

Using the Celestial Sphere

Part 1

Instructional Objectives

After viewing the program and participating in the follow-up activities, the student will be able to:

1. define circumpolar stars,
2. find the coordinates for a given star on the celestial globe, and
3. identify what stars and/or constellations can be seen in the sky from a specific locale when given a particular date and time (after teacher print follow up).

Synopsis

Program 21 provides an introduction to the celestial globe, which is a model of the celestial sphere. The celestial sphere is an imaginary sphere enclosing the earth on which stars, planets, and the sun seem to be held as one looks up into the sky. The celestial globe is a tool that is used to locate a star or the planets on the celestial sphere. The program highlights the main parts of a celestial globe, and explains how one's location on the earth affects which stars are seen. The coordinate system used on a celestial globe is illustrated and explained. The teacher print for Program 21 will help students see how to use the celestial globe to see what stars can be viewed in the night sky from a specific place on a specific date and time.

Pat Parker, Deputy of the Operations Division at the Space Telescope Science Institute, is highlighted in "The People Behind the HST." Pat's fast paced job is to assure that the day to day operations of her division are working smoothly.

Vocabulary

Angular Measurement - The system used to measure the size or distance of objects in the sky. Units of angular measure are degrees, minutes, and seconds of arc.

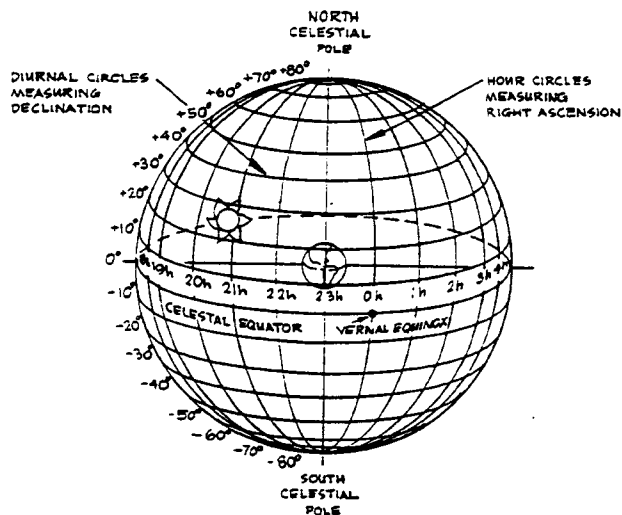
Celestial Globe - A model of the celestial sphere. Many celestial globes are transparent, so that one can look at the celestial sphere from the inside by looking through the opposite side of the sphere as if one were looking up at the sky from a particular location.

Celestial Sphere - The imaginary sphere enclosing the earth on which stars, the sun, and planets are attached. It represents what the sky looks like as seen from the earth.

Circumpolar Stars - Stars that circle the celestial pole, never setting from the observer's point of view.



Declination - Measures the distance of a star from the celestial equator.



Diurnal Circles - The part of the coordinate system used on the celestial sphere. Diurnal circles indicate declination north or south of the celestial equator.

Ecliptic - The sun's apparent path in the sky during the course of a year.

Horizon - The line that appears to separate the earth from the sky.

Horizon Ring - On the celestial globe, it represents the limit of what can be seen from a given location.

Hour Circles - The coordinates that run between the celestial poles. Each coordinate represents an hour, or 15 degrees. They are used to measure right ascension.

Meridian - The circle that passes through the observer's zenith and the two celestial poles.

Right Ascension - Measures the east/west position of objects in the sky.

Sidereal Time - Time based on the rotation of the earth in reference to the background stars, often called star time.

Zenith - The point on the celestial sphere that is directly overhead.

Previewing

Ask the students if they have ever observed the sky at night. What observations can they share with the class?

Ask the students if, when looking up at the sky, stars look as if they are at different distances from the earth. Why or why not?

Ask the students what they think the term celestial sphere means. To assist them, have them divide the term into its two components.

If any students have ever seen or worked with a celestial globe before, have them share their information with the class.

Have the students describe the system that maps or globes of the earth use to mark the location of places.

Postviewing

Have students point out the celestial globe's celestial equator, the north and south celestial poles, the hour circles, the diurnal circles, and the ecliptic line. Ask them to identify the day intervals on the globe's ecliptic line.

Have the students read the legend on their celestial globe and then identify the brightest stars of the constellations, Orion, Ursa Minor (Little Dipper), and Ursa Major (Big Dipper). On the celestial globe, have the students identify the right ascension and declination for the brightest star of each of the constellations.

Have the students point out the two places on the celestial globe where the celestial equator crosses the ecliptic. What dates are those? Discuss what occurs on these dates.

