(Photo by Getty Images, Inc.)

PART 5

Earth Science Skills

EXERCISE 22

Location and Distance on Earth

The ability to find places and features on Earth's surface using maps and globes is an essential skill required of all Earth scientists. This exercise introduces the most commonly used system for determining location on Earth. Using the system as a foundation, you will examine ways to measure distance on Earth's surface.

Objectives

After you have completed this exercise, you should be able to:

1. Explain the most common system used for locating places and features on Earth.
2. Use Earth's grid system to accurately locate a place or feature.
3. Explain the relation between latitude and the angle of the North Star (Polaris) above the horizon.
4. Explain the relation between longitude and solar time.
5. Determine the shortest route and distance between any two places on Earth's surface.

Materials

ruler
protractor
calculator

Materials Supplied by Your Instructor

globe
world wall map
atlas
50–80 cm length of string

Terms

Earth's grid
latitude
parallel of latitude
equator
North Pole
South Pole
longitude
meridian of longitude
prime meridian
hemisphere
solar time
standard time
great circle
small circle

Introduction

Globes and maps each have a system of north–south and east–west lines, called the **Earth's grid**, that forms the basis for locating points on Earth (Figure 22.1). The grid is, in effect, much like a large sheet of graph paper that has been laid over the surface of Earth. Using the system is very similar to using a graph; that is, the position of a point is determined by the intersection of two lines.

Latitude is north–south distance on Earth (Figure 22.1). The lines (circles) of the grid that extend around Earth in an east–west direction are called **parallels of latitude**. *Parallels of latitude mark north and south distance from the* ***equator*** *on Earth's surface.* As their name implies, these circles are parallel to one another. Two places on Earth, the **North Pole** and **South Pole**, are exceptions; they are points of latitude rather than circles.

Longitude is east–west distance on Earth (Figure 22.1). **Meridians of longitude** are each halves of circles that extend from the North Pole to the South Pole on

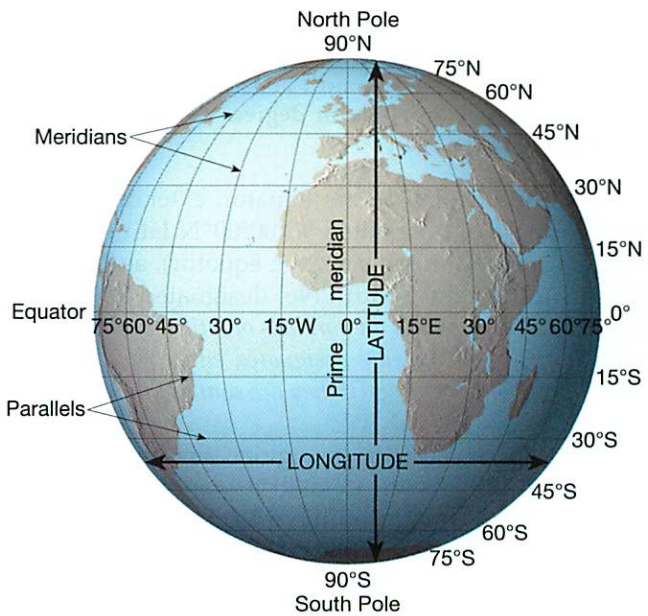

Figure 22.1 Earth's grid system.

one side of Earth. *Meridians of longitude mark east and west distance from the* ***prime meridian*** *on Earth's surface.* Adjacent meridians are farthest apart on the equator and converge (come together) toward the poles.

The intersection of a parallel of latitude with a meridian of longitude determines the location of a point on Earth's surface.

Earth's shape is nearly spherical. Since parallels and meridians mark distances on a sphere, their designation, like distance around a circle, is given in *degrees* (°). For more precise location, a degree can be subdivided into sixty equal parts, called *minutes* (′), and a minute of angle can be divided into sixty parts, called *seconds* (″). Thus, 31°10′20″ means 31 degrees, 10 minutes, and 20 seconds.

The type of map or globe used determines the accuracy to which a place may be located. On detailed maps it is often possible to estimate latitude and longitude to the nearest degree, minute, and second. On the other hand, when using a world map or globe, it may only be possible to estimate latitude and longitude to the nearest whole degree or two.

In addition to showing location on Earth, latitude and longitude can be used to determine distance. Knowing the shape and size of Earth, the distance in miles and kilometers covered by a degree of latitude or longitude has been calculated. These measurements provide the foundation for navigation.

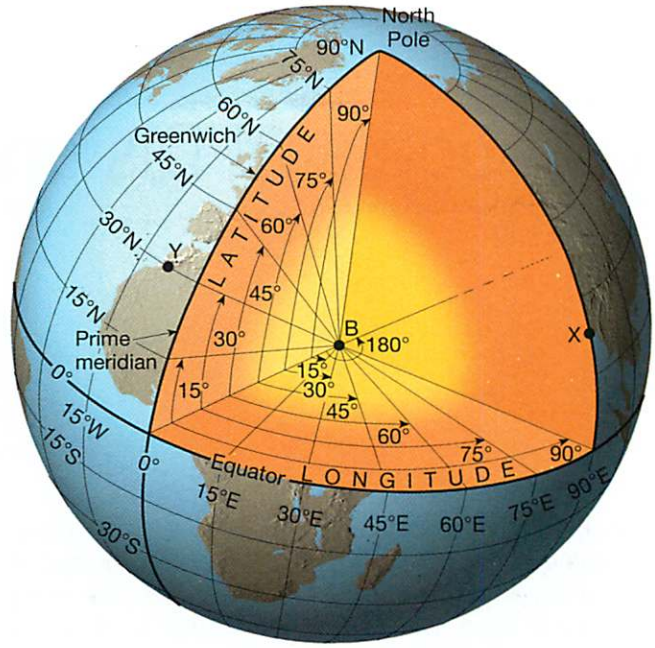

Figure 22.2 Measuring latitude and longitude. The angle measured from the equator to the center of Earth (B) and then northward to the parallel where point Y is located is 30°. Therefore, the latitude of point Y is 30°N. All points on the same parallel as Y are designated 30°N latitude.

