

Chapter 2

Earth's Dimensions and Navigation



WHAT IS EARTH'S SHAPE?

Most ancient people thought of Earth as a flat and boundless expanse. Earth is so large that a person on the surface cannot see its curvature. (See Figure 2-1.) Until people became world travelers and they invented electronic communication, the idea of a flat and endless surface was all people needed. Besides, some people reasoned that if Earth's surface were curved, gravity would pull us off the edge.



Evidence of Earth's Shape

Although Earth looks flat and endless, there were some ancient scholars who believed that Earth is a gigantic sphere. The scholars came to this conclusion because they noticed that as a ship sails away to sea, it seems to disappear hull first. Ships appear to sail over and below the horizon as shown in Figure 2-2.

Another indication of Earth's shape came from observing the moon. During an eclipse of the moon, Earth's shadow

Figure 2-1 To an observer on the surface, Earth looks flat and endless.



moves over the surface of the moon. The edge of that shadow is always a uniformly curved line. Ancient Greek observers knew that the only shape that casts a uniformly curved shadow is a sphere. (See Figure 2-3 on page 32.)

You may know that if you place a telephone call to someone several hundred miles away, that person's local time will probably be different from yours. If it is noon in New York, it is only 9 A.M. for a person in California. At the same time, people in Europe are having their evening meal. For a person in central Asia or Australia, it might be midnight. When time differences over the whole planet are considered, it is clear that Earth is a gigantic sphere.

There is also evidence of Earth's shape in the observation of distant objects in the night sky. A person at the North Pole

Figure 2-2 As a ship sails over the horizon, it seems to disappear from the bottom upward.

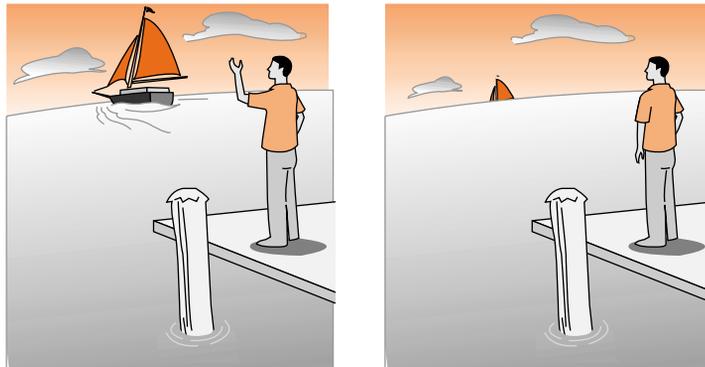
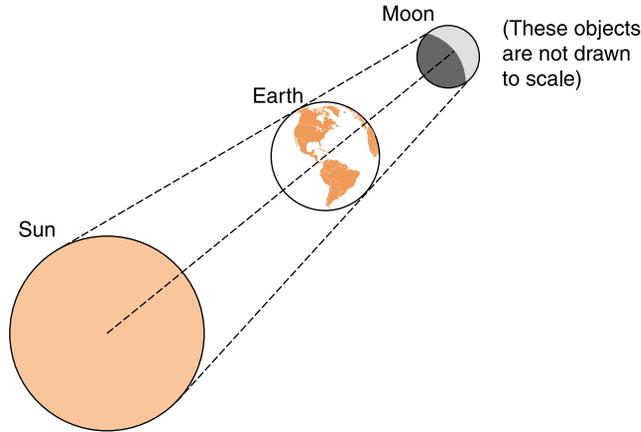


Figure 2-3 During an eclipse of the moon, the moon moves into Earth's shadow. Because the edge of Earth's shadow always shows a uniform curvature, scientists infer that Earth is a sphere.



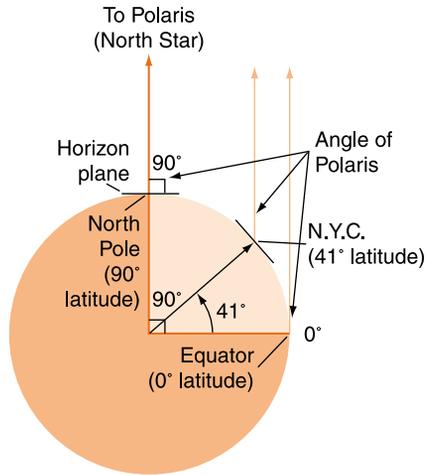
sees the North Star, Polaris, directly overhead. To a person located farther south, Polaris appears lower in the sky. In fact, at the equator, Polaris is along the horizon. (See Figure 2-4.) The **equator** is an imaginary line that circles Earth half way between the North and South Poles. South of the equator, Polaris is not visible at all. (Observers south of the equator can see the stars of the Southern Cross, which is never visible in New York.) These observations support the idea of a spherical planet.

The exploration of space has allowed direct observations and photographs of Earth to be taken from far above its surface. The Apollo program, which explored the moon in the late 1960s, brought astronauts far enough from Earth to show that our planet is a nearly spherical object orbiting in the vastness of space.

