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METHODOLOGY OF TEACHING THE TOPIC "HEAVENLY COORDINATES"

Fodadaboyeva Kokon
DPI vbdocent,

M. A. Rakhimberdiyeva
Master's Student of Kok on DPI,

N A Tajiyeva
Koq on DPI Graduate Student ,

Sh. Umarova
Student of Koq on DPI.

Abstract
This article provides recommendations on the methodology of teaching the subject of celestial coordinates .

Keywords: Celestial sphere and its principal point, line, circles, annual apparent motion of the Sun, Ecliptic, Pole star, constellations, celestial coordinates, geographic longitude, latitude, longitude, and latitude.

Educational objective: To teach students that the main purpose of entering sky coordinates is to determine the position of lights. To give basic concepts about the scale of stellar magnitudes.

Educational goal: Forming a scientific, enlightened and spiritual worldview in imparting historical knowledge of mankind's understanding of the world, preventing astrological fictions, training to work in the study of practical astronomy, training in aesthetic education by studying the coordinates of the sky.

Developmental goal: to use the displacement map of the starry sky, to form the skills of using astronomical calendars and spravochniks, to find the pole star in the sky and to get orientation, to find the main constellations in the sky and the brightest stars visible at the time of observation, etc. formation of skills.

Lesson equipment: celestial sphere model, globe, star maps, diagrams and slides to explain celestial coordinates.

Lesson plan. (Note: The teacher can make changes to the stages and time of the lesson organization based on the ability of the students of the class).

no	Stages of the lesson	Time
1	Organizational part	2 minutes
2	Repeating the previous topic	6 minutes
3	Introductory interview	3 minutes
4	Learning a new topic	22 minutes
5	Consolidation of a new topic (student assessment)	8 minutes
6	Homework	4 minutes

The course of the lesson:

1. Organizational part. The teacher shares the impressions and thoughts of the students from the previous lesson and from observing the starry sky.

2. Repetition of the subject. A question-and-answer session will be held by the teacher on the topic "Diurnal visible movements of luminaries, constellations" taught in the previous lesson.

3. Description of the new topic. Before explaining the new topic to the students, "What is determined by the celestial coordinate system?" "Problematic situation" is created with the question. After that, the teacher gives an understanding through the introduction of the 11th grade Astronomy e-study guide or topic in the following sequence.

Sky coordinates

Plan:

1. Geographic coordinate system.
2. Horizontal coordinate system.
3. 1-Equatorial coordinate system.
4. 2-Equatorial coordinate system.
5. Ecliptic coordinate system.
6. Maps of the stars.
7. Apparent stellar magnitudes of stars.

Geographic coordinate system

When studying the coordinates of the sky, let's remember that the point of intersection of the meridian of the Earth passing through the city of Greenwich, Great Britain, with the equator is taken as the starting point for the coordinates of settlements on the Earth's surface, which we are familiar with from the geography course. In it, we recall the geographical coordinates of the city of Tashkent, which are known to all of us, defining the geographical l-longitude and φ-latitude (Fig. 1).