The angle measured from the prime meridian where it crosses the equator to the center of Earth (B) and then eastward to the meridian where point X is located, is 90°. Therefore, the longitude of point X is 90°E. All points on the same meridian as X are designated 90°E longitude.

Determining Latitude

The equator is a circle drawn on a globe that is equally distant from both the North Pole and South Pole. It divides the globe into two equal halves, called **hemispheres**. The equator serves as the beginning point for determining latitude and is assigned the value 0°00′00″ latitude.

Latitude is distance north and south of the equator, measured as an angle in degrees from the center of Earth (Figure 22.2).

Latitude begins at the equator, extends north to the North Pole, designated 90°00′00″N latitude (a 90° angle measured north from the equator), and also extends south to the South Pole, designated 90°00′00″S latitude. *The poles and all parallels of latitude, with the exception of the equator, are designated either N (if they are north of the equator) or S (if they are south of the equator).*

1. Locate the equator on a globe. Figure 22.3 represents Earth, with point B its center. Sketch and label the equator on the diagram in Figure 22.3. Also label the Northern Hemisphere and Southern Hemisphere on the diagram.
2. On Figure 22.3, make an angle by drawing a line from point A on the equator to point B (the center of Earth). Then extend the line from point B to point C in the Northern Hemisphere. The angle you have drawn (∠ABC) is 45°. Therefore, by definition of latitude, point C is at 45°N latitude.

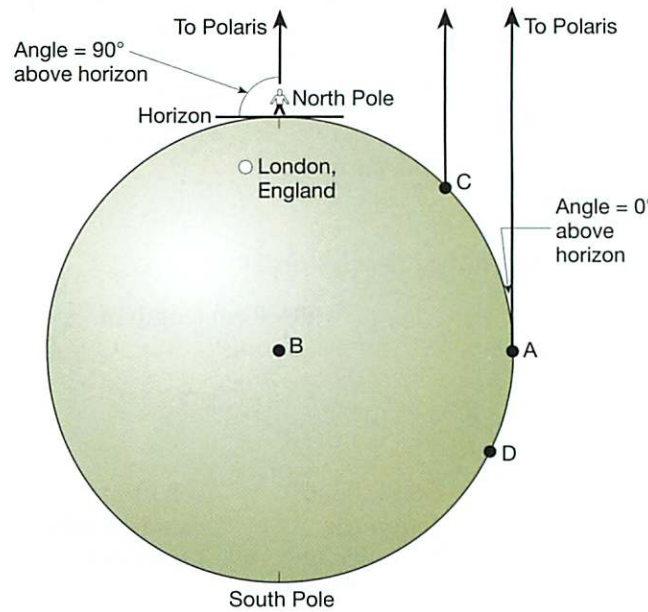

Figure 22.3 Hypothetical Earth.

3. Draw a line on Figure 22.3 parallel to the equator that also goes through point C. All points on this line are 45°N latitude.
4. Using a protractor, measure ∠ABD on Figure 22.3. Then draw a line parallel to the equator that also goes through point D. Label the line with its proper latitude.

On a map or globe, parallels may be drawn at any interval.

5. How many degrees of latitude separate the parallels on the globe you are using?

   _____ degrees of latitude between each parallel

6. Keep in mind that the lines (circles) of latitude are parallel to the equator and to each other. Locate some other parallels on the globe. Sketch and label a few of these on Figure 22.3.
7. Use the diagram that illustrates parallels of latitude, Figure 22.4, to answer questions 7a and 7b.

   a. Accurately draw and label the following additional parallels of latitude on the figure.

   5°N latitude
   10°S latitude
   25°N latitude

   b. Refer to Figure 22.4. Write out the latitude for each designated point as was done for points A and B. Remember to indicate whether the point is north or south of the equator by writing an N or S and include the word "latitude."

   Point A: (30°N latitude) Point D: _____

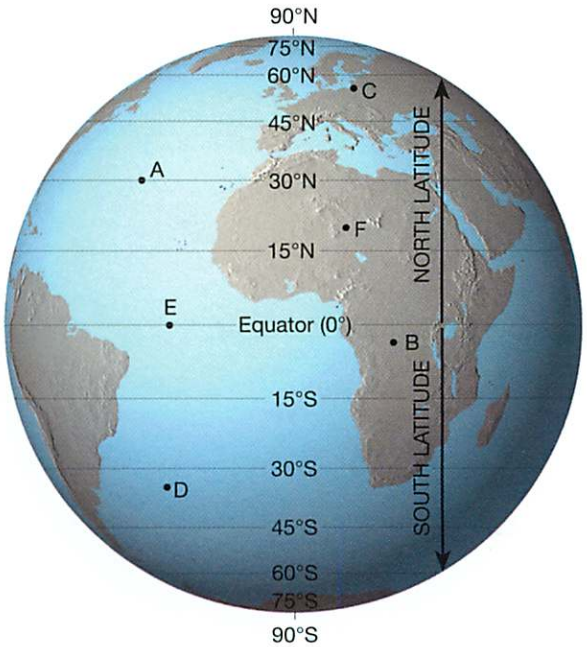

Figure 22.4 Parallels of latitude.