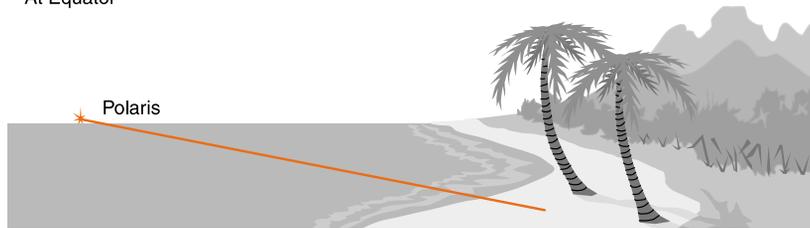
ACTIVITY 2-1 HOW ROUND IS EARTH?

Careful measurements of Earth have shown that it is not a perfect sphere; its equatorial radius is 6378 km, and its polar radius is 6357 km. Earth's rotation on its axis causes a bulge at the equator. But how much of a bulge is there? Earth is not perfectly round. It is **oblate**, or slightly flattened at the poles.

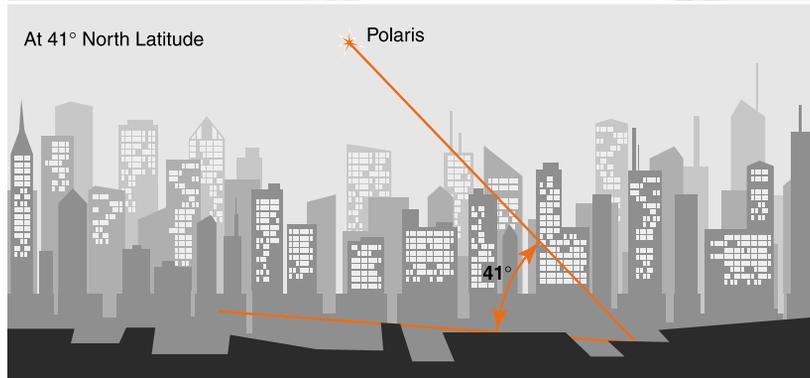
To calculate Earth's degree of flattening, use the formula on page 34. If the result is a large number, Earth is not very round.



At Equator



At 41° North Latitude



At North Pole

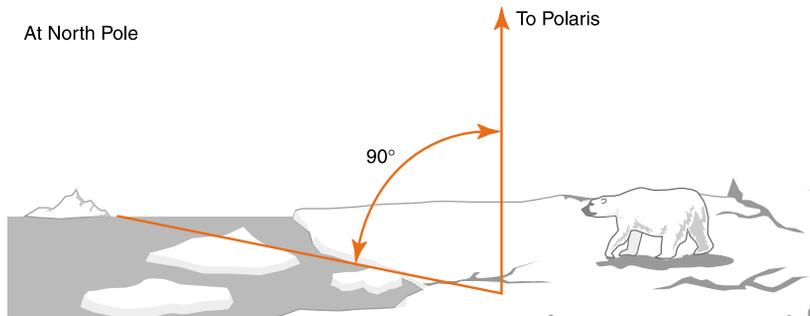


Figure 2-4 The observation of changes in the angular altitude of Polaris that are made as one travels north or south are consistent with a spherical planet.

$$\text{Degree of flattening} = \frac{\text{difference between equatorial and polar radii}}{\text{equatorial radius}}$$

Next, use a drawing compass to draw two large circles centered on the same point. Make one circle according to the polar radius and the second determined by the equatorial radius. By comparing these two circles, state how far from round Earth would appear from space.



How Large Is Earth?

A Greek scholar named Eratosthenes (era-TOSS-then-ease) made the first recorded calculation of Earth's size about 2000 years ago. He knew that on the first day of summer the noon sun was directly overhead at the town of Syene in Egypt. In Alexandria, 5000 *stadia* (approximately 800 km, or 500 mi) to the north, the sun was 7.2° from the overhead position. (*Stadia* is the plural form of *stadium*, a unit of distance used in Eratosthenes' time.) Since 7.2° is $\frac{1}{50}$ of a circle, Eratosthenes reasoned that the distance around the Earth must be 50×5000 *stadia*, or 250,000 *stadia*. Although the exact length of a *stadium* is not known, Eratosthenes' figure appears to be remarkably close to the more accurate measurements made today.



WHAT ARE EARTH'S PARTS?

Based on differences in composition, Earth can be divided into three parts. These parts form spheres, one inside the other, separated by differences in density. Each sphere is also a different state of matter: gas, liquid, or solid.

The **atmosphere** is the outer shell of gas that surrounds Earth. The **hydrosphere** is the water of Earth. About 99 percent of this water is contained in Earth's oceans that cover

about three-quarters of the planet. The **lithosphere** is the solid rock covering Earth. (The crust is the rocky outer layer the lithosphere.)