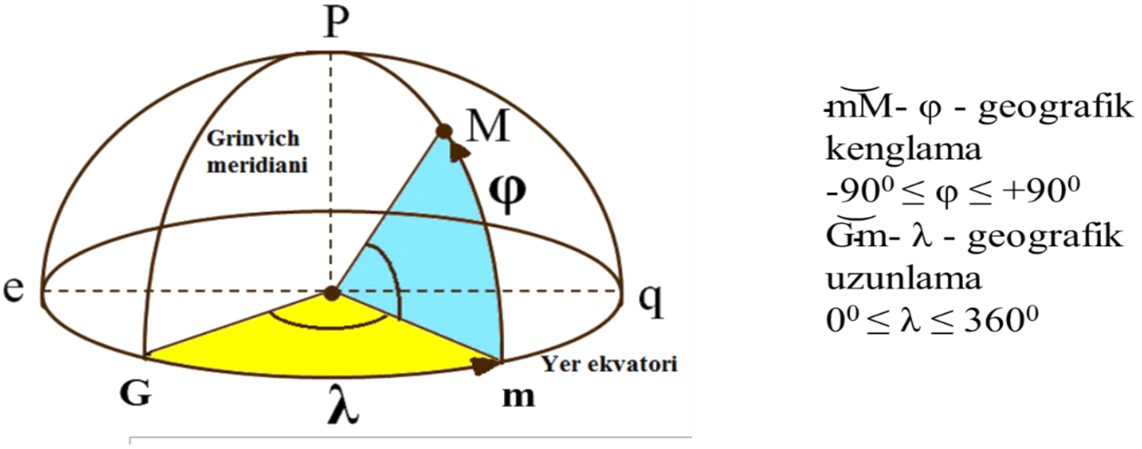


***Figure 1:** Geographic coordinate system*

Horizontal coordinate system

The position of the lights in the horizontal coordinate system is characterized by two coordinates. One of these is called A-azimuth of the illuminator, and the other is called h-height. In this system, the south point (S) is taken as the coordinate origin. The azimuth of the illuminator is *the* spherical angle formed by the vertical semicircle passed through it at the zenith with the south meridian. Often, the azimuth is measured by an arc drawn to this angle and directed along the mathematical horizon, that is, by the length of the arc from the south point (S) to the intersection point (K) of the mentioned vertical circle with the mathematical horizon. The height of the lamp is measured by the length of the arc from the intersection of the vertical circle with the mathematical horizon (K) to the lamp (M). A-azimuth for an observer in the center of the celestial sphere has a positive sign if it is measured clockwise along the mathematical horizon; and in the opposite direction, it has a negative sign. The measurement limit is up to 180 ^{0} . Altitude has a positive sign above the mathematical horizon and a negative sign below it. Instead of the height of the lamp, sometimes its distance from the zenith Z is taken. Since h+Z=90 is ^{0} .

The magnitudes A and h (or Z) of the horizontal coordinate system are measured in degrees, minutes and seconds of arc. it will be possible to work only in certain observatories or observation points (Fig. 2).