   Point B: (5°S latitude) Point E: _____
   Point C: _____ Point F: _____

8. Use a globe or atlas to locate the cities listed below and give their latitude to the nearest degree. Indicate N or S and include the word "latitude."

   Moscow, Russia: _____
   Durban, South Africa: _____
   Your home city: _____
   Your college campus city: _____

9. By using a globe or atlas, give the name of a city or feature that is equally as far south of the equator as your home city is north.

   _____

10. The farthest one can be from the equator is (45, 90, 180) degrees of latitude. Circle your answer.
11. The two places on Earth that are farthest from the equator to the north and to the south are called the

    _____ and _____.

There are five special parallels of latitude marked and named on most globes.

12. Use a globe or atlas to locate the following special parallels and indicate the name given to each.

	NAME OF PARALLEL
66°30′00″N latitude:	_____
23°30′00″N latitude:	_____
0°00′00″ latitude:	_____
23°30′00″S latitude:	_____
66°30′00″S latitude:	_____

Latitude and the North Star

Today most ships use GPS navigational satellites to determine their location. (For information about the Global Positioning System, visit the website listed at the end of this exercise.) However, early explorers were well aware of the concept of latitude and could use the angle of the North Star (a star named Polaris) above the horizon to determine their north–south position in the Northern Hemisphere. As shown on Figure 22.3, someone standing at the North Pole would look overhead (90° angle above the horizon) to see Polaris. Their latitude is 90°00′00″N. On the other hand, someone standing on the equator, 0°00′00″ latitude, would observe Polaris on the horizon (0° angle above the horizon).

Use Figure 22.3 to answer questions 13–14.

13. The angle of Polaris above the horizon for someone standing at point C would be (45°, 90°, 180°). Circle your answer.

14. What is the relation between a particular latitude and the angle of Polaris above the horizon at that latitude?

_____

15. What is the angle of Polaris above the horizon at the following cities?

	ANGLE OF POLARIS ABOVE THE HORIZON
Fairbanks, AK:	_____ degrees
St. Paul, MN:	_____ degrees
New Orleans, LA:	_____ degrees
Your home city:	_____ degrees
Your college campus city:	_____ degrees

Determining Longitude

Meridians are the north–south lines (half circles) on the globe that converge at the poles and are farthest apart along the equator. They are used to determine longitude, which is distance east and west on Earth (Figure 22.1). Each meridian extends from pole to pole on one side of the globe.

Notice on the globe that all meridians are alike. The choice of a zero, or beginning, meridian was arbitrary. The meridian that was chosen by international agreement in 1884 to be 0°00′00″ longitude passes through the Royal Astronomical Observatory at Greenwich, England, located near London. This internationally accepted reference for longitude is named the *prime meridian*.

Longitude is distance, measured as an angle in degrees **east and west of the prime meridian** (Figure 22.2).

Longitude begins at the prime meridian (0°00′00″ longitude) and extends to the east and to the west, halfway around Earth to the 180°00′00″ meridian, which is directly opposite the prime meridian. *All meridians, with the exception of the prime meridian and the 180° meridian, are designated either E (if they are east of the prime meridian) or W (if they are west of the prime meridian).*

16. Locate the prime meridian on a globe. Sketch and label it on the diagram of Earth, Figure 22.3.

17. Label the Eastern Hemisphere, that half of the globe with longitudes east of the prime meridian, and the Western Hemisphere on Figure 22.3.

On a map or globe, meridians can be drawn at any interval.

18. How many degrees of longitude separate each of the meridians on your globe?

_____ degrees of longitude between each meridian

19. Keep in mind that meridians are farthest apart at the equator and converge at the poles. Sketch and label several meridians on Figure 22.3.

20. Use the diagram that illustrates meridians of longitude, Figure 22.5, to answer questions 20a and 20b.

    a. Accurately draw and label the following additional meridians of longitude on the figure.

    35°W longitude

    70°E longitude

    10°W longitude

    b. Refer to Figure 22.5. Write out the longitude for each designated point as was done for points A and B. Remember to indicate whether the point is east or west of the prime meridian by writing an E or W and include the word "longitude."

    Point A: (30°E longitude) Point D: _____

    Point B: (20°W longitude) Point E: _____

    Point C: _____ Point F: _____

21. Use a globe or atlas to locate the cities listed below and give their longitude to the nearest degree. Indicate either E or W and include the word "longitude."

    Wellington, New Zealand: _____

    Honolulu, Hawaii: _____

    Your home city: _____

    Your college campus city: _____

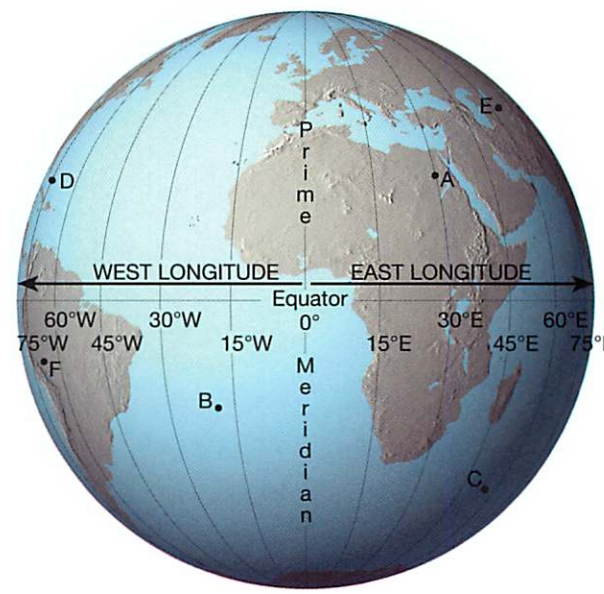

Figure 22.5 Meridians of longitude.

