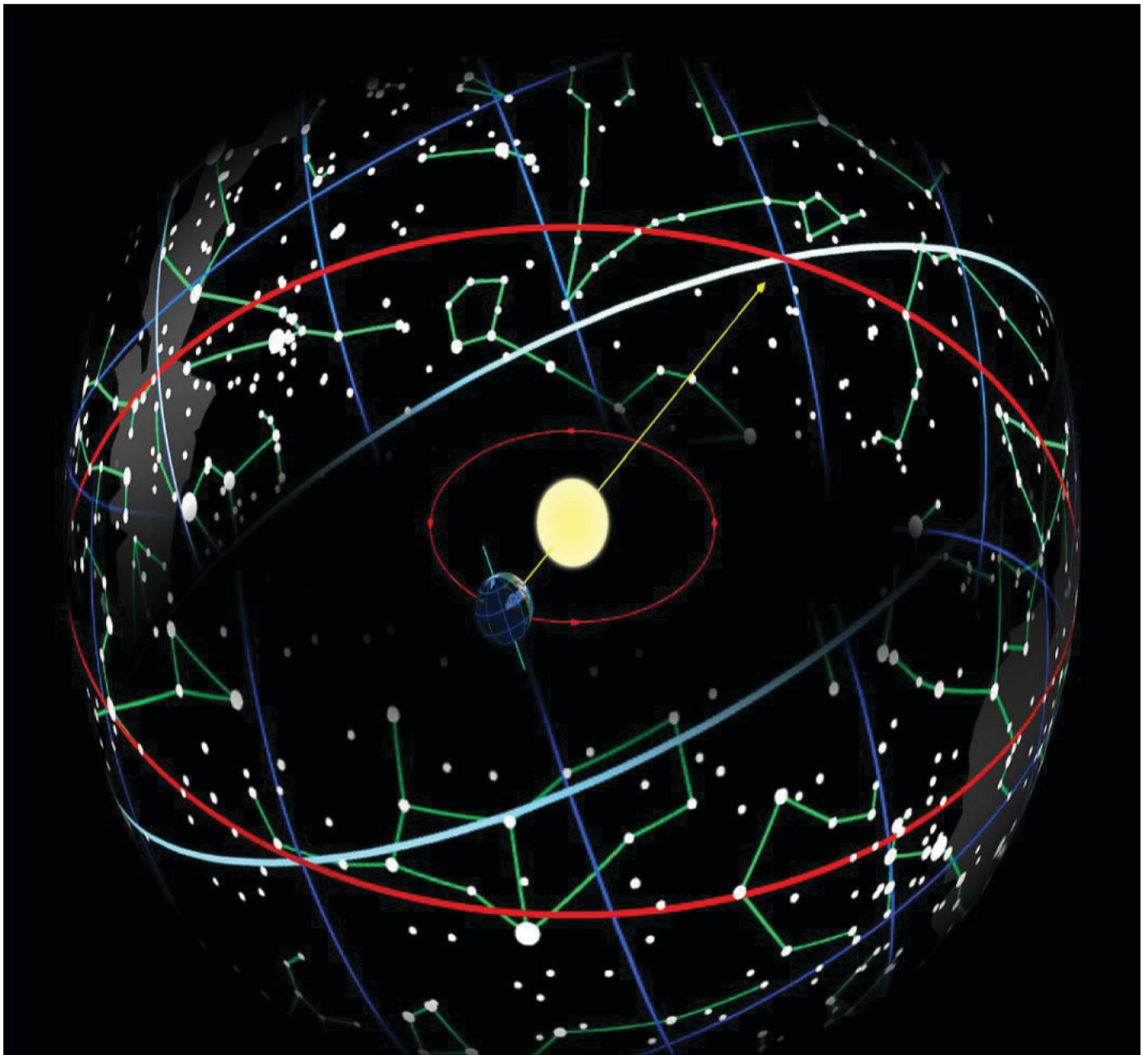


Fig. 12.1

other in the form of groups. Some group of stars form special shapes in the sky, by their arrangement. So this is how our universe appears to some extent. Many other celestial bodies can be observed using astronomical telescope, which are invisible to our naked eyes. On observing minutely these views change because all celestial bodies are in a state of continuous motion.

Activity 12.1

- Divide all students in groups of five each.
- Teacher should write the following lines on the black board : "Enlist the celestial bodies that you have seen, heard of or have read about.
- Compile all the names that turn up in various groups on the black board.

There are many small, big and very big bodies in the universe. These are known as the celestial bodies. Sun, stars, planets, asteroids, meteorites, comets, galaxies, moon - all are celestial bodies. You must have heard about polar-star, sapt-rishi mandal etc. from your elders - they also are celestial bodies which have their own light and are therefore known as the stars.

One such star is our Sun. There are many stars farther away from the Sun, hence they appear small and appear to shine to a lesser extent. Many of the stars are much larger than our Sun. The extent of the universe is beyond our imagination. It has been described, though in another form, even in our Vedas.

Indian calendar (almanac) is an astronomical book based on mathematical calculations in which are mentioned the names of various celestial bodies and their movements. Millions of years ago when there were no watches or other type of time measuring devices, our ancestors determined time, date, month etc. by observing the position of these celestial bodies. The Indian almanac was prepared on this basis.

Activity 12.2

The teacher discuss the following questions with the students :

- When is full moon seen in the sky?
- When is there no moon in the sky?
- When and on which day the lunar eclipse occurs?
- The workers involved in construction

work keep a holiday on which day?

- From where do we get the knowledge of all such things in our day to day life?

Teachers express answers given by the students in a comprehensive manner and make it clear that all these information have been mentioned in our Bhartiya calendar since time immemorial. Various astronomical event can be predicted on the basis of mathematical calculations provided in the almanac.