TABLE 2-1. Average Chemical Composition of Earth's Crust, Hydrosphere, and Troposphere

Element (symbol)	Crust		Hydrosphere, Percent by Volume	Troposphere, Percent by Volume
	Percent by Mass	Percent by Volume		
Oxygen (O)	46.40	94.04	33.0	21.0
Silicon (Si)	28.15	0.88		
Aluminum (Al)	8.23	0.48		
Iron (Fe)	5.63	0.49		
Calcium (Ca)	4.15	1.18		
Sodium (Na)	2.36	1.11		
Magnesium (Mg)	2.33	0.33		
Potassium (K)	2.09	1.42		
Nitrogen (N)				78.0
Hydrogen (H)			66.0	
Others	0.66	0.07	1.0	1.0

Table 2-1 lists the abundance of chemical elements in each sphere. Rocks in Earth's crust represent the lithosphere because these are the rocks that are found at and near the surface. (Deep inside Earth, denser elements, such as iron and magnesium, are more common than they are near the surface.) Notice that oxygen is among the most common elements in all three parts of Earth. Elements are shown rather than chemical compounds because the crust is composed of thousands of minerals, each with a different chemical composition. However, most minerals contain roughly the same

elements. Most of the atmosphere is composed of elements in the form of gases. Only the hydrosphere is made mostly of a single compound: water. Water is composed of two parts hydrogen to one part oxygen.

ACTIVITY 2-2 PIE GRAPHS OF EARTH'S SPHERES

Use the data in Table 2-1 to make a pie graph of the chemical composition of each of the following: the crust, hydrosphere, and lithosphere.



The Atmosphere

A thin layer of gas, the atmosphere, surrounds the solid Earth and oceans. Most of the mass of the atmosphere, clouds, and weather changes occur in the troposphere, the lowest layer of the atmosphere. (See Figure 2-5.) Although the atmosphere accounts for a tiny part of the total mass and volume of the planet, it is in this changing environment that people and most other life-forms live.

Air is a mixture of gases composed of about 78 percent nitrogen (N_2), a stable gas that does not readily react with other elements or compounds. About 21 percent of the atmosphere



Figure 2-5 The atmosphere is the layer of air that surrounds us.

is oxygen (O_2), which combines with many other elements in the processes of oxidation, combustion, and cellular respiration. Living things depend on cellular respiration to make use of the energy stored in food. The inert gas argon, which almost never reacts with other elements or compounds, makes up about 1 percent of the atmosphere.

The proportions of other gases in the atmosphere are variable. The amount of water vapor, water in the form of a gas, can vary from as high as several percent in warm, tropical locations to a tiny fraction of a percent in deserts and cold areas. Carbon dioxide, a common product of respiration and the burning of fossil fuels, makes up far less than 1 percent. However, carbon dioxide needed by plants for photosynthesis, and it may play an important role in climate change, which will be explored in Chapter 25.

The paragraph above describes the composition of the atmosphere's lowest layer, the **troposphere**. Note that the names of the layers of the atmosphere end in *-sphere* because this is their shape around Earth. The names of the boundaries between layers end in *-pause* as in stopping. Therefore, the tropopause is the place where the troposphere ends.

The atmosphere is divided into layers based on how the temperature changes with altitude. (See Figure 2-6.) Because

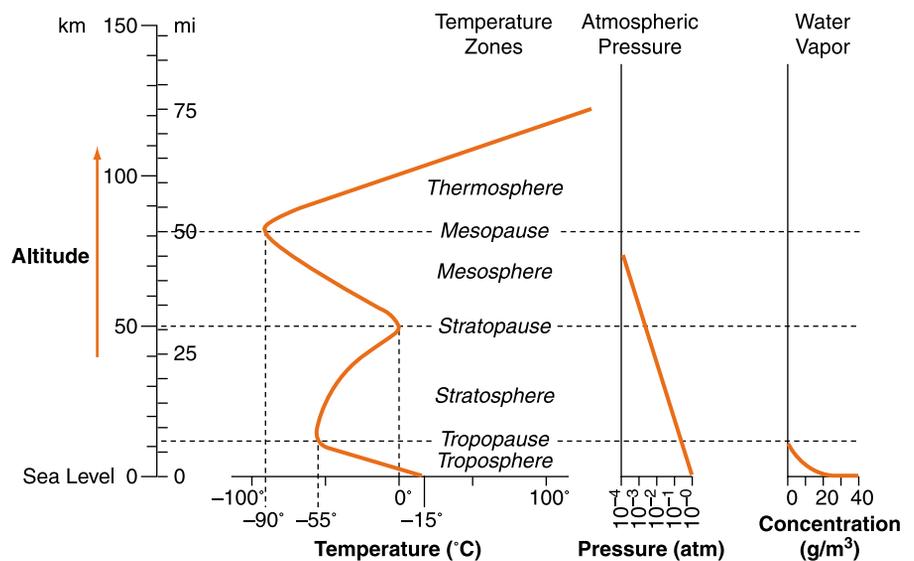


Figure 2-6 Selected properties of Earth's atmosphere.

the layers of the atmosphere are a result of density differences, the atmosphere is most dense at the bottom of the troposphere. Actually, the troposphere contains most of the mass of the atmosphere even though it extends only about 7 mi (12 km) above Earth's surface. Nearly all the atmosphere's water vapor, clouds, and weather events occur in this lowest layer.

Within the troposphere as altitude increases, temperature decreases. Have you ever noticed that snow lasts longer in the high mountains? The world's highest mountains extend nearly to the top of the troposphere. Above that height, the temperature change reverses and it actually becomes warmer with increasing altitude. The altitude at which the reversal occurs is known as the tropopause.