22. Using a globe or atlas, give the name of a city, feature, or country that is at the same latitude as your home city but equally distant from the prime meridian in the opposite hemisphere.

_____

23. The farthest a place can be directly east or west of the prime meridian is (45, 90, 180) degrees of longitude. Circle your answer.

Longitude and Time

Time, while independent of latitude, is very much related to longitude. This fact allows for time to be used in navigation to accurately determine one's location. By knowing the difference in time between two places, one with known longitude, the longitude of the second place can be determined.

Time on Earth can be kept in two ways. **Solar, or Sun, time** uses the position of the Sun in the sky to determine time. **Standard time**, the system used throughout most of the world, divides the globe into 24 standard time zones. Everyone living within the same standard time zone keeps the clock set the same. Of the two, solar time is used to determine longitude.

The following basic facts are important to understanding time.

- Earth rotates on its axis from west to east (eastward) or counterclockwise when viewed from above the North Pole (Figure 22.6).
- It is noon, Sun time, on the meridian that is directly facing the Sun (the Sun has reached its highest position in the sky, called the *zenith*) and midnight on the meridian on the opposite side of Earth.

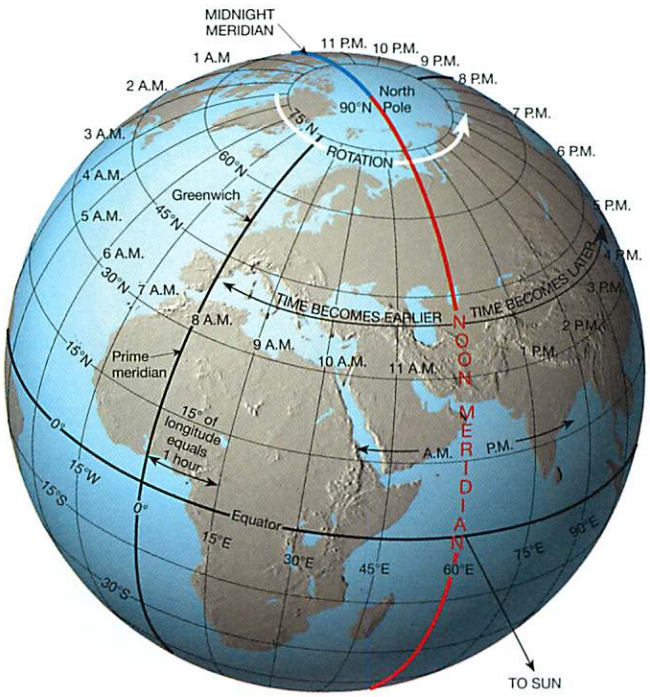

Figure 22.6 The noon meridian and solar time.

- The time interval from one noon by the Sun to the next noon averages 24 hours and is known as the *mean solar day*.
- Earth turns through 360° of longitude in one mean solar day, which is equivalent to 15° of longitude per hour or 1° of longitude every 4 minutes of time.
- Places that are east or west of each other, regardless of the distance, have different solar times. For example, people located to the east of the noon meridian have already experienced noon; their time is afternoon [P.M.—*post* (after) *meridiem* (the noon meridian)]. People living west of the noon meridian have yet to reach noon; their time is before noon [A.M.—*ante* (before) *meridiem* (the noon meridian)]. *Time becomes later going eastward and earlier going westward.*

Use the basic facts of time to answer questions 24–26.

24. What would be the solar time of a person living 1° of longitude west of the noon meridian? Be sure to indicate A.M. or P.M. with your answer.

    Solar time: _____ (A.M., P.M.)

25. What would be the solar time of a person located 4° of longitude east of the noon meridian?

    Solar time: _____ (A.M., P.M.)

26. If it is noon, solar time, at 70°W longitude, what is the solar time at each of the following locations?

	SOLAR TIME
72°W longitude:	_____
65°W longitude:	_____
90°W longitude:	_____
110°E longitude:	_____

Early navigators had to wait for the invention of accurate clocks, called *chronometers*, before they could determine longitude. Today most navigation is done using satellites, but ships still carry chronometers as a backup system.

The shipboard chronometer is set to keep the time at a known place on Earth, for example, the prime meridian. If it is noon by the Sun where the ship is located, and at that same instant the chronometer indicates that it is 8 A.M. on the prime meridian, the ship must be 60° of longitude (4 hours difference × 15° per hour) east (the ship's time is later) of the prime meridian (Figure 22.6). The difference in time need not be in whole hours. Thirty minutes difference in time between two places would be equivalent to 7.5° of longitude, twenty minutes would equal 5°, and so forth.

27. It is exactly noon by the Sun at a ship's location. What is the ship's longitude if, at that instant, the time on the prime meridian is the following? (*Note:* Drawing a diagram showing the prime meridian, the ship's location east or west of the prime meridian, and the difference in hours may be helpful.)

6:00 P.M.: _____

1:00 A.M.: _____

2:30 P.M.: _____

Using Earth's Grid System

Using both parallels of latitude and meridians of longitude, you can accurately locate any point on the surface of Earth.

28. Using Figure 22.7, determine the latitude and longitude of each of the lettered points and write your answers in the following spaces. As a guide, Point A has already been done. Remember to indicate whether the point is N or S latitude and E or W longitude. The only exceptions are the equator, prime meridian, and 180° meridian. They are given no direction because each is a single line and cannot be confused with any other line. Convention dictates that latitude is always listed first.

Point A: (30°N) latitude, (60°E) longitude

Point B: _____ latitude, _____ longitude

Point C: _____ latitude, _____ longitude

Point D: _____ latitude, _____ longitude

Point E: _____ latitude, _____ longitude

29. Locate the following points on Figure 22.7. Place a dot on the figure at the proper location and label each point with the designated letter.

