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CHAPTER 2—SKILL SHEET 2: CELESTIAL NAVIGATION

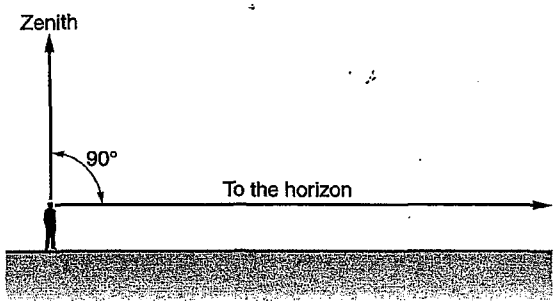

FIGURE 2-7. The zenith is the imaginary point in the sky straight overhead.

Before the invention of GPS technology, how were people on ships far at sea, out of the sight of land, able to tell where they were? For thousands of years mariners have navigated their ships by the stars. The procedure of finding your position through observations of the stars is called celestial navigation. Understanding how it works is not very difficult.

It is important that you work through this activity step by step. Proceed slowly and with care. If you do not understand something, review the earlier steps or ask for help.

The point in the sky straight overhead is known as the zenith. The zenith is at an angular elevation of 90° above the horizon. Figure 2-7 illustrates the meaning of zenith.

1. Define zenith. _____

2. The zenith is located _____ above the horizon.

3. In Figure 2-8, which observer will see Polaris at the zenith? _____

4. ***a.*** Does everyone, no matter where they are on Earth, see the same stars in the night sky?

   _____ (See Figure 2-8.)

   b. Explain

   _____

   _____

5. At the North Pole, an observer would see Polaris _____ above the horizon.

6. An observer at the equator would see Polaris _____ above the horizon, and at the equator.

7. ***a.*** In Figure 2-8, would man C be able to observe Polaris? _____

   b. Explain

   _____

8. Polaris is visible only to observers north of

   _____

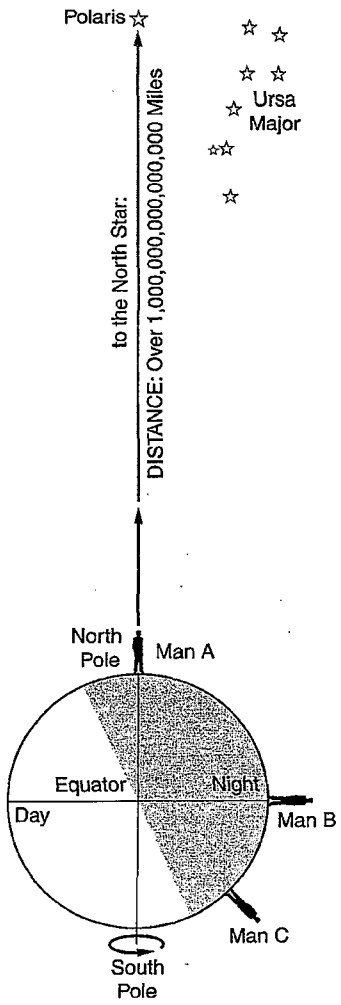

FIGURE 2-8.

Important Fact #1

Your latitude north of the equator is equal to the angle from the horizon to Polaris.

9. Copy the statement above in the space below.

_____

10. An observer at 40° North latitude could observe Polaris _____ above the horizon.

11. A person at the equator would see the North Star _____ above the horizon, and his or her latitude is _____.

Finding latitude is simple. Just measure the angle from the northern horizon up to Polaris. Polaris is easy to find because, for us, it is always in the same position in the northern sky. However, determining longitude is more difficult. Because our observations are made from a rotating earth, the sun and all the other stars appear to move through the sky. Determination of your longitude requires the use of a very accurate clock or a radio, both relatively modern technologies.

Note that in Figure 2-9 you are looking down from a point high above the North Pole. You can see that Earth is turning to the east. (That is, any location on Earth moves eastward as Earth rotates.)

Base your answers to questions 12–15 on Figure 2-9.

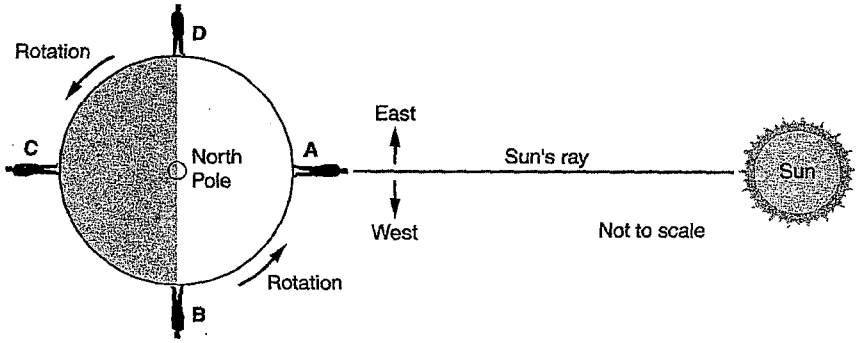

FIGURE 2-9. Earth as observed from high above the North Pole.