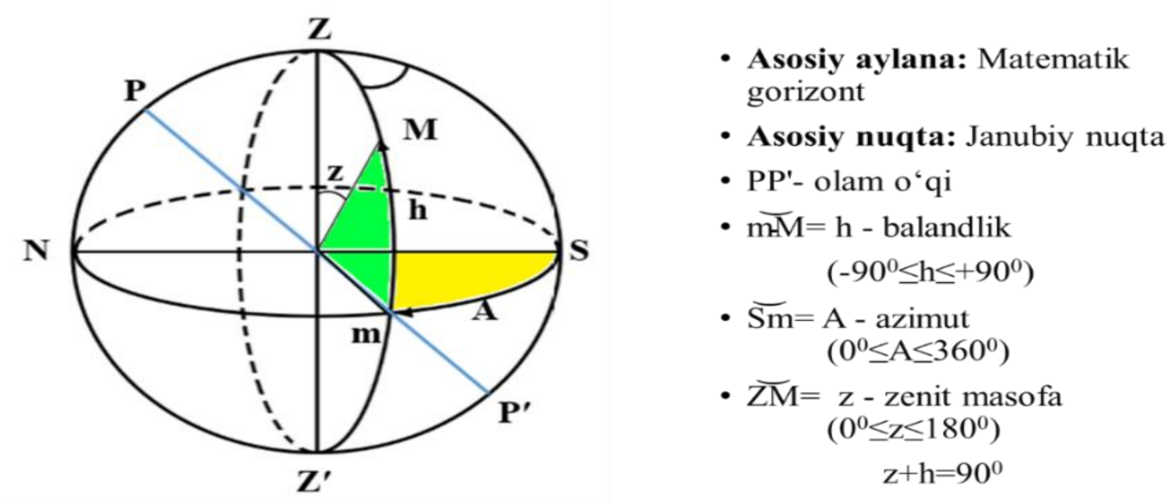


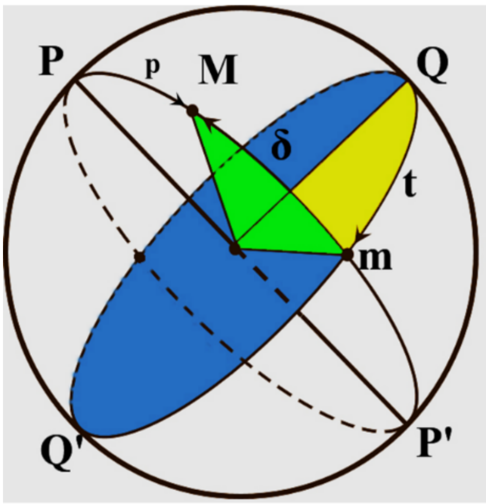
***Figure 2:** Horizontal coordinate system*

The first equatorial coordinate system

In this system, the position of the lamps is measured in δcoordinates called the hour angle (t) and the deviation angle ( ) . To find the clockwise angle of any illuminant in the sky, a half deviation circle is passed through it, and its point of intersection with the equator of the sky is found. The distance of this point from the coordinate origin or the spherical angle formed by the south meridian of the semi-declination circle passing through the illuminant is the soap angle of the illuminant. is called

The deviation of the illuminator is measured by the length of the arc from the intersection point of the semi-declination circle passing through the illuminator with the celestial equator to the illuminator. The hour angle of the illuminator, the hour angle for the observer standing in the center of the celestial sphere in hours (h), minutes (m) and seconds (s) in the direction of the clockwise arrow, or in other words, in the direction of rotation of the celestial sphere up to 360 ^{0} (measured in arc) or up to 24 hours (in time). ``Nalish'' is considered a positive direction and is calculated up to 180 ^{0} (in arc calculation) or up to 12 ^{h} hours λ ; in the opposite direction, the sign of t is negative, and it is measured up to -12 ^{h} hours (Fig. 3).

The angle of deviation of the lamp has a positive sign in the northern hemisphere of the sky, and a negative sign in the southern hemisphere. The angle of deviation is measured in arc degrees, minutes and seconds. Sometimes, instead of the ρdeviation angle of the lamp, its distance from the pole $\delta$is used. Since the distance of the lamp from the pole is the ρangle that complements $\delta + \rho$the deviation angle by 90 $^{0\text{, i.e.}}$ =90 ^{0} , it is enough to give one of these angles.



- **Asosiy aylana:** Osmon ekvatori
- **Asosiy nuqta:** Osmon ekvatorining janubiy nuqtasi
- PP'- olam o'qi
- $\overset{\frown}{Qm}$ = t - soat burchagi ($0^0 \leq t \leq 360^0$)
- $\overset{\frown}{mM}$=δ-og'ish ($-90^0 \leq \delta \leq +90^0$)
- $\overset{\frown}{PM}$=p - qutb masofa
- p+ δ =90^0

***Figure 3:** 1-Equatorial coordinate system*

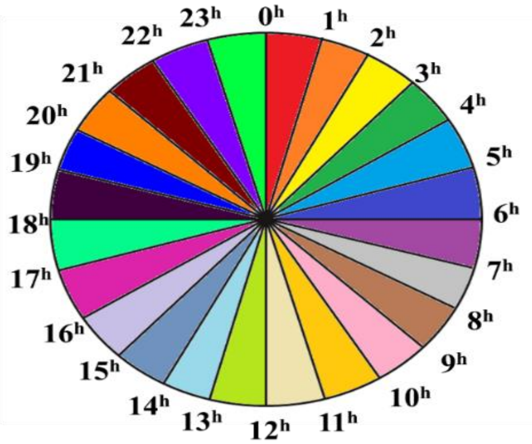
Converting degrees to hours

The hour angle of luminaires is sometimes measured in hours and sometimes in degrees. In this case, you have to convert from degrees to hours or from hours to degrees. An arc of 360 ^{0} is called a circle. Based on this, 360 ^{0} =24 ^{h} . So each hour interval is equal to 15 ^{0} (Figure 4). we know that

1 ^{0} = 60' (minute of arc),

1'=60'' (seconds of arc)

The table below lists the remaining transitions.