Point F: 15°S latitude, 75°W longitude

Point G: 45°N latitude, 0° longitude

Point H: 30°S latitude, 60°E longitude

Point I: 0° latitude, 30°E longitude

30. Use a globe, map, or atlas to determine the latitude and longitude of the following cities.

Kansas City, MO: _____

Miami, FL: _____

Oslo, Norway: _____

Auckland, New Zealand: _____

Quito, Ecuador: _____

Baghdad, Iraq: _____

31. Beginning with a globe or world wall map, and then proceeding to an atlas, determine the city or feature at the following locations.

19°28′N latitude, 99°09′W longitude:

_____

41°52′N latitude, 12°37′E longitude:

_____

1°30′S latitude, 33°00′E longitude:

_____

When you study the Earth sciences, it is important to be familiar with the major physical features of Earth's surface. Identifying the features on a map will help acquaint you with their location for future reference.

32. Use a wall map of the world or world map in an atlas to find the following water bodies, rivers, and mountains. Examine their latitudes and longitudes, and then label each on the world map, Figure 22.8. To conserve space, mark only the

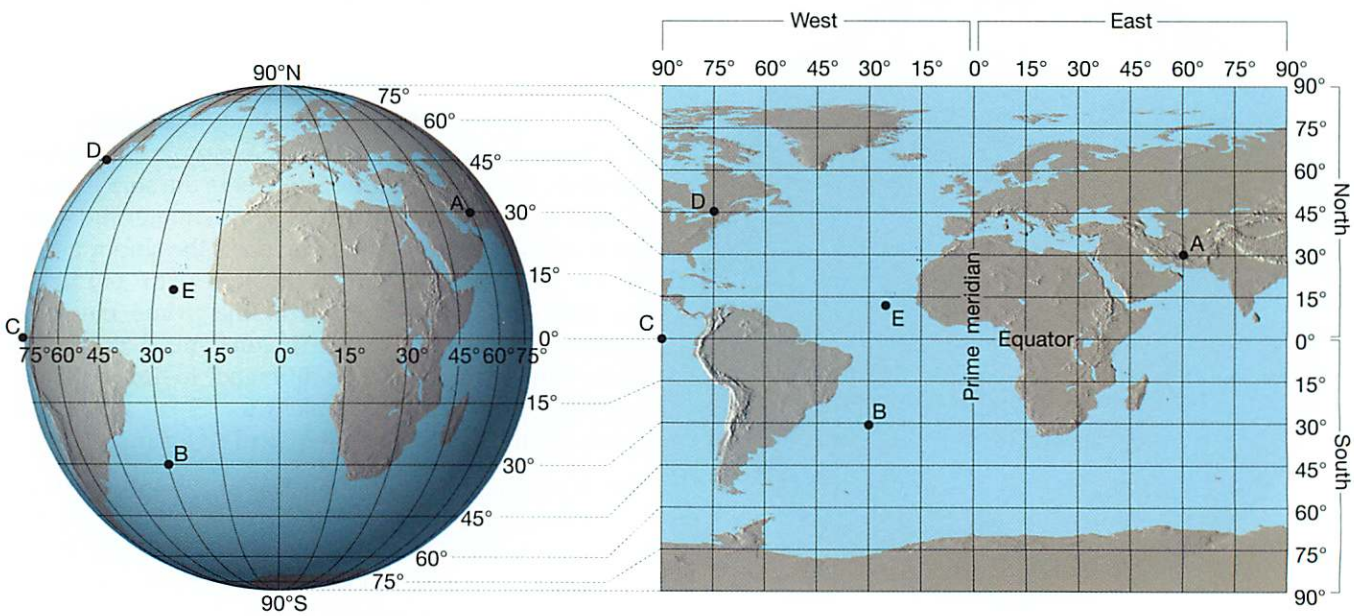

Figure 22.7 Locating places using Earth's grid system.

Figure 22.8 Generalized world map showing select physical features.

number or letter of the feature at the appropriate location on the map.

Water Bodies

A. Pacific Ocean
B. Atlantic Ocean
C. Indian Ocean
D. Arctic Ocean
E. Gulf of Mexico
F. Mediterranean Sea
G. Caribbean Sea
H. Persian Gulf
I. Red Sea
J. Sea of Japan
K. Black Sea
L. Caspian Sea

Rivers

North America
a. Mississippi
b. Colorado
c. Missouri
d. Ohio
South America
e. Amazon
Europe and Asia
f. Volga
g. Mekong
h. Ganges
i. Yangtze
Africa and Australia
j. Nile
k. Congo
l. Darling

Mountains

North America
1. Rocky Mountains
2. Cascade Range
3. Sierra Nevada
4. Appalachian Mountains
5. Black Hills
6. Teton Range
7. Adirondack Mountains
South America
8. Andes Mountains
Europe and Asia
9. Pyrenees Mountains
10. Alps
11. Himalaya Mountains
12. Ural Mountains
Africa and Australia
13. Atlas Mountains
14. MacDonnell Ranges

Great Circles, Small Circles, and Distance

Great Circles

A **great circle** is the largest possible circle that can be drawn on a globe (Figure 22.9). Some of the characteristics of a great circle are

- A great circle divides the globe into two equal parts, called *hemispheres.*
- An infinite number of great circles can be drawn on a globe. Therefore, a great circle can be drawn that passes through any two places on Earth's surface.