Bhartiya Almanac (Calendar) :

There are five main parts of the Bhartiya calendar, hence it is known as the 'Panchang'. They are :

1. **Tithi (Date) :** This is similar to the **date** of the english months, but it is related to the lunar month. There are two phases in a lunar month which are known as the 'Shukl paksha' and the 'Krishan Paksha'. There are 15 'tithis' in each 'Paksha', two of them are the Full Moon (Poornima) and the New Moon (Amawasya).
2. **Vaar (days) :** It is the same as the **days** of the week and are seven in number.
3. **Nakshtra (Constellations/asterisms) :** The path of revolution of moon about the earth has been divided into 27 sectors. A nakshtra is a sector along the lunarecliptic.
4. **Yog (Combination) :** It refers to the difference at a given time in the movement of sun and moon. There are 27 Yog. It is an auspicious moment.
5. **Karan :** Half of the part of a tithi is called a karan. Thus there are two karans in a tithi, to calculate the micro-effects of a tithi.

Apart from these the 'panchaang' presents many other information in a very accurate manner. Some of them have been enumerated as under :

- The daily sun-rise and sun-set time for various cities.
- Time of appearance of moon.
- Movements of sun, moon and various planets.
- Revolution of various planets in Nakshatra and Rashis i.e. in asterisms and constelations.
- Daily tithi, increase and decay in them.
- Rashi, description of the twelve months.

The Bhartiya panchang shows the daily calculations of the time and moment and the position of celestial bodies at each given moment. Of the five parts of a 'panchang', information regarding nakshatra and tithi is being presented in this chapter.

The current prevalent panchang is based on the Bhartiya Panchang. In it, along with the various astronomical events, the festivals and specific events of all religions have been mentioned. It is available in the language of the specific community.

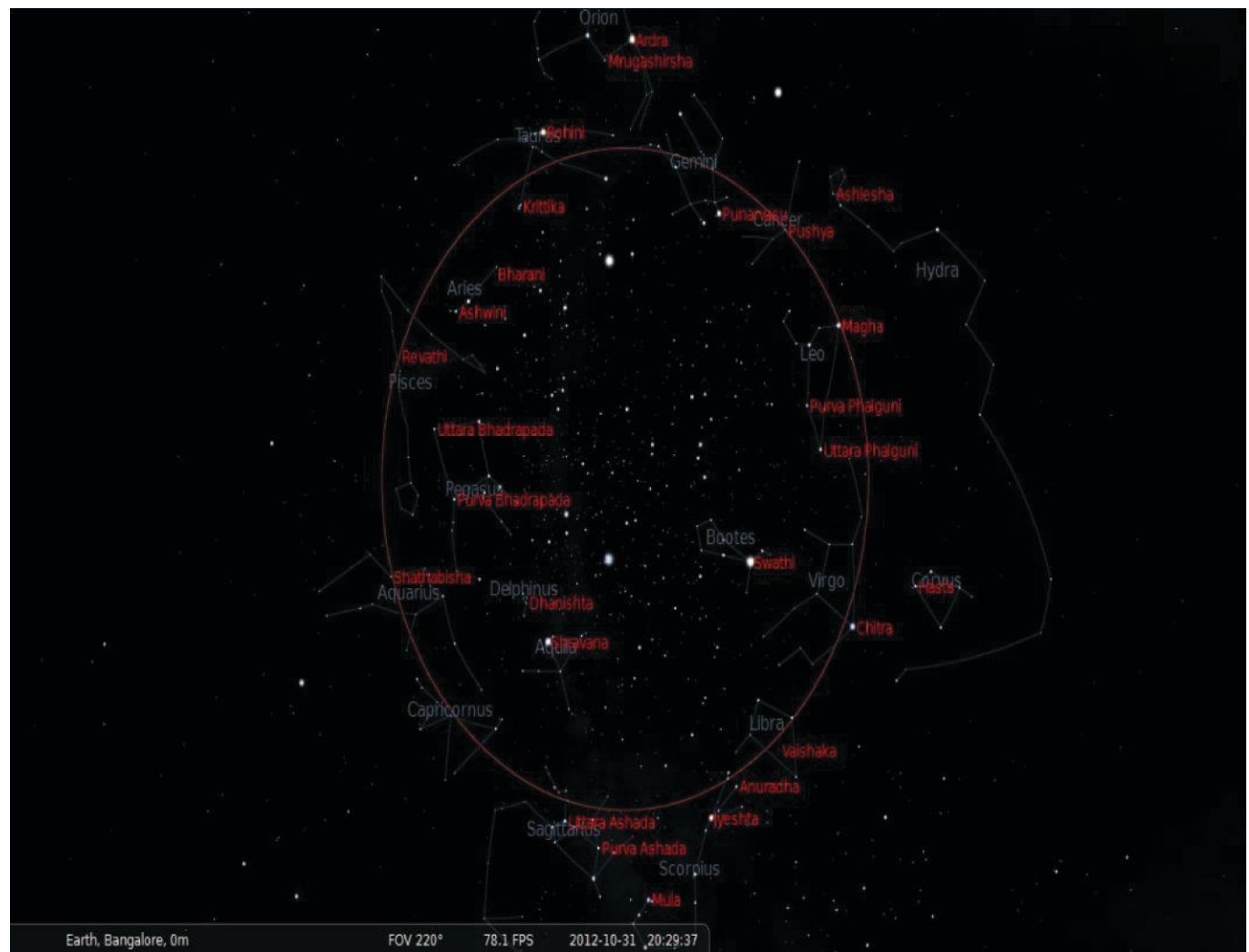


Fig. 12.2

12.3 Nakshatra :

The group of stars in the sky is known as the constellation. In it stars are observed in a recognizable pattern. They are very far from the sun and appear to be static because they do not revolve around the sun. These groups of stars have been named for identification purpose. These names are on the basis of their apparent form or are identified with some mythological figures.

The moon completes its revolution about the earth in about 27 days. The constellations present along the lunar ecliptic are known as nakshatra. The ecliptic of moon has been divided into 27 sectors and these nakshatras present there in, are named. The table below enumerates the detailed description of these 27 nakshatra (Table 12.1).