Yoy o'lchamida	360°	15°	1°	15'	1'	15"
Vaqt o'lchamida	24^h	1^h	4^m	1^m	4^s	1^s

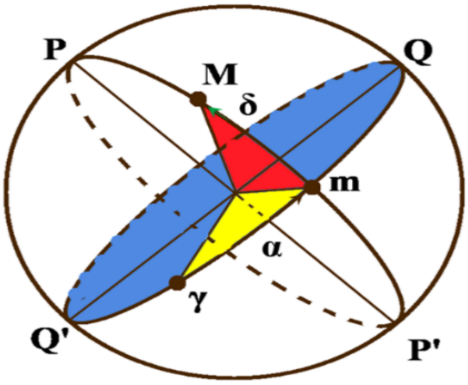
Figure 4: *Transition from arc dimension to time dimension*

The second equatorial coordinate system

In this equatorial system, one of the intersection points of the coordinate head, the ecliptic, and the celestial equator is at the vernal equinox , and the position of the luminaries $\gamma$is characterized by αtheir correct emergence $\alpha$and deviation . It is measured by the distance of the δpoint $\gamma$of intersection of the past half-declination circle with the celestial equator from the vernal equinox , and the hour angle t is measured in hours, minutes and seconds α, γ. is measured (Fig. 5).

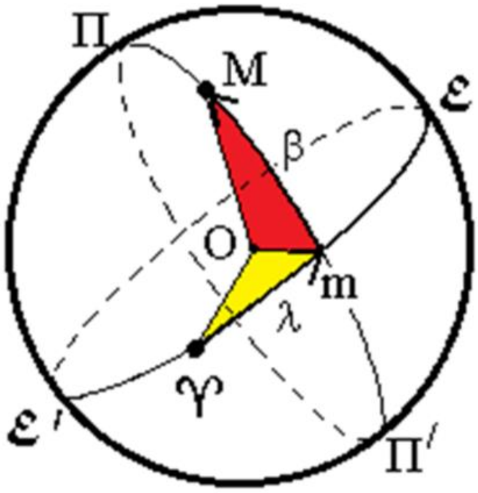
The deviation of the illuminators is measured δas mentioned in the 1-equatorial coordinate system. 2-the coordinates of the lights determined according to the equatorial coordinate system are the same at all points of the Earth. The horizontal coordinates of the illuminator in the equatorial coordinate system A, h, Z, and I change during the day due to the t-hour angle, the diurnal movement of the illuminators $\delta = 0$. will have an exit. The coordinates of the main points of the ecliptic according to this system are as follows: vernal equinox $\gamma(0\,^h;0\,^o)$, autumn equinox $\Omega(12\,^h;0\,^o)$, summer solstice $\varepsilon(6\,^h;+23\,^0 26\,^/)$ and winter solstice standing $\varepsilon'(18\,^h;-23\,^0 26\,^/)$.

The deviation $\delta$of the illuminator is measured as in the first equatorial coordinate system . and the correct output *a is measured in* hours (h), minutes (m), and seconds *(s)* . Other coordinates of the sky *(A - azimuth* , h - height, z - distance from the zenith and δangle of deviation) are measured in arc degrees (°), minutes (') and seconds ("). These two quantities are measured from one to the other tooth is performed as follows:



- **Asosiy aylana:** Osmon ekvatori
- **Asosiy nuqta:** Bahorgi teng kunlik nuqtasi
- PP'- olam o'qi
- $\widetilde{mM} = \delta$ - og'ish
- $(-90^0 \leq \delta \leq +90^0)$
- $\widetilde{\gamma M} = \alpha$ - to'g'ri chiqish
- $(0^h \leq \alpha \leq 24^h)$ yoki
- $(0^0 \leq \alpha \leq 360^0)$

Figure 5: *2-Equatorial coordinate system*



- **Asosiy aylana:** Ekliptika aylanasi
- **Asosiy nuqta:** Bahorgi teng kunlik nuqtasi
- ΠΠ'- ekliptika o'qi
- $\widetilde{\gamma m} = \lambda$ - ekliptik uzunlama
- $(0^0 \leq \lambda \leq 360^0)$
- $\widetilde{mM} = \beta$ - ekliptik kenglama
- $(-90^0 \leq \beta \leq +90^0)$

Figure 6: *Ecliptic coordinate system*

Maps of the stars

Star maps, like geographic maps, are often created as a projection of the stars on a plane. In such maps, the arcs of a -right exit and d -deviation of stars are reflected on mutually perpendicular coordinate axes. For example: b of the Orion constellation shown on the map we find the coordinates of the star. Originally from the star map of the Orion constellation b we will find the star. Then we can determine the approximate coordinates with the help of a ruler or with the naked eye. On the map, the correct output of the lights is in hours, and the deviation is in degrees. b of the Orion constellation approximate coordinates of the star (Fig. 7):

- $a \approx 5^h 16^m$,
- d≈ _ -8 ° 10'

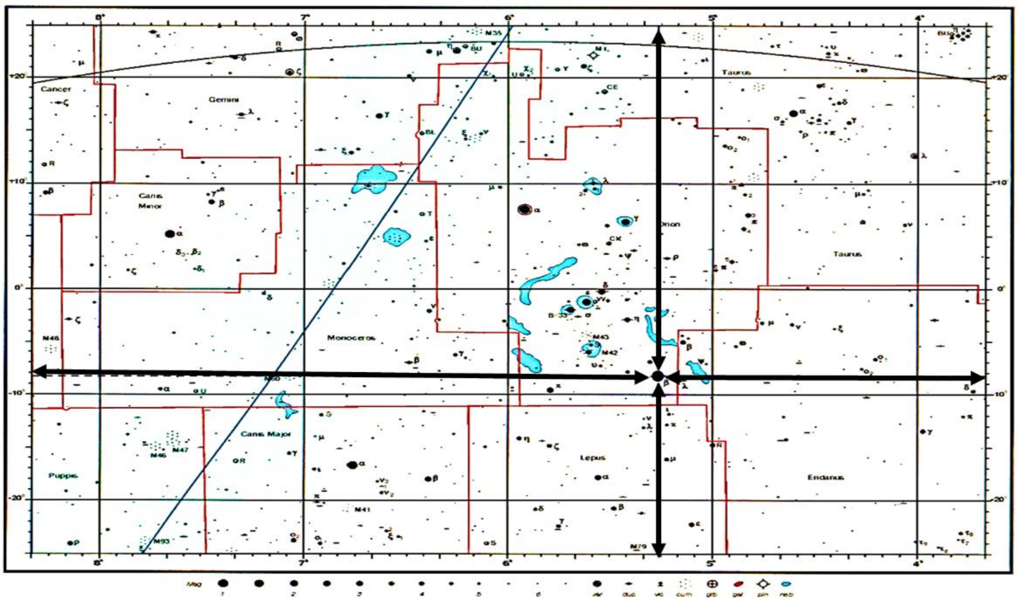


Figure 7: *Positioning of stars in the star atlas*

Apparent star magnitude

Stars are relatively common objects in the Universe. Therefore, the study of their physical nature is considered one of the important issues in astronomy. In astronomy , the concept of stellar magnitude is used to distinguish between the apparent luminosities (brightness levels) of stars. In astronomy, the brightness of luminaries is not expressed in units of illuminance (lux) as in physics, but in relative units called stellar magnitudes , and m is marked with a letter. This is mostly evident in star charts.