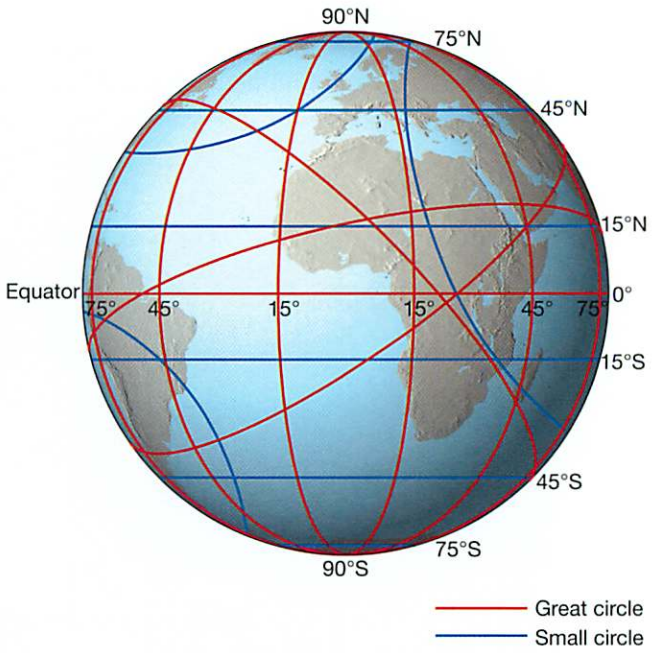

Figure 22.9 Illustrated are a few of the infinite number of great circles and small circles that can be drawn on the globe.

- The shortest distance between two places on Earth is along the great circle that passes through those two places.
- If Earth were a perfect sphere, then one degree of angle along a great circle would cover an identical distance everywhere. Because Earth is slightly flattened at the *poles and bulges slightly* at the equator, there are small differences in the length of a degree. However, for most purposes, *one degree of angle along a great circle equals approximately 111 kilometers or 69 miles.*

Referring to Figure 22.9 and keeping the characteristics of great circles in mind, examine a globe and answer questions 33–35.

33. Remember that great circles do not necessarily have to follow parallels or meridians. Estimate several great circles on the globe. Do this by wrapping a piece of string around the globe that divides the globe into two equal halves. You should be able to see that there are an infinite number of great circles that can be marked on the globe.
34. Which parallel(s) of latitude is/are a great circle(s)?

_____

Meridians of longitude are each half circles. If each meridian is paired with the meridian on the opposite side of the globe, a circle is formed.

35. Which meridians that have been paired with their opposite meridian on the globe are great circles?

_____

Small Circles

Any circle on the globe that does not meet the characteristics of a great circle is considered a **small circle** (Figure 22.9). Therefore, a small circle *does not* divide the globe into two equal parts and *is not* the shortest distance between two places on Earth. Referring to Figure 22.9 and keeping the characteristics of small circles in mind, examine a globe and answer questions 36–38.

36. In general, which parallels of latitude are small circles?

_____

37. Which two latitudes are actually points, rather than circles?

_____

38. In general, which meridians that have been paired with their opposite meridian on the globe are small circles?

_____

39. Indicate, by placing an "X" in the appropriate column, which of the following pairs of points illustrated on the Earth's grid in Figure 22.7 are on a great circle and which are on a small circle.

	GREAT CIRCLE	SMALL CIRCLE
Points A–H	_____	_____
Points D–G	_____	_____
Points C–I	_____	_____
Points B–H	_____	_____

40. Now that you know the characteristics of great and small circles, complete the following statements by circling the correct response.

    a. All meridians are halves of (great, small) circles.

    b. With the exception of the equator, all parallels are (great, small) circles.

    c. The equator is a (great, small) circle.

    d. The poles are (points, lines) of latitude, rather than circles.

Determining Distance Along a Great Circle

Determining the distance between two places on Earth when both are on the equator or the same great circle meridian requires two steps:

Step 1: Determine the number of degrees along the great circle between the two places (degrees of longitude on the equator or degrees of latitude on a meridian).

Step 2: Multiply the number of degrees by 111 kilometers or 69 miles (the approximate number of kilometers or miles per degree for any great circle).

Use a globe and these steps to answer questions 41 and 42.

41. Approximately how many miles would you journey if you traveled from 10°W longitude to 40°E longitude at the equator by way of the shortest route?

_____ miles

42. Approximately how many kilometers is London, England, directly north of the equator?

_____ kilometers

Determining the shortest distance between two places on Earth that are *not* both on the equator or the same great circle meridian requires the four steps (Figure 22.10):

Step 1: On a globe, determine the great circle that intersects both places.

Step 2: Stretch a piece of string along the great circle between the two places on the globe and mark the distance between them on the string with your fingers (Figure 22.10A).

Step 3: While still marking the distance with your fingers, place the string on the equator with one end on the prime meridian. Determine the number of degrees along the great circle between the two places by measuring the marked string's length in degrees of longitude along the equator, which is also a great circle (Figure 22.10B).

Step 4: Multiply the number of degrees along the great circle by 69 miles (111 kilometers) to arrive at the approximate distance. (For example, the great circle distance between X and Y in Figure 22.10 would be approximately 2,070 miles, 30° × 69 miles/degree, or 3330 kilometers, 30° × 111 kilometers/degree.)

Use a globe, a piece of string, and the four steps to answer questions 43 and 44.

43. Determine the approximate great circle distance in degrees, miles, and kilometers from Memphis, Tennessee, to Tokyo, Japan.