S. No.	Name of Nakshatra	No. of stars	Shape or Identity
1.	Ashwini	3	Horse
2.	Bharni	3	Triangle
3.	Krtika	6	Agnishikha
4.	Rohini	5	Cart
5.	Mrigashira	3	Head of a deer
6.	Ardra	1	Bright
7.	Punarvasu	5 or 6	bow & quiver
8.	Pushya	1 or 3	Ruby Colour
9.	Ashlesha	5	The tail of a dog
10.	Mgha	5	Plough
11.	Purvafalguni	2	bed (the front leg)
12.	Uttarafalguni	2	bed (4 legs)
13.	Hast	5	hand palm
14.	Chitra	1	bright jewel, pearl
15.	Swati	1	Kumum
16.	Vishakha	5 and 6	triumphal arch
17.	Anuradha	7	winnowing basket
18.	Jyeshtha	3	Snake
19.	Mool	9 or 11	Shankh
20.	Purvashad	4	Elephant tusk
21.	Uttarashad	4	winnowing basket
22.	Shravan	3	Arrow or Trident
23.	Dhanishtha	5	Drum
24.	Shatbhisha	100	empty circle
25.	Poorv bhadrapda	2	Bell shaped
26.	Uttara bhadrapda	2	Twins
27.	Rewati	32	Fish

The name of the 28th nakshatra is Abhijeet which has been considered with Purvaashad.

12.4 Solar system and its planets :

You have already studied about our solar system in your previous classes. Here we are again going to get the detailed information about our solar system in brief :

- The solar family is made up of the celestial bodies that are revolving in elliptical paths around the sun.
- In the solar family there are planets, satellites, meteorites, comets, asteroids and many unknown bodies which are revolving around the sun.

- They revolve around the sun because of its gravitational force.
- The bodies revolving around the sun are known as planets and those revolving around the planets are known as the satellites. All these planets and satellites are the members of our solar family. Among the celestial bodies our earth comes under the category of planets.
- The planets do not have their light and heat. They only reflect the light of the sun and other planets.
- Sun is the biggest body of our solar system. Its mass makes up more than 99 percent of the mass of our solar system. It is nearly ten lakh times bigger than our earth and is a large ball mainly made up of gases like hydrogen and helium. It is a powerful source of energy. Only a small part of the energy emitted by sun reaches the earth surface. Sun is the reason for rains on the earth, occurrence of day and night and change of seasons. This solar energy affects the life cycle of all the planets and animals.

In the modern era eight celestial bodies have been categorized as the planets, but according to the "Bhartiya Panchang" there are nine planets. In the given chapter we will study about these planets from both point of view.

Planets and their movements according to the modern science :

Table 12.2

Name of Planet	Mass ($\times 10^{24}$ Kg)	Radius (Km)	Distance From Sun ($\times 10^6$ Km)	Time for Revolution (days)	Time for Rotation (hours)
Mercury	0.33	4879	57.9	88	1407.6
Venus	4.87	12104	108.2	224.7	-5832.5
Earth	5.97	12756	109.6	365.2	approx 24
Mars	0.642	6792	227.9	687	24.6
Jupiter	1898	142984	778.6	4331	9.9
Saturn	568	120536	1433.3	10747	10.7
Uranus	86.8	51118	2872.5	30589	-17.2
Neptune	102	49528	4495.1	59800	16.1

The celestial bodies present in the solar system have been categorized into three categories according to the approval of International astronomical union conference, Prague (24 August

2006), the celestial bodies present in the solar system have been categorized into three categories

- (1) **Planets** : The above mentioned eight planets have been recognized in this category. The first four i.e. Mercury, Venus, Earth and Mars have been termed as the terrestrial planets because they have a ground while the next four i.e. Jupiter, Saturn, Uranus and Neptune are heavy planets made up of gases.
- (2) **Dwarf planets** : Pluto, Aries, Ceres etc.
- (3) **Smaller solar system bodies** : It comprises of 166 known satellites and other small astronomical bodies including asteroid belt, comets meteorites and the dust present in between the planets.

The dust and gaseous bodies revolving in the space are attracted towards the earth because of its gravitational force. When they enter the earth's atmosphere they shine bright because of their friction in the atmosphere and most of them are burnt down to ash before reaching the earth's surface. They are known as meteor. Those bodies which do not burn away completely and fall on the earth in the form of rocks, are termed as meteorite.

There is no atmosphere at **Mercury**. This is nearest to the sun. Here the nights are very cold and the days are very hot. There are clouds of sulphuric acid in the atmosphere of **Venus**. The ground surface is laden with rocks and volcanoes. It is the brightest planet and in common parlance is known as the evening star and morning star. It is also known as earth's sister because its size and mass are equal to that of earth.

The **Earth** rotates from west to east therefore we can see the sunrise in the east and the sun-set in the west. Venus and Uranus rotates from east to west.

Mars is also known as the 'Red Planet'. Its highest mountain is "Nix Olympia" which is three times higher than Mount Everest. Recent discoveries have indicated the presence of life on this planet. Mars has two satellites : Phobos and Deimos.

Jupiter is the largest planet of our solar family. Its famous red spot is actually a large hurricane situated in the disturbed clouds. Of the 16 satellites of this planet the important ones are -

Ganymede, Io, Europa, Callisto etc.

The famous ring around **Saturn** actually consist of thousands of spiral belts of waves. All around it there is a ring of gas and minute rock debris. Its famous satellites are Phoebe, Tethys Mimas etc.

It is clear from the table 12.2 that more is the distance of the planet from the sun greater is its time of revolution in its orbit.

Do you know, on 24 September 2014 the Bhartiya scientists were successful in establishing our space shuttle in the orbit of Mars. This Mars space ship was completely indigenous and was launched from Sri Harikota Andhra Pradesh. It took eleven months to reach the orbit of Mars. It is the first example in the entire world that our country successfully established it in its maiden attempt at a very low cost.

According to Bhartiya Panchang the celestial bodies which affect our earth are considered to be the planets. The nature and movement of these planets are very much similar to the ones obtained by modern science after calculations.

Planets and their movement according to Bhartiya Panchang

S. No.	Name of Planets	The planetary movement time (to travel in a rashi)
1.	Sun	One month in one rashi
2.	Moon	2.25 days in a rashi
3.	Mars	1.5 months in a rashi
4.	Mercury	0.75 month in a rashi
5.	Venus	0.75 month in a rashi
6.	Jupiter	13 months in a rashi
7.	Saturn	2.5 years in a rashi
8.	Rahu	1.5 years in a rashi
9.	Ketu	1.5 years in a rashi

Rahu and Ketu both come under the category of shadow planets. They are the points of intersection of the apparent path of the sun with the moon. They are in exact opposition to each other. They are the positions of the moon in which eclipse occurs. In Bhartiya Panchang other planetary movements have also been described which will be

studied in higher classes.