The next layer of the atmosphere is the **stratosphere**, in which the temperature increases with increasing altitude. The stratosphere extends up to the stratopause, where another change in temperature trend takes place. In the **mesosphere**, the temperature falls as altitude increases. Above the mesopause, is the highest layer, the **thermosphere**, in which the air temperature rises significantly. However, that increase in temperature speeds the motion of very few atoms. This increased agitation separates the molecules into positive and negative ions. This layer is sometimes called the ionosphere.

The lower boundary of the atmosphere is quite distinct: the surface of the land or the hydrosphere. However, because the atmosphere thins with altitude, there is no clear upper boundary of the atmosphere. The atmosphere just gets thinner and thinner as you get farther from Earth. When people refer to the atmosphere, they usually mean the troposphere, which contains about three-quarters of the atmosphere's total mass. This is layer in which we live.

ACTIVITY 2-3

INTERPRETING REFERENCE TABLES

You have probably ridden an elevator to the top of a building. What would you experience if you could ride in an open elevator through the atmosphere? Based on the information in Figure 2-6, write a travelers' guide to an elevator ride to a point 150 km above

Earth's surface. Describe changes in temperature, air pressure, and water vapor concentration that a traveler would encounter on the ride. In addition, describe the protective equipment that a traveler would need to survive the trip.



The Hydrosphere

Earth's oceans cover nearly three times as much of our planet as do the continents. People may think oceans are vast, featureless expanses of water; but oceans are not infinite and not featureless. The bottom of the oceans are almost as variable as the land areas. The hydrosphere is Earth's thinnest layer, averaging about 4 km in depth. Furthermore, scientists think the oceans are where life began on Earth.

The liquid hydrosphere can be divided into two parts. About 99 percent of the hydrosphere is made up of the oceans, which are composed of salt water. Salt water is about 96.5 percent water and about 3.5 percent salt, mostly sodium chloride (common table salt). The remaining 1 percent of the hydrosphere is freshwater, which contains much smaller concentrations of dissolved solids. Freshwater is found in streams, rivers, and lakes. However, far more freshwater exists in the spaces within soil and rock. In fact, groundwater is estimated to be 25 times as abundant as the freshwater on Earth's surface.



The Lithosphere

This natural arch in Utah (see Figure 2-7 on page 40) is part of the lithosphere, Earth's rigid outer layer. The great bulk of Earth is the geosphere. We can define the **geosphere** as the mass of solid and molten rock that extends more than 6000 km from Earth's solid surface to its center. The lithosphere, the top 100 km of the geosphere, is the most rigid (unbending) part of the geosphere. Direct explorations in mines have taken humans to a depth of less than 4 km. The deepest drill hole is about 12 km deep. Everything we know about the



Figure 2-7 This natural arch in Utah is part of the lithosphere, the rigid outer layer of the solid Earth.

geosphere at depths greater than 12 km comes from indirect evidence, such as the increasing temperatures with depth, the passage of seismic (earthquake) waves, examination of meteorites, and from the determination of Earth's bulk properties, such as its density.



HOW IS LOCATION DETERMINED?

How can sailors far out on the ocean determine their position? With no familiar landmarks, such as roads, cities, and geographic features, they cannot describe their location in terms of surface features the way people usually do on land. Long ago, explorers solved this problem by establishing a coordinate system that covers the whole Earth.



Terrestrial Coordinates

The grid on a sheet of graph paper is a type of coordinate system. Each point on the paper can have a unique address expressed in terms of numbers along the x - and y -axes. Many cities are laid out in a coordinate system. Much of New York

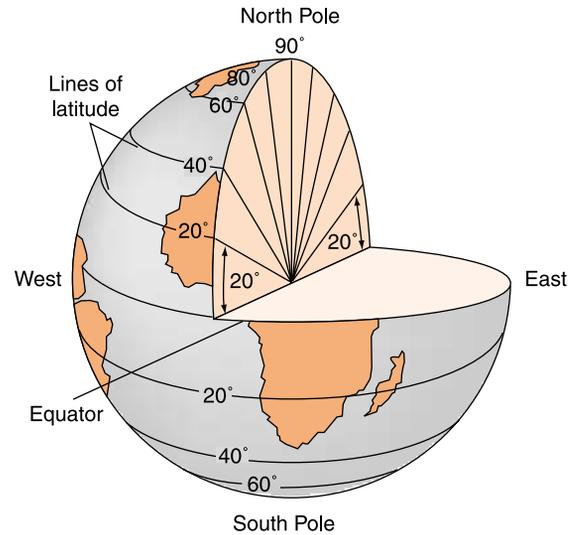


Figure 2-8 Latitude is the angular distance north or south of the equator.

City has numbered avenues that run north-south and numbered streets that run east-west. Knowing the street address of a building can help a person quickly locate it on a map or in the city itself. However, in Earth's undeveloped areas there are no roads or street signs, and there is no way to mark the oceans' surface. Because of this, explorers used their observations of the sun and stars to find their position on Earth's surface.

The coordinate system established by early sailors and explorers is Earth's system of latitude and longitude, called **terrestrial coordinates**. This system is based on the spin (rotation) of Earth on its axis. The **axis** is an imaginary line that passes through Earth's North and South Poles. Halfway between the poles is the equator, an imaginary line that circles Earth. The first terrestrial coordinate value is latitude. As shown in Figure 2-8, **latitude** is the angular distance north or south of the equator.