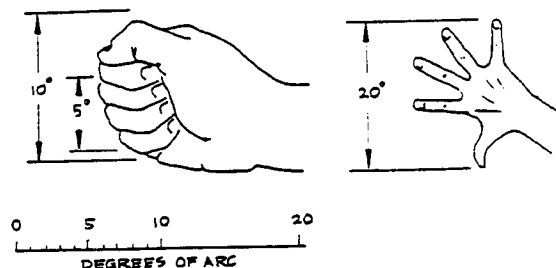
Ask the students if they know what the "a.m." and "p.m." stands for when telling time. If they don't know, give them a hint by informing them that the "m" in both stands for meridian, and that at 12:00 noon the sun is above any location's meridian. The "a" in a.m. stands for ante, which means "before" in Latin. The "p" in p.m. stands for post, which means "after".

Have the class work out the following computation. Divide a circle of 360 degrees by the number of hours in a day. How many degrees do they get? Once they solve the problem, have them look on the celestial globe to find how many degrees separate the hour circles. Ask the students what the hour circles mark.

Active Involvement

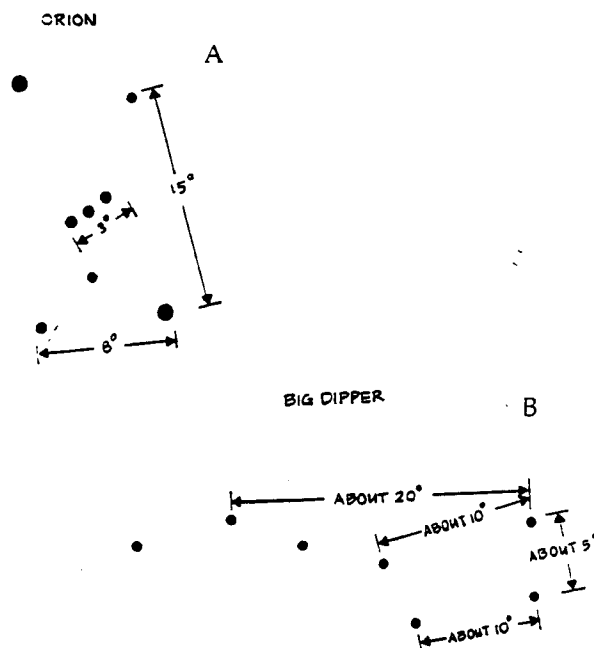
Practice using a hand as a ruler to measure the angular measurement between objects. Use the standard shown in the illustration for the degree of angular measurements that

HAND EXTENDED AT ARMS LENGTH
APPROXIMATE ANGULAR EQUIVALENTS



a hand can mark. To start, have the students go outside and hold out one of their hands at an arm's length. Students should identify objects that are far away from them and measure the distances between these same objects. Do the students' hands all measure approximately the same degrees of distance as marked in illustration above?

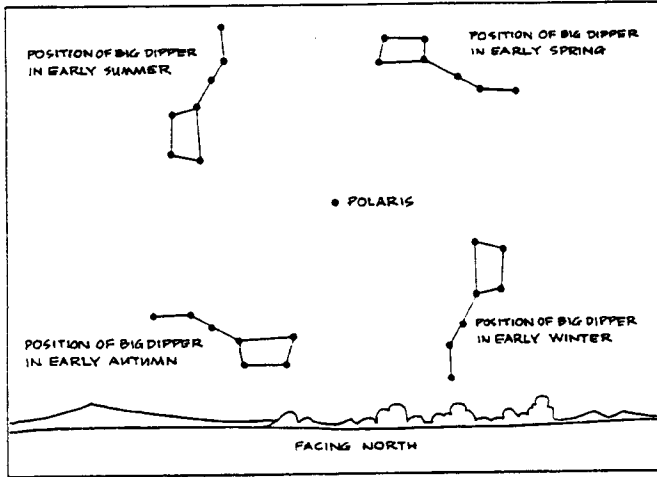
Have the students practice measuring the degrees of arc between objects in the night sky. On a clear night they should record the angular measurement for Orion's belt as well as the distance between a set of horizontal and vertical stars outlining Orion. On the Big Dipper, have them find the angular measurement between the two stars marking the top of the bowl, the two pointer stars, and the stars that mark the Big Dipper's handle (for measurements see illustration B). Have the students measure the distance from the horizon to the point over their head. The measurement should be 90 degrees.