The light of the sun takes approximately eight minutes to reach earth. The light reflected from the moon takes about $1\frac{1}{4}$ seconds to reach the earth, when the velocity of light is 3×10^8 m/s.

12.5 Rashi (Signs) :

Like nakshtra's have been named on the basis of the path of moon, similarly rashi are related with earth's movements. The earth's orbit has been divided into twelve sectors, each sector is considered to be a rashi.

According to the Bhartiya Panchang the

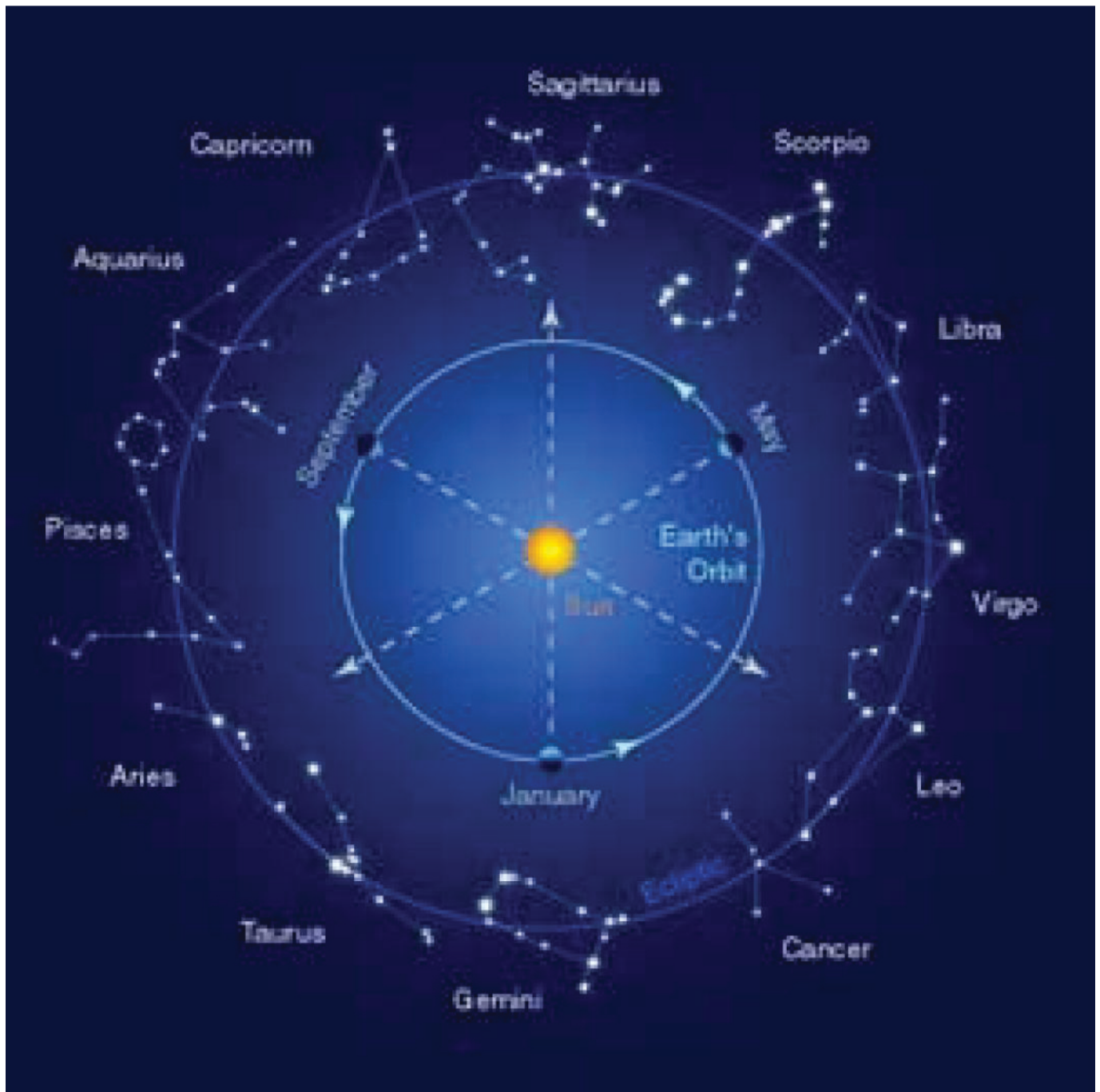


Fig. 12.3

names of these rashis and their shape are on the basis of various constellations present in the sky. The sectors of the rashi-chakra are bigger as compared those of the nakshatra-chakras. Therefore in each to there may be 2 or 3 nakshatras. Each nakshatra has been divided into four steps. Therefore there are 9 charans in a rashi.

In other words we may say that since earth takes nearly one year to move around the sun, therefore the sun will remain in each rashi for about one month. The position of these rashis is known as the twelve solar months. Peruse the different shapes of the various rashis in the table given below (table 12.3).

When the earth moves from one rashi to another it is known as the sakranti i.e the sun's transition. When sun transits in Capricorn it is known as Makar sakranti. Mostly it is on 14 January.

Table 12.3

S.No.	Rashi/sign	Shape
1.	Aries	Ram
2.	Taurus	Bull
3.	Gemini	Pair of male and female
4.	Cancer	Crab
5.	Leo	Lion
6.	Virgo	Girl
7.	Libra	Balance
8.	Scorpio	Scorpion
9.	Sagittarius	Bow
10.	Capricorn	crocodile
11.	Aquarius	pot
12.	Pisces	fish

12.6 Northern Movement and Southern Movement:

You must have heard that during Mahabharat Bhishm "Pitamah" slept on a bed of arrows, before his death, waiting for the sun to start the northern movement. In this chapter we will understand what is the meaning of northern movement.

You know that our earth revolves around the sun. This is known as Earth's orbit. If we divide the earth's orbit into two halves, then the position of sun

for 6 months is daily from east to south-west. This is known as "Northern Movement" i.e. in the Northern Hemisphere. For next six months the daily position of sun is east to north-west. This is known as Southern Movement.