Lines of equal latitude are called parallels because they run east-west and, unlike longitude lines are parallel to each other. The equator is the reference line at latitude 0° . Both north and south of the equator, latitude increases to a maximum of 90° at the poles. Parallels can be drawn at any interval of latitude from the equator (0°) to the north and south poles (90°N and S).

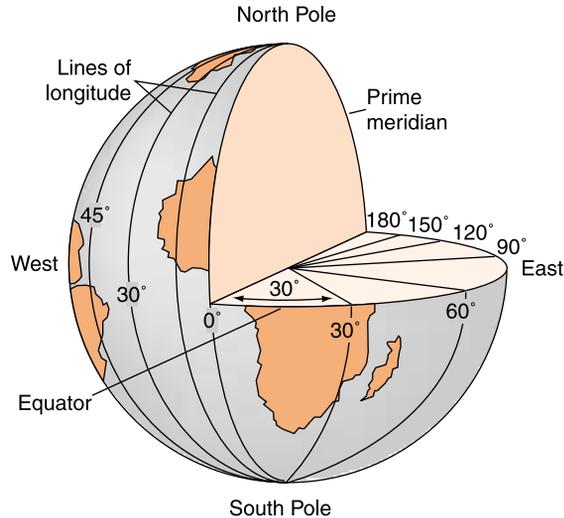


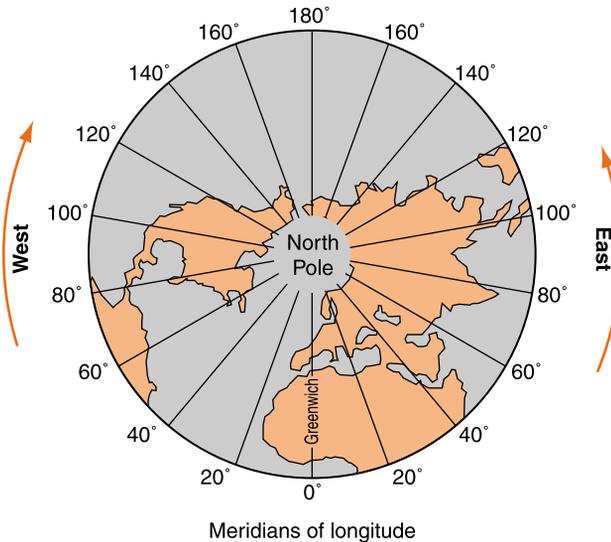
Figure 2-9 Longitude is the angular distance east or west of the prime meridian.

The second terrestrial coordinate value is longitude. As shown in Figure 2-9, **longitude** measures angular distance east and west. Unlike latitude, there is no natural or logical place to begin longitude measurements. English explorers established their reference line at the Royal Observatory in Greenwich (GREN-itch), England. Since England dominated world exploration and mapmaking, a north-south line through Greenwich became the world standard for measurements of longitude. Today, the Greenwich meridian, also known as the **prime meridian**, has become the reference line from which longitude is measured.

Lines of equal longitude are called meridians. Meridians all run from the North Pole to the South Pole. The prime meridian has a longitude of 0° . Longitude increases to the east and west to a maximum of 180° , a line that runs down the middle of the Pacific Ocean. Meridians are not parallel because they meet at the North and South Poles. As shown in Figure 2-10, the Eastern and Western Hemispheres are the two halves of Earth bounded by the prime meridian and the north-south line of 180° longitude.

Unfortunately, some people think of latitude and longitude only as lines. For example, they confuse latitude, the angular distance from the equator, with the lines on a map that show constant latitude. If your only purpose is to read the coordinates on a map, this is not a problem. But, if you want to

Figure 2-10 Lines of longitude meet at the North and South Poles. The 0° meridian and the 180° meridian separate the planet into the Eastern and Western Hemispheres.



understand what latitude is and how it is determined, you need a deeper understanding.



Finding Latitude

Earlier in this chapter you read that observations of Polaris, the North Star, were used to show that Earth is a sphere. Those observations can also be used to tell how far north a person is from the equator. It takes Earth one day, 24 hours, to complete one rotation on its axis. That rotation is responsible for day and night. Although there is no scientific reason that Earth's axis should be aligned with any particular star, it is. The direction in which Earth's axis points moves through a 26,000-year cycle. However, at this time the axis lines up with a relatively bright star called Polaris, or the North Star. (The alignment is not perfect, since Polaris is a little less than 1 degree from the projection of Earth's axis.) Figure 2-11 on page 44 shows how to locate Polaris.