    Degrees along the great circle between Memphis and Tokyo = _____°

    Distance along the great circle between Memphis and Tokyo = _____ miles (_____ km)

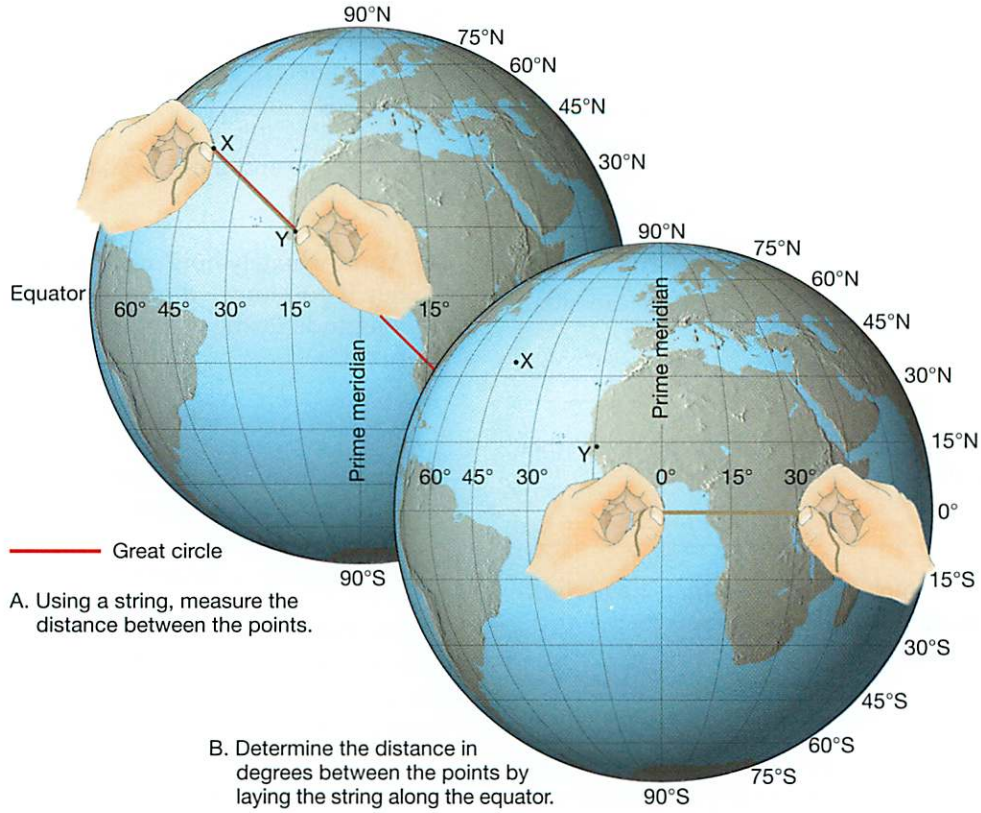

Figure 22.10 Determining the distance between two places on Earth along a great circle other than the equator or great circle meridian. In the example illustrated, the distance between X and Y along the great circle is 30°, which is approximately equivalent to 2,070 miles (3,330 kilometers).

44. Describe the flight route, by listing states, countries, etc., that a plane would follow as it flew by way of the shortest route between Memphis, Tennessee, and Tokyo, Japan.

_____

_____

Determining Distance Along a Parallel

Since all parallels except the equator are small circles, the length of one degree of longitude along a parallel, other than the equator, will always be less than 69 miles or 111 kilometers. Table 22.1 shows the length of a degree of longitude at various latitudes on Earth.

45. Examine a globe. What do you observe about the distance around Earth along each parallel as you get farther away from the equator?

_____

46. Use Table 22.1, "Longitude as distance," to determine the length of one degree of longitude at each of the following parallels.

LENGTH OF 1° OF LONGITUDE

15° latitude: _____ km, _____ miles

30° latitude: _____ km, _____ miles

45° latitude: _____ km, _____ miles

80° latitude: _____ km, _____ miles

47. Use the Earth's grid illustrated in Figure 22.7 to determine the distances between the following points.

Distance between points D and G:

_____ degrees × _____ miles/degree

= _____ miles

Distance between points B and H:

_____ degrees × _____ km/degree

= _____ km

Memphis, Tennessee, and Tokyo, Japan, are both located at about 35°N latitude.

48. Use a globe or world map to determine how many degrees of longitude separate Memphis, Tennessee, from Tokyo, Japan.

Table 22.1 Longitude as Distance

	Length of 1° Long.			Length of 1° Long.			Length of 1° Long.	
°Lat.	km	miles	°Lat.	km	miles	°Lat.	km	miles
0	111.367	69.172	30	96.528	59.955	60	55.825	34.674
1	111.349	69.161	31	95.545	59.345	61	54.131	33.622
2	111.298	69.129	32	94.533	58.716	62	52.422	32.560
3	111.214	69.077	33	93.493	58.070	63	50.696	31.488
4	111.096	69.004	34	92.425	57.407	64	48.954	30.406
5	110.945	68.910	35	91.327	56.725	65	47.196	29.314
6	110.760	68.795	36	90.203	56.027	66	45.426	28.215
7	110.543	68.660	37	89.051	55.311	67	43.639	27.105
8	110.290	68.503	38	87.871	54.578	68	41.841	25.988
9	110.003	68.325	39	86.665	53.829	69	40.028	24.862
10	109.686	68.128	40	85.431	53.063	70	38.204	23.729
11	109.333	67.909	41	84.171	52.280	71	36.368	22.589
12	108.949	67.670	42	82.886	51.482	72	34.520	21.441
13	108.530	67.410	43	81.575	50.668	73	32.662	20.287
14	108.079	67.130	44	80.241	49.839	74	30.793	19.126
15	107.596	66.830	45	78.880	48.994	75	28.914	17.959
16	107.079	66.509	46	77.497	48.135	76	27.029	16.788
17	106.530	66.168	47	76.089	47.260	77	25.134	15.611
18	105.949	65.807	48	74.659	46.372	78	23.229	14.428
19	105.337	65.427	49	73.203	45.468	79	21.320	13.242
20	104.692	65.026	50	71.727	44.551	80	19.402	12.051
21	104.014	64.605	51	70.228	43.620	81	17.480	10.857
22	103.306	64.165	52	68.708	42.676	82	15.551	9.659
23	102.565	63.705	53	67.168	41.719	83	13.617	8.458
24	101.795	63.227	54	65.604	40.748	84	11.681	7.255
25	100.994	62.729	55	64.022	39.765	85	9.739	6.049
26	100.160	62.211	56	62.420	38.770	86	7.796	4.842
27	99.297	61.675	57	60.798	37.763	87	5.849	3.633
28	98.405	61.121	58	59.159	36.745	88	3.899	2.422
29	97.481	60.547	59	57.501	35.715	89	1.950	1.211
30	96.528	59.955	60	55.825	34.674	90	0.000	0.000