During Northern Movement the position of earth is such that the sun's light remain on the earth for more time therefore the days are long and nights are short in the Northern Hemisphere. The tilt of the northern hemisphere towards sun i.e. the northern movement starts from "Makarsakranti". Thus makarsakranti signifies the progress from darkness towards light. The six signs that fall in the path of the earth during northern movement are Capricorn, Aquarius, Pisces, Aries, Taurus and Gemini. Similarly, the Southern Movement i.e. tilt of the northern hemisphere away from the sun and Southern Hemisphere towards the sun, begins from the "Karka sakranti". During this time sun rays fall directly on the Southern Hemisphere and hence the days in the northern hemisphere are short while the nights are long. The remaining six rashis which fall in the path of earth during this time i.e. southern movement are Cancer, Leo, Virgo, Libra, Scorpio and Sagittarius.

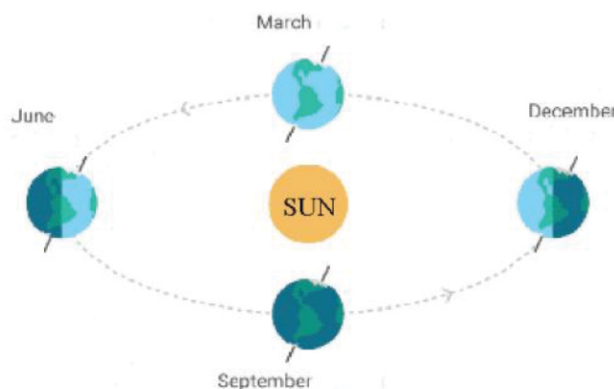


Fig. 12.4 Revolution of the Earth

On 21st June and 22nd December the Tropic of Cancer and the Tropic of Capricorn receives direct rays of the sun, respectively. (21st June - Summer solstice and 22nd December - Winter solstice.)

When the Equator receives direct rays of the sun i.e. neither of the two poles is tilted towards the sun, the length of the day and night is equal i.e. 12 hours each. This happens twice a year - on 21st March (Spring Equinox) and 22nd September (Autumn Equinox).

Activity 12.3 :

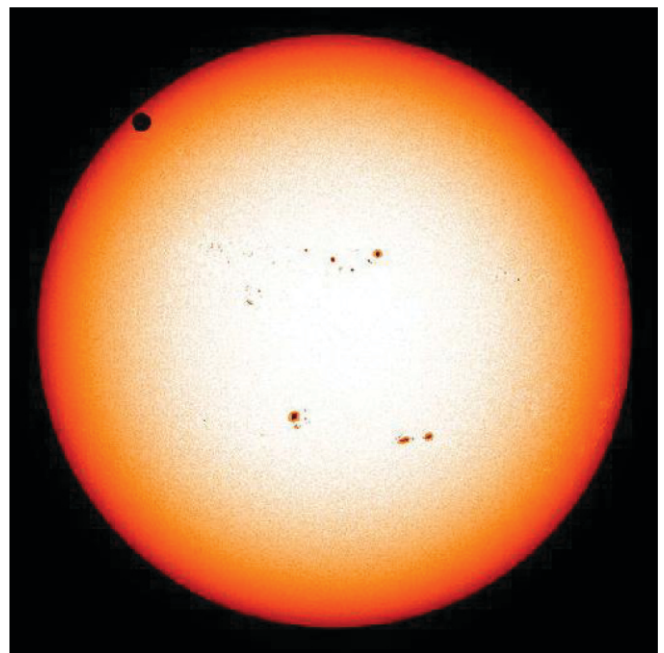
- Ask the students what all is done on the day of Makar Sakranti.
- Discuss the scientific and moral basis of the activities done on Makar Sakranti.

The sun is considered the stationary member of our solar family, hence by movement of sun, we mean change in position of sun due to earth, movement. It is similar to the case when we see a tree from the window of a moving train.

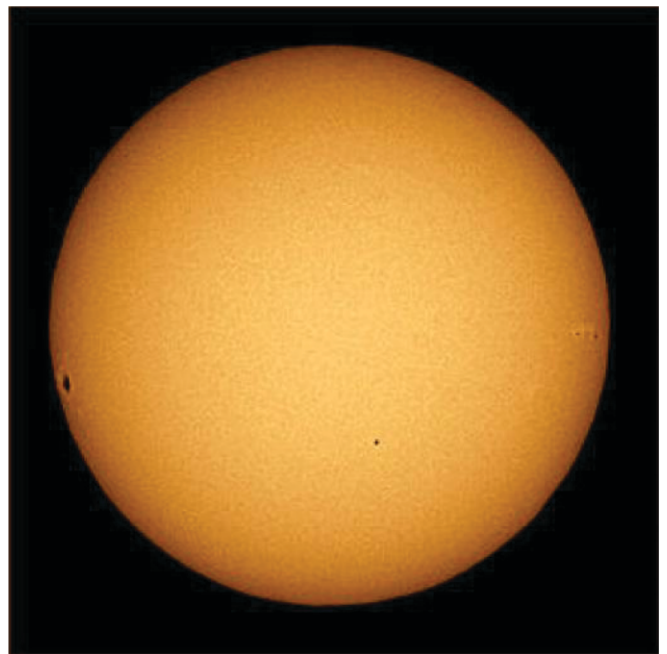
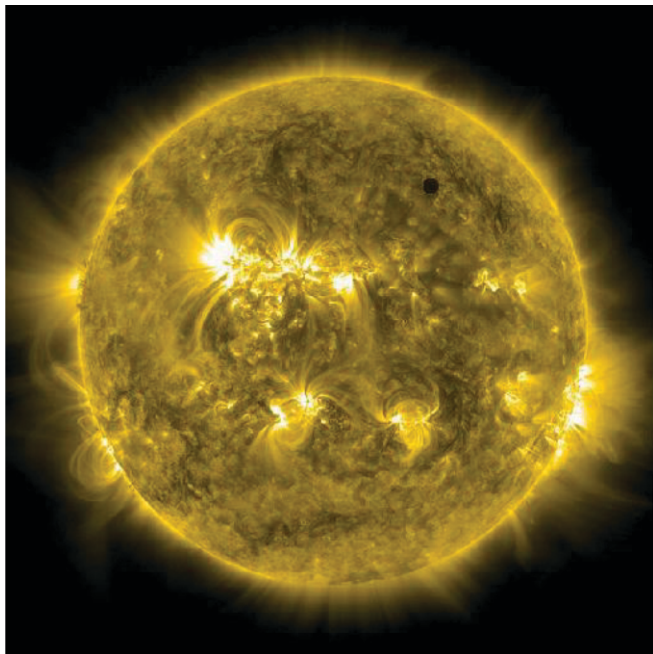
12.7 Transition of Mercury and Venus :