It is defined as follows: ....-5^m, -4^m, -3^m, -2^m, -1^m, 0^m, 1^m, 2^m, 3^m, 4^m, 5^m..... .

Determining the brightness of stars in stellar magnitudes was started by the Greek astronomer Hipparchus in the 2nd century BC based on the sensitivity of the human eye to light. According to the scale adopted by him, the difference in luminosity of stars that differed from each other by 1 star magnitude corresponded to approximately n 2.5 times (Fig. 8).

Figure 8: *Apparent stellar magnitude*

The Sun illuminates the Earth's surface with 10^5 lux, and the illuminance produced by the Sun outside the Earth's atmosphere is 137,000 lux . ,61·10^6 lk.

An international candle with a luminous intensity of 1 candela appears as a 0.8^m star from 1 km and as a 5.8^m star from 10 km . That is, the illumination produced by the lamp depends on its distance. The stellar magnitude found from illumination measurements is called the apparent stellar magnitude (Figure 9).

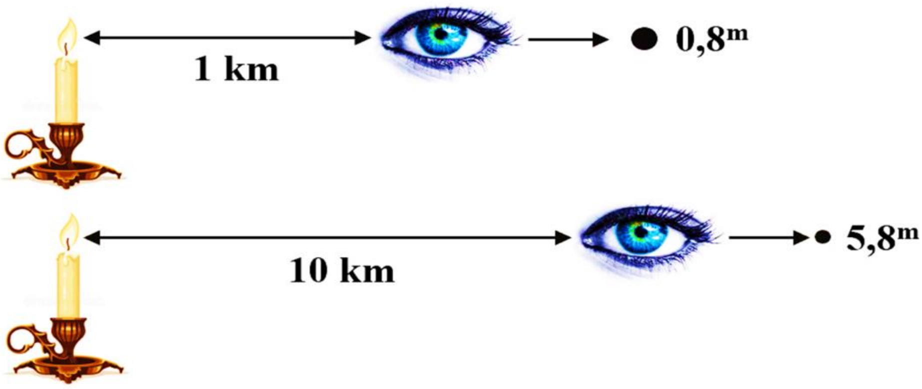


Figure 9: *Explanation of apparent stellar magnitude*

At the moment, determination of star sizes is accepted on a scientific basis, i.e. following the psychophysiological laws of sensitivity of the human eye. For this purpose, the difference in the magnitudes of two stars whose luminosities differ by 100 times is conventionally assumed to be equal to the magnitude of five stars. Since this difference in magnitudes is taken for a five-magnitude interval , the difference in luminosities or magnitudes of two stars corresponding to one magnitude $\sqrt[5]{100}$equals =2.512.

It is calculated by **Pogson's formula** (1):

$$m_1 - m_2 = -2{,}5\lg\frac{E_1}{E_2} \qquad (1)$$

In short, a star's magnitude scale refers to a logarithmic scale that compares the brightness of observed luminaries. The normal human eye can see stars up to 6th magnitude. Among the bright stars, the stellar magnitude of Vega (the brightest star in the Lyra constellation) is + 0.04 ^{m} , that of Venus is -4.4 ^{m} (at its brightest), that of the full moon is -12.5 ^{m} , and that of the Sun is -26.7 ^{m} is enough. Modern telescopes are up to 100 million times fainter than the faintest stars we can see (the star's magnitude
+ 24 ^{m} , +25 ^{m}) can see the stars (Fig. 10).

Figure 10: *Apparent stellar magnitude scale*

4. Consolidation of a new topic. A question-and-answer session will be conducted with the students based on the following questions:

1. On the given star map, the vertical lines represent the arcs of what circles in the celestial sphere? What about horizontal lines?
2. (a) and deviation (d) of light are measured in the equatorial coordinates of the sky .
3. What is the hour angle (t) of the lamp and how is it measured?
4. What is the name of the relationship between the apparent magnitudes of stars and their brightness?
5. Write and explain Pogson's formula.