An observer at the North Pole sees Polaris directly overhead in the night sky. The angle from the horizon up to Polaris is therefore 90°. That observer is also located 90° north of the equator. As the latitude of the observer decreases, the altitude of Polaris also decreases. At the equator, Polaris is visible

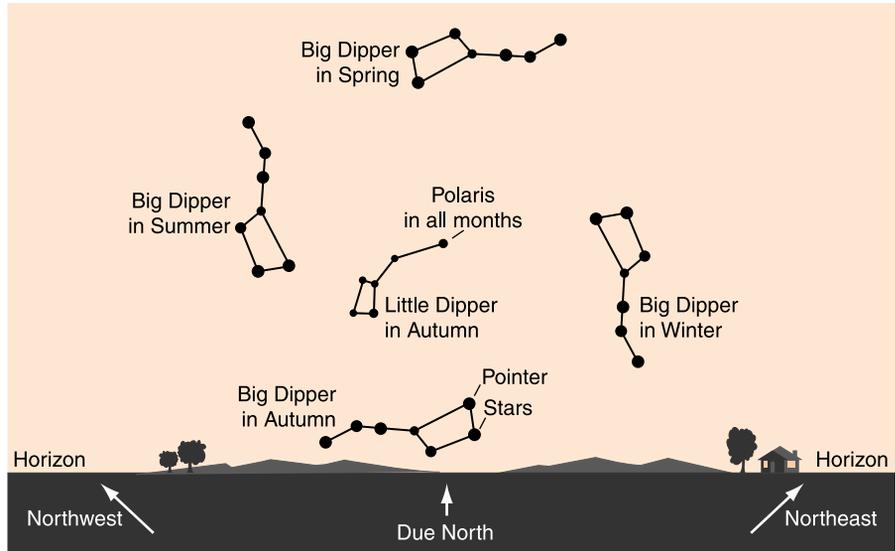


Figure 2-11 The easiest way to find Polaris, the North Star, is to locate the Big Dipper and follow the pointer stars at the end of its bowl as they point to Polaris. This diagram shows the way the Big Dipper looks in the evening sky at the middle of each season. The Little Dipper also rotates around Polaris, but it is shown only in its autumn position.

right on the northern horizon. Here, Polaris is 0° above the horizon, the latitude at Earth's equator is 0° . Therefore, for any observer in the Northern Hemisphere, latitude can be determined by observing the angle of Polaris above the horizon. The altitude of Polaris equals the latitude of the observer.

South of the equator the North Star is not visible. However, with a star map, an observer can determine the point in the night sky that is directly above the South Pole. It is near the constellation called the Southern Cross. In a procedure similar to what is done in the Northern Hemisphere, south latitude is equal to the angle of that point in the starry sky above the horizon. For people used to sighting on Polaris, it did not take long to master finding latitude in the Southern Hemisphere.

ACTIVITY 2-4 DETERMINING YOUR LATITUDE

You can construct an instrument to measure your latitude using the following simple materials: a protractor, a thin string, a weight, and a sighting device such as a soda straw. This instrument is called an

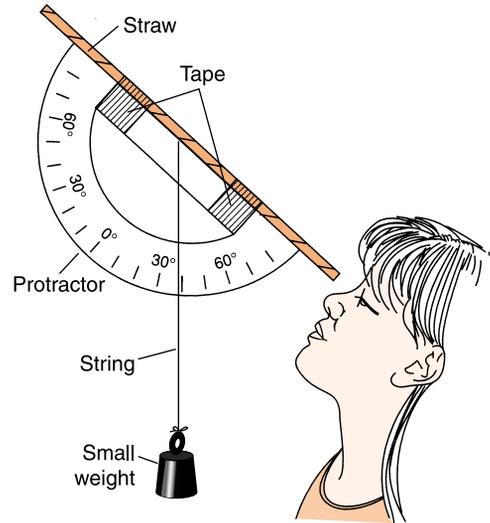


Figure 2-12 The astrolabe is used to measure the angular altitude of an object in the sky.

astrolabe. It is similar in principle to instruments used by mariners for hundreds of years. Figure 2-12 shows how to construct and use a simple astrolabe.

If you use a standard protractor when you sight along the horizon, the string will fall along the 90° line. Similarly, if you look straight up, the string will line up with 0° . In these cases, you will need to subtract your angle readings from 90° to find your latitude. Your latitude is equal to the angle of the star Polaris above a level horizon.



Finding Longitude

Longitude can be determined by observations of the position of the sun. If it is noon where you are, it must be midnight halfway around Earth. (A full circle is 360° , so halfway around the planet is 180° .) The sun appears to move around Earth from east to west. Therefore, when it is noon where you are, in places to your east, the local time is afternoon, and in places to your west it is still morning. Because the sun appears to move around Earth in 24 hours, each hour of time difference represents $\frac{1}{24}$ of 360° , or 15° . So, each 1-hour difference in time from one location to another represents 15° of longitude.

Using the time difference of 15° per hour, you can determine the numerical value of longitude. But how can you determine whether it is east or west longitude? If local time is earlier than Greenwich time, the observer is located in the Western Hemisphere. Observers in the Eastern Hemisphere will note that local time is later than Greenwich time. To make this clearer, you can look at a globe and imagine the sun at the noon position in England. Remember that Earth spins toward the east. On your globe, most of Europe and Asia, at eastern longitudes, are in the afternoon or evening. At the same time in those places to the west of England, it is still morning.

Of course, this is based on solar time. Solar noon is the time the sun reaches its highest point in the sky. Clock time may differ from solar time by half an hour, even more if daylight savings time is in effect. If people set their clocks to the apparent motion of the sun across the sky in their location, clock time would be different from one place to another. This was done before time was standardized. In those days, towns had a clock that chimed on the town hall, so the citizens would know the local time. At that time, watches were difficult to make and too expensive for most people to own. Only places on a north-south line (at the same longitude) would have exactly the same clock time. If you wanted to meet someone in another town at a particular time, you could not use a clock set to the time in your town because you would probably show up early or late. Radio and television programs would not necessarily begin on the hour or half-hour. To standardize time, the United States is divided into four time zones: Eastern, Central, Mountain, and Pacific Time. In each time zone, all clocks are set to the same time.