Many predictable celestial events take place in our sky. Some of them are repeated after years. These events appear differently in different parts of the earth. Two such events are the Mercury transit and the Venus transit which are being described here:

Venus Transit : Transit of Venus occurs when the Venus comes in between the earth (or any

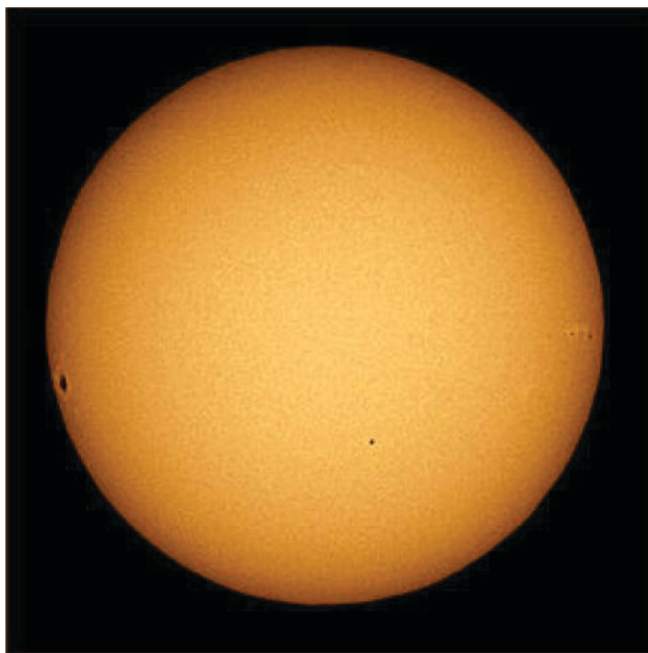


S. No.	Longitudinal difference between the sun & moon	Tithi
1.	0-12	Pratipada or Ekam
2.	12-24	Dwitya
3.	24-36	Tritiya
4.	36-48	Chaturthi
5.	48-60	Panchmi
6.	60-72	Shashthi
7.	72-84	Saptmi
8.	84-96	Ashtmi
9.	96-108	Navmi
10.	108-120	Dashmi



11.	120-132	Ekadashi
12.	132-144	Dwadashi
13.	144-156	Tryodashi
14.	156-168	Chaturdashi
15.	168-180	Poornima

This duration of fifteen days is the brighter phase or Shukla paksha. Similarly, for the next fifteen days the longitudinal angle decreases i.e. 180-168 degree is the pratipada of the darker phase



or Krishan paksha and so on till it is Amavasya with the longitudinal difference between the moon and the sun being 12-0 degree.

In this way both Krishan paksha and Shukla paksha last for a duration of 15 tithis each; each tithi beginning at a different time of the day and vary in duration i.e. the duration of all tithis is not the same.

12.9 Celestial relation of the names of the Bhartiya months :

In the previous section you came to know about the twelve solar months which are related to the movement of the earth in relation to the sun. Similarly the lunar months are governed by the movement of the moon. There are 12 lunar months which have been named according to the constellations and rashis in the path of the moon's orbit.

For example after amavasya, when the moon

appears in Aries rashi and Ashwini Nakshtra and gradually increasing phase by phase becomes the full moon in Chitra Nakshtra, then this month becomes the "Chaitra" (because of Chitra Nakshtra). In other words, the month is named on the basis of the location of the moon, on Full Moon day, in a particular nakshtra. Like the full moon will be in Kritika Nakshtra during the Kartik month. The table below enlists the nakshtras with their respective months.

Table 12.5			
S. No.	Nakshtra	Rashi	Name of the month
1.	Chitra	Aries	Chaitra
2.	Vishakha	Taurus	Vaisakha
3.	Jaishtha	Gemini	Jyaishtha
4.	Poorvashada Uttarashada	Cancer	Asadha
5.	Shravan	Leo	Sharavana
6.	Poorvabhadrapada Uttarabhadrapada	Virgo	Bhadrapada or Bhadra
7.	Ashwini	Libra	Ashwin
8.	Kritika	Scorpio	Kartik
9.	Mrgshira	Sagittarius	Margshirsh
10.	Punarvasu/Pushya	Capricorn	Paush
11.	Magh	Aquarius	Magh
12.	Poorafalgun Uttarafalgun	Pisces	Falgun

There is a difference in the duration of the lunar year and the solar year because of the difference in the rate of revolution of the moon and the earth. To co-ordinate between the lunar and solar months there is an increase in lunar month, every three year, which is known as the 'adhik maas'. One month is decreased in every 150 to 200 years.

12.10 Knowledge About Bhartiya Scientists

You have learnt about so many things about this universe in this chapter, have you ever thought of who provided all these informations and calculations?

This is the result of the continuous efforts of numerous astronomers, mathematicians and scientists over the years. The results and inferences of one scientists are carried by another and in this manner the forward knowledge expands. It is on the basis of the concepts and principles presented

by our ancient philosophers and scientists that many of our modern equipments, gadgets, machines etc. are invented.

The contribution of Bhartiya scientists in various spheres has been immense and have astonished the world by the depth and understanding of the subject concerned. You will feel proud to study about the brief biography and the contributions made by them, that have been presented in the following section.

Aryabhata :

Aryabhata was a great astronomer and mathematician of ancient Bharat. He was born in 476 BC. He studied at Nalanda and later on taught at this institute as he was a knowledgeable person. He brought into existence, great texts like Aryabhatiya in a very short time. It is a purely mathematical and astronomical scientific text.

The direct description of Aryabhata's work has been known from the Aryabhatiya text only. The entire work consists of 108 verses and 13 extra in the form of introduction. It has been divided into four chapters :

1. **Geetikpaad** (13 verses) describes the bigger units of time like - Kalp, Manvantar, Yuga etc.