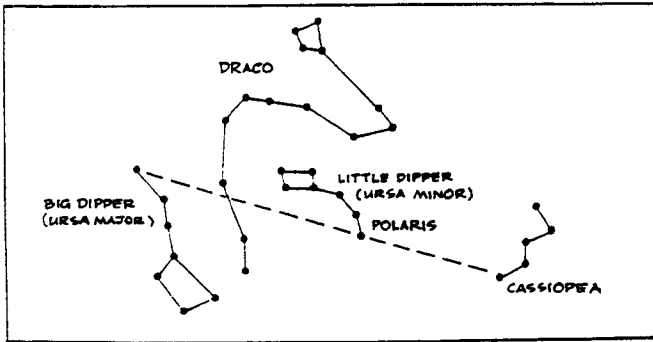
Using the Celestial Sphere

Part 2

Practice finding the circumpolar stars. The Big Dipper stays above the horizon throughout the year for most of the United States. A star chart showing the northern stars with Polaris at the center would be helpful for this activity. Look at the illustration showing the Big Dipper's position in



the sky for different times of the year. Go out on a clear night and face north. Find the Big Dipper in the sky. Draw an imaginary line in the sky from the end of the handle of the Big Dipper to Polaris (see below). Continue the



line beyond Polaris to the constellation of Cassiopeia. This distance should be slightly less than the distance from the end of the Big Dipper's handle to Polaris. Cassiopeia has the shape of a big "W", with the top of the "W" nearest to Polaris.

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Remember that in the autumn the Big Dipper may not be visible because it is close to the northern horizon. At this time, look for Cassiopeia; it is high in the sky and you can use it to help find Polaris. Using your star chart, find the Little Dipper in the sky, or if you know where Polaris is located, you can find the Little Dipper, as it is the star that marks the end of the Little Dipper's handle. Find Draco. Draco the Dragon winds around between the Big and Little Dippers (see illustration).

You have found most of the circumpolar stars in the northern United States. What makes circumpolar stars unique? Go out early in the evening and locate a star (or constellation) that is low on your eastern horizon. Go back out every hour to the same location and plot its change in position on a graph. Do the same with a circumpolar star. How do the movements of these two stars or constellations differ? If you were to continue going out every hour until morning, what would be your predictions on the change of position for each star or constellation?

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See for Yourself: Experiments/Projects



Setting the Celestial Globe for Your Geographic Location and Star Time

Adapted in part with permission from Leo Blitz and Michael F. A'Hearn, Astronomy Department, University of Maryland, College Park.

► MATERIALS:

- a celestial globe with a transparent sphere

► DIRECTIONS:

1. With the celestial globe resting on its base on a table in front of you, position it so that the hand hole is facing you. Adjust the horizon ring so that the south edge (where the open section is located) is toward you, with the west on your left and the east on your right.
2. Hold the horizon ring and rotate the earth globe knob until the longitude for your location bisects the open section of the horizon ring.
3. Move the position of the celestial globe on its base so that your location is exactly on top of the earth globe. Up will be directly overhead (zenith point) and down will be toward the center of the earth.
4. Adjust the horizon ring so that it is parallel to the ground. [Here is a way to check the accuracy of the horizon ring's setting. The North Star, Polaris, is always the same number of degrees above your location's horizon as your location is above the equator. To calculate this, count the number of degrees down from the north celestial pole to the north edge of the horizon ring. It should equal the number of degrees in your latitude.]
5. Choose a specific date and set the sun on the date closest to your choice, as marked on the ecliptic. Different celestial globes mark the dates of the year at different intervals.

Calculating Star Time (Sidereal Time)

Adapted in part from Stars and Planets by W.S. Kals. Copyright 1990 by W.S. Kals. Adapted with permission of Sierra Club Books.

The following equation will calculate the approximate star time for midnight at any date of the year.

- Use the constant $4\frac{1}{2}$ h.
- Add to the constant the number of the month (For example, January = 1, December = 12) multiplied by 2h.
- Add $\frac{1}{2}$ h for every eight days in a month:
 - for days 1-7 add $\frac{1}{2}$ h
 - for days 8-15 add 1h
 - for days 16-24 add $1\frac{1}{2}$ h
 - for days 24-31 add 2h

Example: March 24, midnight

constant: $4\frac{1}{2}$ h

3rd month $\times 2 = 6$

24th day: 2h

star time is: $12\frac{1}{2}$ h

Practice: Calculate star time for midnight for the following dates: January 5, May 10, September 15 and for the current day.

For times other than midnight, first find the star time at midnight. For times before midnight subtract, for times after midnight add. Following are two examples.