ACTIVITY 2-5

FINDING SOLAR NOON

It is quite easy to measure local time by observations of the sun. To determine the time of solar noon, you will need to be at a location where a tall, vertical object, such as a flagpole or the high corner of a tall building, casts a shadow onto a level surface. Throughout the middle of the day, mark the exact position of the

point of the shadow, and label the positions with the accurate clock time. (To avoid making permanent marks, use a substance such as chalk that will wash away in the rain.) Call these marks the time points. Connecting the points will form a curved line north of the object casting the shadow.

The next step is find where the curved shadow line comes closest to the base of the shadow object. (You will probably need to use a long metal tape measure to measure the distance.) Mark this point "Solar Noon." Finding the clock time of solar noon will probably require you to estimate between the marked time points to establish the precise time of "Solar Noon."

An added benefit of this procedure is that it provides a line that runs exactly north to south. The line from the vertical base of the shadow object could actually be extended to the North Pole. The English navigators dominated world exploration and mapmaking after the defeat of the Spanish Armada in 1588. These mapmakers set their clocks to observations of the sun made at the Royal Observatory in Greenwich, England. Therefore a north-south line running through Greenwich became the line from which longitude was measured. Modern clocks have become so precise they can measure small changes in Greenwich noon throughout the year. Therefore, **Greenwich Mean Time (GMT)**, which evens out these small annual changes, is used as the basis of standard time throughout the world.

The method of determining longitude became quite clear. However, in practice, it was not so easy. A navigator at sea needs to know the precise time noon occurs back in Greenwich. Although ships carried the most accurate clocks available at that time, after a long sea voyage, changes in temperature, and the rocking motion of the ship caused these mechanical devices to become inaccurate. It was easy enough to observe local time by observing when the shadow of a vertical object pointed exactly north. But comparing local time with the time back in England depended on those mechanical clocks. Until very accurate clocks could be manufactured, measurements of

longitude were poor, and maps generally showed large errors in the east-west direction.

ACTIVITY 2-6 DETERMINING YOUR LONGITUDE

Longitude equals the time difference between local solar time and Greenwich Mean Time (GMT) in hours and hundredths of an hour multiplied by 15° per hour of difference. If you performed the solar noon activity earlier in this chapter, you can use your data to determine your longitude. In that activity, you determined the difference between clock time and solar time. For example, if you determined that solar noon occurred 11:55 A.M., the difference between clock time and solar time is -5 minutes. If solar noon occurred at 12:09 P.M., the difference between clock time and solar time is $+9$ minutes. (Convert your solar time from hours and minutes to hours and hundredths of an hour by dividing the minutes by 60.)

For any location in New York State, you can find Greenwich Mean Time by adding 5 hours to your clock time. For example, if it is 1:15 P.M. clock time, Greenwich Mean Time is 6:15 P.M. (*Note:* If it is daylight savings time in New York, you would add only 4 hours.)

Once you have calculated your longitude experimentally, you can check your results with a map of New York State, such as the *Generalized Bedrock Geology of New York State* found on page 433 or in the *Earth Science Reference Tables*, that shows local latitude and longitude.

(*Note:* Mean Time and solar can differ by as much as 15 minutes. This could cause an error of as much as 4° of longitude. The following Web site explains this issue, known as the Equation-of-Time <<http://www.analemma.com/Pages/framesPage.html>>)

Today, finding the angle north or south of the equator (latitude) and the angle east or west of the prime meridian (longitude) has become simple and accurate thanks to modern

technology. There are very accurate timepieces that use the precise vibrations of quartz crystals to measure time. In addition, radio and telephone communications provide Greenwich time to great accuracy. Even better, is the use of Global Positioning System (GPS) devices that analyze signals from orbiting satellites, allowing people to find latitude and longitude with great accuracy. Using a GPS device allows people to pinpoint their position to within a few meters. These devices are now small and inexpensive enough to be used by hikers and sportsmen. On land or at sea, it has become remarkably easy to find your place on the planet's terrestrial coordinates.

DIVISIONS OF ANGLES Just as meters can be divided into centimeters and millimeters, degrees of angle can be divided into smaller units. Each degree is made up of 60 minutes ($60'$) of angle. So, $23\frac{1}{2}$ degrees is 23 degrees and 30 minutes ($23^{\circ}30'$). Furthermore, one minute of angle ($\frac{1}{60}$ of a degree) can further be divided into 60 seconds ($60''$). On Earth's surface, an accuracy of a second of latitude or longitude would establish your location to within a rectangle that measures about 30 meters on each side.

ACTIVITY 2-7

READING LATITUDE AND LONGITUDE ON MAPS

The Earth Science Reference Tables contain three maps (one New York map and two world maps) that can be used to read latitude and longitude. However, these world maps do not show cultural features, such as cities and political boundaries. To complete this activity it is best to use an atlas or a world map.