2. **Ganitpaad** (33 verses) is a compilation of geometric progression and simple, quadratic, simultaneous and indeterminate equations.

3. **In Kaal Kriyapaad (25 verses)** these are the different units of time and the method of determining the position of planets at a particular day. It also includes the calculation of "adhika mass" (i.e. the extra lunar month) and "Kshya mass" (i.e. the decay month or the decrease in lunar month) and the names of the various days of a week.

4. **Golapada** (50 verses) includes the geometric and trigonometric aspects, orbits, shape of the earth, reasons of day and night etc.

Aryabhata had initiated the discoveries a thousand years ago for which Copernicus became famous (1473-1543 AD). The main discoveries by Aryabhata include :

1. Represented the value of pie (π)

accurately.

2. Earth rotates on its own axis.
3. Relation between the circumference and radius of a circle.
4. Area of a triangle.
5. Presented hypothesis regarding the geocentric model of the solar system and analyzed the reasons for the solar and lunar eclipse.
6. The time taken by earth to rotate around fixed stars was calculated to be 365 days 6 hours 12 minutes 30 seconds - which by the present day calculations have an error of just 3 minutes 20 seconds.
7. Calculated the perimeter of the earth which was just 0.2% less than the actual value.
8. Aryabhata was the first person who created the sine tables from 0 to 90°.

The methods of astronomical calculations presented by him were very spectacular which



remained useful as the micro-calendar in Europe for centuries. The calculation of dates done by Aryabhata and his followers have been of practical importance in Bharat.

The various discoveries made by Aryabhata without the availability of advanced means are of great significance. To commemorate his work, the first Bhartiya satellite was named as "Aryabhata".

He was a revolutionary thinker. He presented his correct opinion, although against the prevailing traditions, and paved the path of healthy traditions of scientific research in Bharat.

Varahmihir :

Varahmihir was a Bhartiya mathematician and astronomer of the 5th-6th century. He was born in a Brahmin family at Ujjain in 499 AD. He learnt the traditional mathematics and astronomy from his father Adityadas and carried extensive research in the field. He invented the time measuring device. The iron-pillar at Indraprastha was constructed by him and established the observatory at Jundishahpur on the invitation of the emperor of Iran. All these present a glimpse of his contributions. The center of advanced mathematical science developed by him at Patthak (Ujjain) remained unique for seven hundred years.

On his visit to Kusumpur (Patna) Varahmihir met the great mathematician Aryabhata. Young Varahmihir was so much impressed by him that he made astrology as his aim of life. Chandragupt II on coming to know about his extent and depth of knowledge, included him in his nine gems. Varahmihir gave important formulae in the field of trigonometry, optics and astronomy. Moreover he worked on the accuracy of the sine tables prepared by Aryabhata I. He died in 587 AD.

Panchsiddhantika summarises five earlier astronomical texts - Surya Siddhanta, Romak Siddhanta, Paulisa Siddhanta, Vasishtha Siddhanta and Paitama Siddhanta. Varahmihir was the first person in the history who said that there exists a force which attracts things to the earth. Today that force is known as the gravitational force.

Varahmihir's main aim was to connect mathematics and science to public interest. In fact, this has been the tradition in Bharat from Vedic times. Varahmihir totally followed it.

Bhaskaracharya or Bhaskar II :

Bhaskar II, who is also known as Bhaskaracharya was born in 1114 AD at Bijapur, Karnataka. He was the famous mathematician and astronomer of twelfth century in Bharat. He wrote the first text with full and systematic use of the decimal number system. Bhaskaracharya wrote simple commentaries on the work of Aryabhata for the common man to understand. He also wrote his own texts based on these works. He wrote a book Siddhant Shiromani in Sanskrit at the age of 36 years. It has four parts - Lilawati, Bijaganitadhyay, Grahaganitadhyay and Goladhyay which are the detailed descriptions of arithmetic, algebra, Planetary mathematics and sphere. He was the chief of the Ujjain's Astronomical observatories. Much before Newon, Bhaskaracharya had mentioned, in one of his texts that the earth pulls celestial bodies towards itself by virtue of a special force. 'Karan Kautuhal' is another composition by Bhaskar II, in which he has done various astronomical calculations. It is referred to while preparing the almanac (panchang). In another text, Suryasiddhanta, Bhaskaracharya had made it clear that earth is round and moves around the Sun continuously in a defined orbit.

Bhaskara II also completed the incomplete works of the famous mathematician Bhramgupta (598-665 AD) whom he considered to be his Guru. Bhaskaracharya was the first mathematician who stated that the answer of any number divided by zero, is infinity. During the era when Bhaskaracharya was born and remained active in the field of science, was the time when many superstitions prevailed in our society. At such a time a rumour was spread by staunch and traditional superstitious people that earth was baseless and was sinking. They did it by misinterpreting the Puranic texts for selfish ends to keep their control over the society on the whole. At such a time, Bhaskar II, the great astronomer, fulfilled his duty as a scientist, by stating that although Earth is baseless but various planets & nakshtras present around it kept it in a balanced position by exerting gravitational force on it. The earth will remain as such and will never sink.

These facts are all the more important because the Bhartiya astronomers declared these facts years before the western astronomers and scientists did, which is a substantial proof of Bharat

being the forerunner in the field of science.

Bhaskara's astronomical views have been translated in various languages, over the years. Thus the important Bhartiya information regarding mathematics and astronomy were accepted on a global level. The great scholar Faizi, of Samrat Akbar's court, translated Bhaskaracharya's work 'Lilawati' in Persian. This text was translated into English by an english scholar Colebrooke in 1710. As a tribute to the works of this great astronomer - mathematician, the Government of India named its second artificial satellite 'Bhaskara'.

The term II is connected to his name to distinguish him from Bhaskara I who was born in approx 6th century. He also, was a famous mathematician.

Other Bhartiya mathematicians who have done commendable work includes Brahmguta (628 AD), Jain mathematician Mahaveeracharya (80 AD), Shri Bhaskaracharya (991 AD) Ramanujan (1887) Subhramanyan Chandrashekhar (1936). Sawai Jai Singh II (1686-1743 AD) of the Jaipur Royal family who built observatories at Jaipur, Delhi, Mathura, Varanasi and Ujjain. These are known as the Jantar-Mantar.