March 24, 9 pm

Star time at midnight: $12\frac{1}{2}$

Hours before midnight: -3

Star time is: $9\frac{1}{2}$ h

March 24, 4 am

Star time at midnight: $12\frac{1}{2}$ h

Hours after midnight: +4

Star time is: $16\frac{1}{2}$ h

When star time is greater than 24h, subtract 24 from it to find the correct star time. For example, for October 12, calculating star time at midnight gives $25\frac{1}{2}$ h. $25\frac{1}{2} - 24 = 1\frac{1}{2}$ h. Star time for midnight on October 12 is $1\frac{1}{2}$ h.

Practice: Find the star time for October 25 at 5 am.

Once you know your star time, move the earth so that the hour circle with the correct star time is on the meridian for your location.

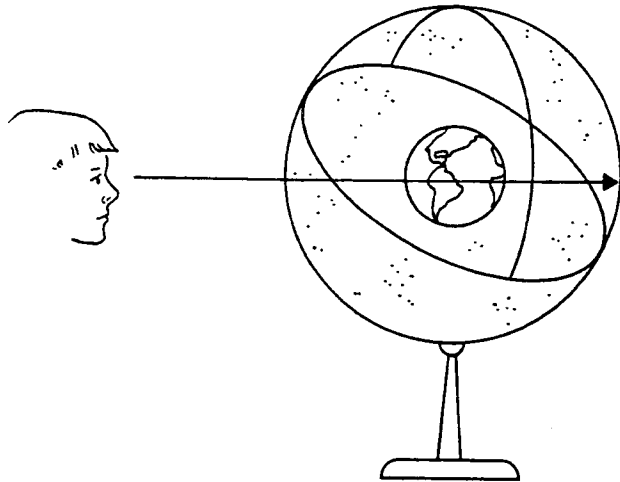
Now you will be able to adjust the celestial sphere for any location on earth, and any date and time.

Extension Activities

Set the celestial globe for a specific date, time, and place. Find a star that is below your eastern horizon. How many hours will it take to rise?

On the celestial globe, with the horizon ring adjusted for your location, locate a star on the eastern edge of your horizon ring. Slowly rotate the earth towards the east. In what direction does the star appear to move in relation to the earth? How many hour circles will pass above your location's meridian before the star has reached your location's meridian?

Set the date and time for tonight. Look at illustration E to see how to read a celestial globe. What constellations will you be able to see in different directions? Which ones are nearest to your horizon? Which ones are near your zenith? Which ones do you think will be easiest to see and why? Write down the declination and right ascension of the brightest stars in each constellation as well as for the Big Dipper. Using a star chart, locate the constellations you will see in your night sky and go look for them at the correct time. To have the clearest view of the stars, go to a high area with few lights around it. Find the Big Dipper in the sky. Using your knowledge of the Big Dipper's right ascension and declination and your hand to measure the distances, find the location for the bright constellations in the sky.



Science Career Profile

Pat Parker

Deputy of Operations Division

Space Telescope Science Institute

Education: B.S. Management and Technology



Chief Responsibilities

Pat Parker manages the day to day activities of the Operations Division. Her responsibilities include providing a schedule of science activities to the computers on the Hubble Space Telescope (HST), monitoring live science data transmissions, and processing data for the scientists. As a manager, Pat must coordinate activities among 10 to 15 different groups that support and use HST.

A Typical Day

Because the HST is working at all times, Pat's division operates twenty-four hours a day. Pat's first meeting is usually at 8:30 in the morning. At this time she gets together with the division members who are leaving the midnight shift and those who are starting the day shift. In these meetings, the status of all schedules are discussed. From this information, Pat plans the day's course of action. Pat's work is very fast paced, and she likes it that way. Her division has to keep information constantly flowing to the HST, and as information flows back to the ground, her division has to make sure that the data move through the Space Telescope Science Institute's computer systems. As Pat puts it, "Everything has to keep moving." In order to make sure that everything is working as it should, Pat must keep in close touch with all aspects of the division's functions. She moves between different meetings with key people who are responsible for different aspects of the HST's operations. In these meetings she brainstorms with her colleagues to find solutions to any problems that may arise.

Career Viewpoint

When Pat was a child growing up in the small town of Leroy, New York, she never imagined ending up as an integral member of the Space Telescope Science Institute. In junior and senior high school, she was involved in every type of club there was, from editor of the newspaper to sports and music clubs. And even though science was not her strong point, in her current position, Pat is continuously learning about different aspects of it. She now thinks that this is one of the factors that makes her position so interesting. "The scientists are right here, and right away you start hearing what they've seen or what they're analyzing or doing, so that's really been a plus." The pace, problem solving aspects, organizational requirements, and the interaction with a variety of people all complement Pat's personality and talents.

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