Your teacher may ask you to make a small "X" at each world location on a paper copy of the Tectonic Plates world map from the Reference Tables.

What cities are located at the following coordinates? (Please use a sheet of notebook paper. You should not mark in this book or on any reference materials.)

(1) 36°N , 122°W

(2) 33°S , 18°E

(3) 35°N , 140°E

(4) 55°N , 37°E

List the latitude and longitude coordinates of the following places on a world map. Please estimate values to the nearest degree of latitude and longitude.

- | | |
|---------------------|-----------------------|
| (5) New York City | (7) Sydney, Australia |
| (6) London, England | (8) Honolulu, Hawaii |

Find the terrestrial coordinates of each of these places in New York. Ask your teacher if and how you should divide degrees of latitude and longitude and how accurate your answers should be.

- | | |
|-------------|----------------|
| (9) Buffalo | (11) Mt. Marcy |
| (10) Albany | (12) Rochester |
- (13) What three lines of latitude and longitude have been used to define the political boundaries of New York State?

TERMS TO KNOW

atmosphere	hydrosphere	oblate
axis	latitude	prime meridian
equator	lithosphere	stratosphere
geosphere	longitude	terrestrial coordinate
Greenwich Mean Time	mesosphere	thermosphere

CHAPTER REVIEW QUESTIONS

- As altitude increases within Earth's stratosphere, air temperature generally

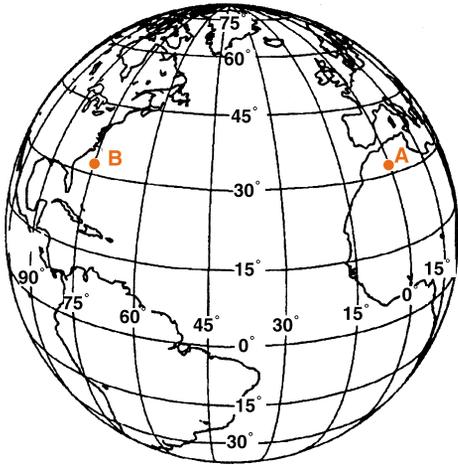
(1) decreases only.	(3) increases, only.
(2) decreases, then increases.	(4) increases, then decreases.
- When the time of day for a certain ship at sea is 12 noon, the time of day at the prime meridian (0° longitude) is 5 P.M. What is the ship's longitude?

(1) 45°W	(3) 75°W
(2) 45°E	(4) 75°E

5. Earth's hydrosphere is best described as the

- (1) solid outer layer of Earth.
- (2) liquid outer layer of Earth.
- (3) liquid layer located below Earth's crust.
- (4) gaseous layer of Earth located above Earth's crust.

6. The diagram below shows the latitude-longitude grid on an Earth model. Points A and B are located on the surface.



The solar time difference between point A and point B is

- (1) 1 hour.
- (2) 2 hours.
- (3) 5 hours.
- (4) 12 hours.

7. Earth's troposphere, hydrosphere, and lithosphere contain relatively large amounts of which element?

- (1) iron
- (2) oxygen
- (3) hydrogen
- (4) potassium

8. Ozone is concentrated in Earth's atmosphere at an altitude of 20 to 35 km. Which atmospheric layer contains the greatest concentration of ozone?

- (1) mesosphere
- (2) thermosphere
- (3) troposphere
- (4) stratosphere

9. At which location will Polaris be observed at the highest altitude?
- (1) equator (3) central New York State
(2) Florida (4) Arctic Circle
10. Earth's shape is most similar to a
- (1) basketball. (3) egg.
(2) pear. (4) apple.
11. Which two New York State cities experience solar noon (the time when the sun is highest in the sky) at almost exactly the same time?
- (1) Watertown and Binghamton (3) Binghamton and Elmira
(2) Buffalo and Albany (4) Buffalo and Ithaca
12. What is the most abundant element in Earth's atmosphere?
- (1) oxygen (3) hydrogen
(2) argon (4) nitrogen
13. An explorer rode a balloon high into Earth's atmosphere, taking a continuous record of atmospheric pressure. In which layer was the explorer most likely located when the atmospheric pressure was 10^{-2} atmospheres?
- (1) troposphere (3) mesosphere
(2) stratosphere (4) thermosphere
14. What percent of Earth's hydrosphere is fresh water?
- (1) 99% (3) 23%
(2) 75% (4) 1%
15. Approximately what percentage of Earth's surface is covered by water?
- (1) 100% (3) 50%
(2) 75% (4) 25%

Open-Ended Questions

16. Give three types of evidence that are a result of Earth's spherical shape.
17. Describe a simple procedure that can be used to find latitude in the Northern Hemisphere.

The table below shows the concentration of ozone, in ozone units, in Earth's atmosphere. (One ozone unit is equal to 10^{12} molecules per cubic centimeter.)

Concentration of Ozone	
Altitude (km)	Ozone Units
0	0.7
5	0.6
10	1.1
15	3.0
20	4.9
25	4.4
30	2.6
35	1.4
40	0.6
45	0.2
50	0.1
55	0.0

18. In which zone of the atmosphere is the concentration of ozone the greatest?
19. On what basis, has Earth's atmosphere been divided into its four layers?
20. What is the relationship between the density of Earth's layers the position of each layer?