12. In this view, is Earth rotating clockwise or counterclockwise?

_____

13. If the sun is directly overhead for observer *A*, his local time must be _____.

14. For observer *B*, on the equator where the sun is just rising, the local time is _____.

15. For observer *C*, the local time is _____.

Important Fact #2

Every hour, Earth rotates through 15° of longitude.

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16. Please copy Fact #2 below.

Because different places around Earth have different local times, you can determine your longitude. Follow the steps below, then, answer questions 17–20.

Step 1: On the outside of the circle in Figure 2-10, complete the labeling at 30° intervals from 30° to 360°. (Some have been done for you.)

Step 2: Notice that inside the circle some of the intervals have been labeled like a 24-hour clock.

Step 3: Complete labeling the inside of the circle in two-hour intervals. (Some have already been done for you.)

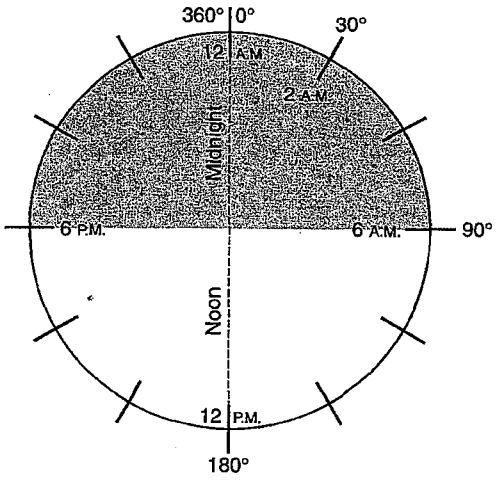

FIGURE 2-10.

17. Every hour Earth rotates through _____.

18. _____ means the same as "spin."

Earth can be split into time zones based on degrees of longitude.

19. Around the whole Earth there are _____ or _____ hours.

20. Thus, two places 15° of longitude apart are _____ apart in time.

If you look at very old maps, you will find that the measurements of latitude are accurate. However, distortion results from inaccurate determinations of longitude. The determination of longitude depends upon the use of a clock set to standard time. For this use, the ship's clock had to remain accurate after many weeks at sea. An error of only one hour would mean an error of 15° of longitude on a map.

The British dominated exploration and map-making in the 1600s and 1700s. They set their clocks to observations of the sun made at the Royal Observatory in Greenwich, near London, England. Greenwich Mean Time (GMT) therefore became the standard upon which longitude was based. Accurate maps could not be made until mariners had precise clocks (chronometers) that would keep accurate time on a long ocean voyage. If the navigator knew Greenwich time and his local time, based upon observations of the sun and stars, he could calculate his longitude.

21. To what time did the navigators set their clocks?

If a ship's clock set to Greenwich Mean Time (GMT) reads 12 noon, but it takes one more hour for the sun to reach its highest point in the sky (local noon), the ship must be 1 hour, or 15°, west of the Prime Meridian.

22. If the local time is 3 hours behind GMT, the ship's longitude must be _____ West. (Hint: 3 × 15°)

23. If the local time is 2 hours ahead of GMT, the ship is _____ East.

24. If GMT and the local time are 12 hours apart, the ship is _____ from the Prime Meridian.

Longitude is calculated by comparing local time with Greenwich Mean Time.

Important Fact #3
Longitude = time difference (in hours) from GMT × 15° per hour

25. Copy the statement from the box above into the space below.

_____

26. What object in the sky is used to determine the local time? _____

Use Figure 2-11 to answer the questions 27–39.