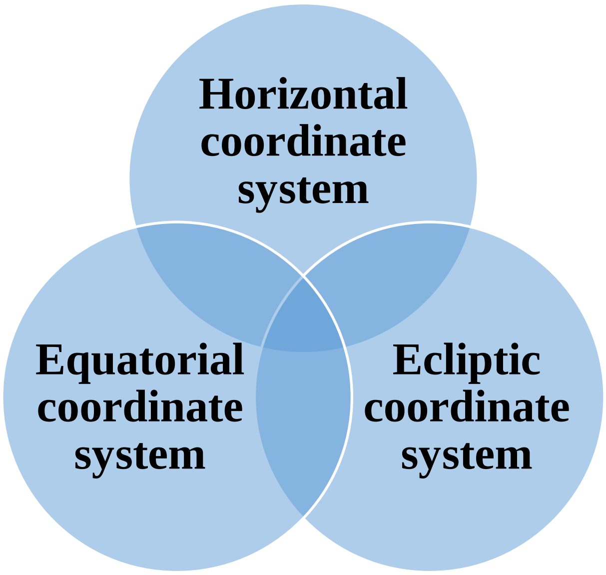
Interactive methods used in the lesson

Using the Veen diagram interactive method

What names are the coordinates of the horizontal coordinate system called and measured?

1. What is the disadvantage of the horizontal coordinate system?
2. What names are the coordinates of the equatorial coordinate system called and measured?
3. Give information about the names of ecliptic (astronomical) coordinates and their measurement.

Answer these questions by completing the Veen diagram.



11(a): *Veen diagram*

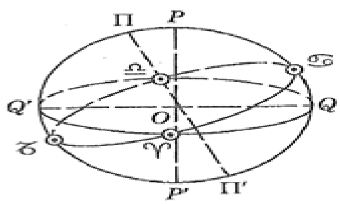
5. Evaluation of students. Students are graded based on their activities.

6. Homework.

1. Reading the topic from the Astronomy textbook and independent use of the Astronomy e-learning guide.
2. Answering the questions and assignments given at the end of the topic.
3. Analyze with pictures the problem of determining the position of lighting in works of art and fiction.
4. Determine the equatorial coordinates of skylights and objects using the main circles of the star map, or do the reverse problem. Complete the table.

The name of the object	Equatorial coordinates	What constellation is the object in?
The star of Lyra is Vega		
The a of the big dog is Sirius		
	$a=5^{h}30^{m}; d=-5^{0}$	
Comet Heila-Boppa	$\alpha=21^{h}08^{m}; \delta=+^{3}$	
Kitning Mira yulduzi		
	$\alpha=0^{h}41^{m}; \delta=+^{4}$	
Aquarius meteor- gamma radiation	$\alpha=22^{h}40^{m}; \delta=^{-1}$	

Remember. The apparent annual path of the center of the Sun's disc along the celestial sphere is called the ecliptic. The ecliptic and the celestial equator intersect at 2 points on the vernal and autumnal equinoxes. As a result of the movement of the center of the solar disk along the ecliptic, the deviation angle of the Sun changes. When the declination of the Sun is $+23.5^{0}$, it is at the summer solstice, i.e. (in



11 (b)-rasm

Crab), when the declination of the Sun is -23.5 ^{0}, it is at the winter solstice (Fig. 11 (b)).

The Earth's axis and the Sun are in the same direction, that is, from west to east (if this movement is observed from the north pole of the ecliptic, it is in the opposite direction). The plane of movement of the Earth around the Sun is called the plane of the Earth's orbit. The plane of the celestial equator is parallel to the plane of the geographic equator.

4. Complete the table for the main 4 points of the ecliptic.

The cardinal point of the ecliptic	Point sign	Correct output	Deviation	Name of the day
Vernal equinox	gamma	0 ^{hours}	0 ^{0}	Vernal equinox

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