Important Points

1. Stars, sun, planets, asteroids, meteorites, comets, galaxies, moon etc. are the celestial bodies of our universe.
2. The Bhartiya almanac (panchang) is the book based on various calculations and provides information regarding the position and movement of various celestial bodies.
3. There are five main parts of the panchang - Tithi, Vaar, Nakshatra, Yog and Karan.
4. The constellations of specific shape lying in the moon's orbit are known as the nakshatras. There are 27 nakshatras recognizable during the movement of the earth and moon.
5. Our solar family is made up of various celestial bodies orbiting around the sun in different paths. These include planets, asteroids, comets, satellites etc.
6. The number of planets recognized by the international astronomical union is 8 which, in order of there distance from the sun are - Mercury, Venus, Earth, Mars. Jupiter, Saturn,

Uranus and Neptune.

7. Jupiter is the biggest planet of our Solar System. Moon is a natural satellite of Earth.
8. According to the Bhartiya Panchang the celestial bodies, whose gravitational force affects the earth, are known as the 'grah' or planet. They are 9 in number viz. Sun, Moon, Mercury, Venus, Jupiter, Mars, Saturn and two shadow planets named Rahu and Ketu.
9. All the planets orbit around the sun and at the same time rotate on their axis. The time of revolution and rotation is different for each planet.
10. The earth completes its one revolution around the sun in 12 months. The earth's orbit has been divided into 12 parts. The constellation (nakshtra) present in each part of the orbit are known as the Rashi. They are - Aries, Tauras, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricorn, Aquarius and Pisces.
11. If the earth's orbit is divided into two parts of six months each, during six months the northern hemisphere is tilted towards the sun and receives the direct sun rays. This is the northern movement (Uttarayan). During next six months the tilt of northern hemisphere is away from sun. The sun's position being east - south west. This is the Dakshirayan or the southern movement.
12. When during its revolution around the sun, Mercury comes in between the Sun and the Earth, it appears as a dark spot on the sun's face which gradually moves ahead. This is known as the Mercury Transit. Similarly Venus transit also takes place. These events have been observed by scientists and will happen in future too.
13. At the end of Amavasya the longitudinal angle between the sun and the moon is more or less the same in the same rashi. Gradually during moon's movement there is a change in this angle. The tithis pratipada occurs when the angle is 0-12°. Thus other thiti also occur for each consecutive 12° longitude.
14. There are two phases in each month (Maas) Shukla paksha (increasing phase) and Krishan paksha (decreasing phase). Each paksh has 15 tithis. The last tithi of sukla paksha is Poornima

while that of krishan paksha is Amavasya.

15. The Lunar Month is named according to the position of the moon on full moon day in a given nakshatra. The twelve lunar months - Chaitra, Vaishakha, Jaishtha, Aashad, Shravan, Bhadrapada, Ashwini, Kartika, Margshirsh, Paush, Magh, Phalgun, are all named on this basis.
16. The analysis and forecast of various celestial events is possible by having the knowledge of the nature, movement and mutual relation of the celestial bodies. In ancient Bharat, many renowned astronomers and mathematicians like Aryabhata, Varahmihir, Bhaskaracharya etc. worked on various formula, theory and new information in the field and have astonished the world.

Questions

Objective Type :

1. The celestial bodies having their own light and heat are known as :
(a) Stars (b) Planets
(c) Satellites (d) Meteor
2. In which category has moon been placed in the solar system ?
(a) Star (b) Planet
(c) Satellite (d) Asteroid
3. The number of nakshatra according to panchang is :
(a) 15 (b) 27
(c) 12 (d) 07
4. What is the number of rashis according to the Panchang :
(a) 15 (b) 27
(c) 12 (d) 07
5. Which is the largest body of our solar system
(a) Jupiter (b) Sun
(c) Earth (d) Saturn
6. Which is the largest planet of our solar-system :
(a) Jupiter (b) Saturn
(c) Uranus (d) Neptune
7. The "adik mass" (extra month) appears in the lunar calendar at an interval of :
(a) 1 year (b) 2 years
(c) 3 years (d) 4 years
8. At the initiation of the southern movement the earth is in which rashi :
(a) Cancer (b) Leo
(c) Capricorn (d) Aquarius

Very short answer type questions :

1. Who was the author of the book Lilawati based on arithmetic?
2. The first Bhartiya satellite has been named after which great scientist?
3. Which tithi falls after Chaturdashi of the brighter phase (Shukl paksha)?
4. What will be the name of the lunar month if the moon on Purnima is in Mrigshira Nakshatra?
5. Which planet has the smallest period of revolution?
6. Write the name of the planets according to their increasing distance from the sun.
7. Name the terrestrial planets.
8. Apart from earth, which planet has the possibility of existence of life?
9. According to the Bhartiya Panchang which 'grah' belong to the category of shadow planets?
10. Two planets A and B are at a distance of X and Y, from the sun, respectively. If the value of Y is more than X, then which planet will have a longer revolutionary period.

Short Answer Type Questions :

1. Write the names of planets with increasing distance from the earth?
2. Write the name of the five parts of the Bhartiya Panchang.
3. What is meant by Nakshatra? How many nakshtras are there? Name any five nakshtra.
4. How is a tithi determined according to the Bhartiya Panchang? Explain in brief.
5. Write the names of the planets according to their increasing size.
6. What is meant by northern and southern movement?
7. Explain the various motions of the earth.
8. According to the Bhartiya Panchang, rashi are related to whose movement? How are the rashis determined?
9. What is the meaning of Makar-Sakranti?
10. What do you understand by "adhik maas"?
11. Explain mercury transit. Compare it with the Venus transit.
12. Write the names of lunar months according to the Bhartiya Panchang.

Essay type answer questions :

1. Write the main points of the biography of Aryabhata and explain his contributions in detail.
2. Outline the biography of Bhaskaracharya and describe in detail the work accomplished by him.
3. What is the basis of the nomenclature of the Bhartiya months (maas)? Write the names of the Bhartiya months (lunar months) and explain in detail the celestial position formed at that time in the sky.
4. Write in detail about our solar system.

Answer Key

1. (a) 2. (c) 3. (b) 4. (c) 5. (b)
6. (a) 7. (b) 8. (a)