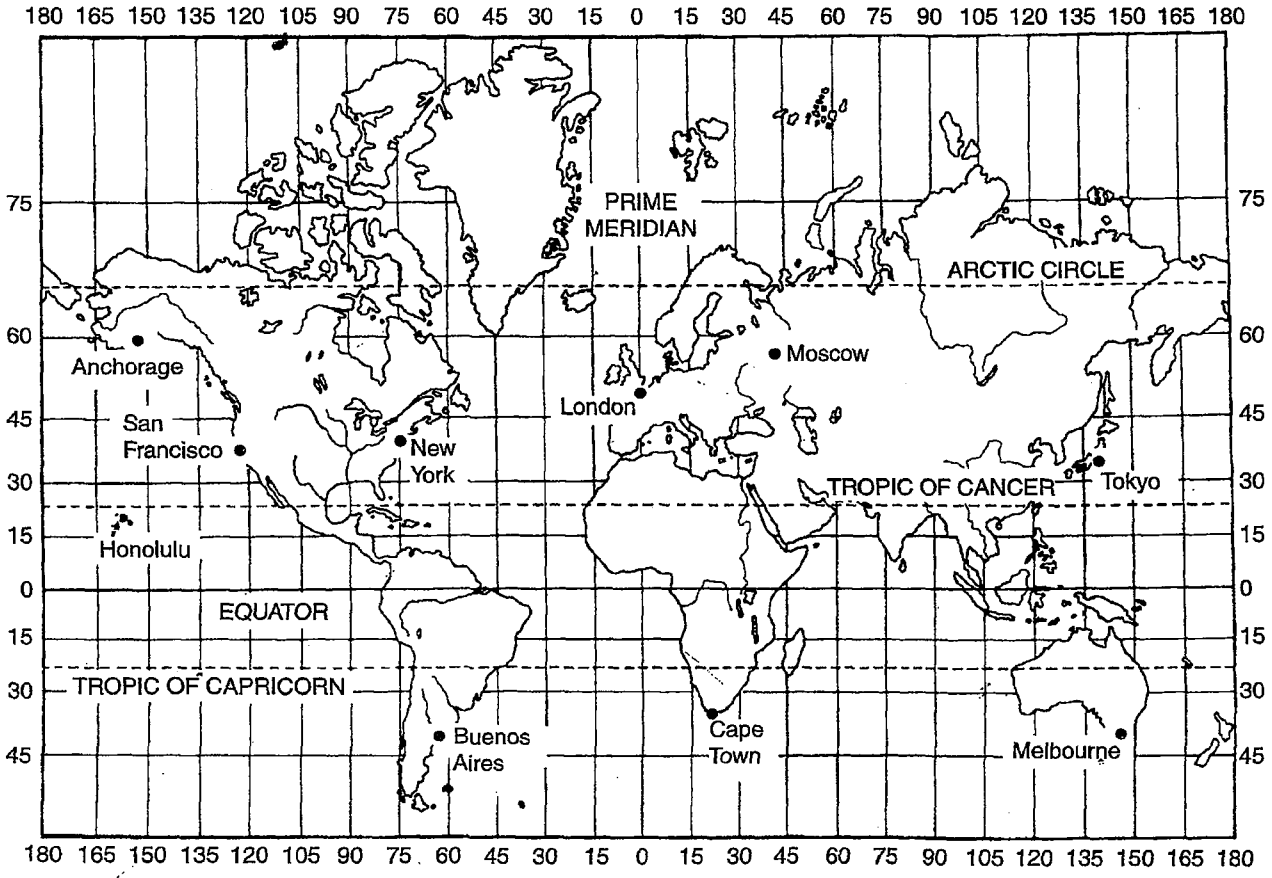

FIGURE 2-11.

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Complete the table below.

Terrestrial Coordinates

Name of City	Latitude	Longitude
27. _____	35°N	140°E
28. _____	33°S	18°E
29. _____	55°N	37°E
30. London	_____	_____
31. Melbourne	_____	_____
32. Honolulu	_____	_____

33. During one day, the sun appears to move from east to west. Circle the name of the city at which noon will come first. *San Francisco* *New York*

34. On the same day, is it noon in Moscow *before* *or* *after* at is noon in London. Circle the correct word.

35. A person in Rome, 42° North latitude, and a person in Chicago, also 42° North latitude, both see Polaris on the same night. Which, if either, will see it higher in the sky? Explain your answer

_____

36. What is the angular elevation of Polaris in your location?

_____

37. If it is noon in London, what time is it in New York? _____

38. If it is noon in Tokyo, what time is it in Melbourne? _____

39. How high above the horizon is Polaris in Cape Town, South Africa?

_____

40. Briefly explain a way to find your latitude using your own observations.

_____

41. Briefly explain a way to find your longitude by using your own observations.

_____

_____

42. Figure 2-12 contains information used by an observer to find her terrestrial coordinates.

a. What is the observer's latitude? _____, longitude? _____

b. Where is this person located? _____

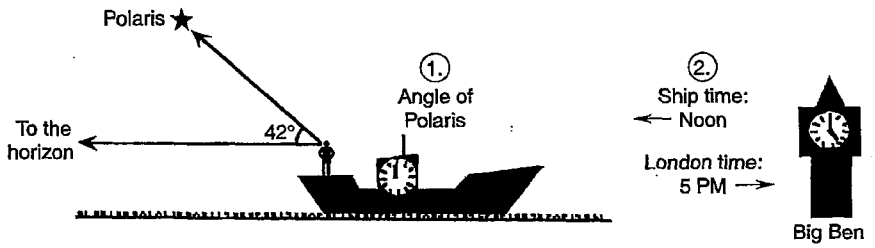

FIGURE 2-12.

43. As an observer travels due east or due west, what happens to the angle of Polaris?

_____

44. Lines of constant _____ run east and west, but they measure how far north or south you are.

45. The _____, is the reference line for latitude, and the _____, is the reference line for measurements of longitude. What are the terrestrial coordinates (latitude and longitude) at the point where they meet? _____

46. Define latitude:

_____

47. Define longitude:

_____