_____ degrees of longitude separate Memphis, Tennessee, and Tokyo, Japan.

49. From the longitude as distance table, Table 22.1, the length of one degree of longitude at latitude 35°N is

_____ km (_____ miles).

50. How many miles is Tokyo, Japan, *directly* west of Memphis, TN? Show your calculation below.

_____ miles

51. In question 43 you determined the great circle distance between Memphis, Tennessee, and Tokyo, Japan. How many miles shorter is the great circle route between these cities than the east–west distance along a parallel (question 50)?

The great circle route is _____ miles shorter.

Location and Distance on Earth on the Internet

Continue your analyses of the topics presented in this exercise by completing the corresponding online activity on the *Applications & Investigations in Earth Science* website at http://prenhall.com/earthsciencelab

Notes and calculations.

Location and Distance on Earth

Date Due: _____

Name: _____

Date: _____

Class: _____

After you have finished Exercise 22, complete the following questions. You may have to refer to the exercise for assistance or to locate specific answers. Be prepared to submit this summary/report to your instructor at the designated time.

1. In Figure 22.11, prepare a diagram illustrating Earth's grid system. Include and label the equator and prime meridian. Refer to the diagram to explain the system used for locating points on the surface of Earth.

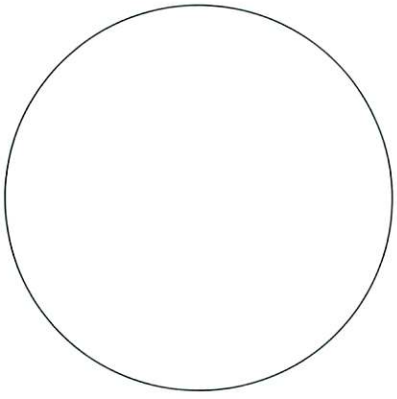

Figure 22.11 Diagram of Earth's grid system.

Explanation: _____

_____

_____

2. Define the following terms.

Parallel of latitude: _____

_____

Meridian of longitude: _____

_____

Great circle: _____

_____

3. Determine whether or not the following statements are true or false. If the statement is false, correct the word(s) so that it reads as a true statement.

T F a. The distance measured north or south of the prime meridian is called latitude.

T F b. All meridians, when paired with their opposite meridian on Earth, form great circles.

T F c. The equator is the only meridian that is a great circle.

4. What is the relation between the latitude of a place in the Northern Hemisphere and the angle of Polaris above the horizon at that place?

_____

5. Approximately how many miles does one degree equal along a great circle?

One degree along a great circle equals _____ miles.

6. What is the latitude and longitude of your home city?

_____ latitude, _____ longitude

7. Use a globe or map to determine, as accurately as possible, the latitude and longitude of Athens, Greece.

_____ latitude, _____ longitude

8. Write a brief paragraph describing how to determine the shortest distance between two places on Earth's surface.

_____

_____

_____

9. From question 51 of the exercise, how many miles shorter is the great circle route between Memphis, Tennessee, and Tokyo, Japan, than the straight east–west distance along a parallel?

   _____ miles shorter

10. Approximately how many miles is it from London, England, to the South Pole? (Show your calculation.)

    _____ miles

11. Using Figure 22.12, determine the latitude and longitude of each of the lettered points and write your answers in the following spaces.

    Point A: _____

    Point B: _____

    Point C: _____

    Point D: _____

    Point E: _____

12. You are shipwrecked and floating in the Atlantic Ocean somewhere between London, England, and New York, New York. Fortunately, you managed to save your globe. You have been in London so your watch is still set for London time. It is noon, by the Sun, at your location. Your watch indicates that it is 4 P.M. in London. Are you closer to the United States or to England? Explain how you arrived at your answer.

    _____

    _____

    _____

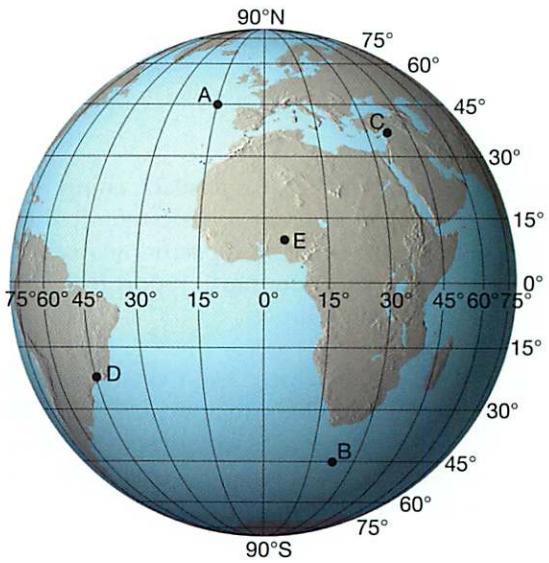

Figure 22.12 Locating places using Earth's grid.