TOPIC 8

Mapping Our World

For centuries, people have made maps to show the locations of places. A map is a graphic representation of part or all of Earth's surface. Maps show where specific places are located in relation to others, and they allow us to quickly determine the direction and distance from one point to another. In this topic, you will learn about the grid of lines that is used to identify positions on Earth's surface. You will also learn about different types of maps and how to identify symbols and measure distances on a map.

SUBTOPIC A LATITUDE AND LONGITUDE

Covers National Science Content Standards UCP.1, UCP.2, UCP.3; E.1, E.2

Unifying Concepts and Processes

UCP.1	Systems, order, and organization
UCP.2	Evidence, models, and explanation
UCP.3	Change, constancy, and measurement

Science and Technology

E.1	Abilities of technological design
E.2	Understandings about science and technology

VOCABULARY

cartography	prime meridian
equator	longitude
latitude	International Date Line

The process of making maps is known as **cartography.** To locate points on Earth accurately when making a map, cartographers refer to an imaginary grid of lines that cover Earth's nearly spherical surface. On this grid, lines that run from east to west intersect with lines that run from pole to pole.

Latitude

The most familiar of the east-west lines on Earth is the **equator,** which circles Earth halfway between the north and south poles. As Figure 8-1A shows, the equator divides Earth into the northern hemisphere and the southern hemisphere. The equator also serves as the reference line for **latitude,** the distance in degrees north or south of the equator. The equator is given the latitude of 0°.

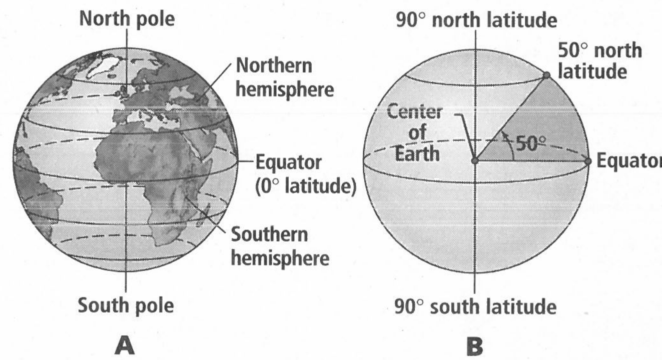


Figure 8-1 The equator is the reference line for latitude. It divides Earth into the northern and southern hemispheres (A). The latitude of a point on Earth's surface equals the angular distance in degrees between that point and the equator (B).

All points that have the same latitude form a circle that is parallel to the equator. Such circles are called lines of latitude, parallels of latitude, or often just parallels. Lines of latitude are called parallels because they are all parallel to one another. Lines of latitude run east to west, like the equator, but they measure the distance north and south of the equator.

Measuring Latitude

To understand how latitude is measured, refer to Figure 8-1B. Imagine drawing a line between the center of Earth and a point on Earth's surface in the northern hemisphere. This line forms an angle with the plane of the equator. The number of degrees in that angle is the latitude of that point. In the example shown in Figure 8-1B, the angle measures 50°, so the point is located at 50° north latitude. Any point an equal distance due south of the equator is located

Conic Projection

A **conic projection** is made by transferring points and lines from Earth's surface onto a cone. As Figure 8-7 shows, the cone is positioned directly over one of the poles and contacts Earth at a particular line of latitude, called the standard parallel. When the cone is slit along a meridian and rolled out, it produces a map of the part of Earth's surface between that pole and the standard parallel. Maps drawn by conic projection show greater distortion the closer you get to the poles. For points near the standard parallel, however, such maps represent the areas and shapes of landmasses with great accuracy. For this reason, conic projection is often used to make road maps and weather maps that cover relatively small areas.

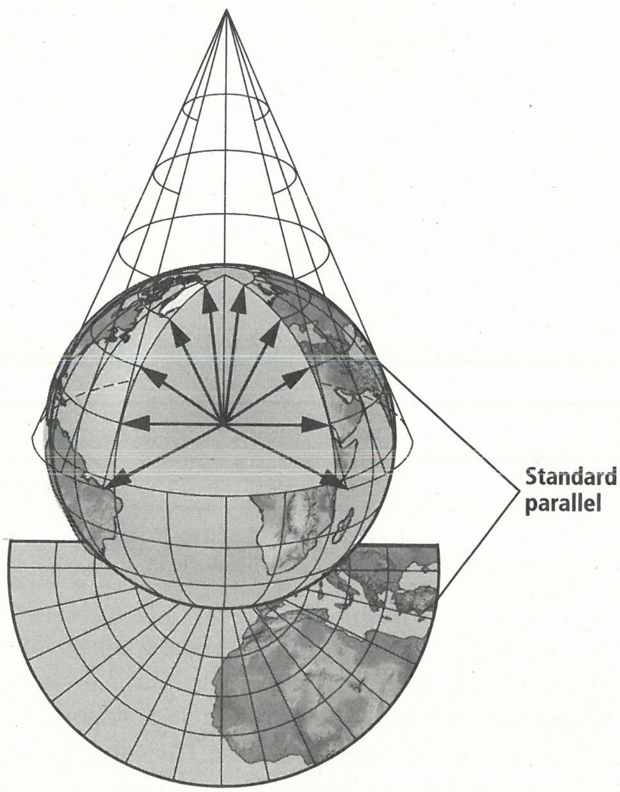


Figure 8-7 In a conic projection, points and lines are transferred from Earth's surface onto a cone that contacts Earth at a line of latitude called the standard parallel. The cone is then opened and flattened.

Gnomonic Projection

A **gnomonic projection** is made by transferring points and lines from Earth's surface onto a plane that contacts Earth at a single point. That point may be one of the poles, as shown in Figure 8-8, or any other location. The point of contact is the center of the map. The center has very little distortion, but as you move toward the edges of the map, distortion increases. A map made by gnomonic projection can never show more than half of Earth's surface.

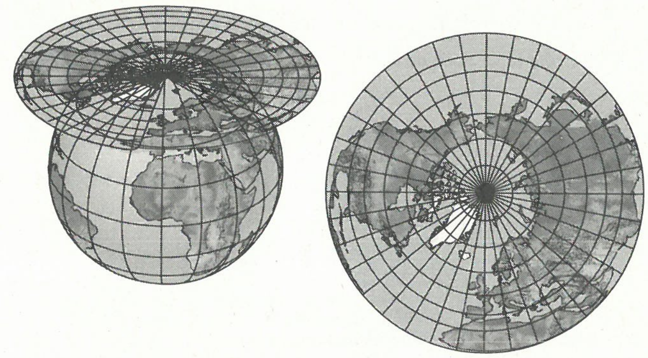


Figure 8-8 In a gnomonic projection, points and lines are transferred from Earth's surface onto a plane. The point where the plane contacts Earth is at the center of the map.

Gnomonic projections are used by navigators to plot long-distance trips by air or by sea. Navigators usually try to find the shortest route to their destination. If there are no obstacles in the way, the shortest route always lies along a great circle. A great circle is a circle that divides Earth into two equal parts. Great circles include the equator as well as any two meridians that form a complete circle, such as the prime meridian and the 180° meridian. On a map made by gnomonic projection, great circles appear as straight lines. This makes it easy for navigators to find the shortest route for their trip.

Topographic Maps

Many maps show the locations of tall mountains and deep canyons. Some maps, however, are made specifically to show elevation—the difference in height between sea level and each point on Earth's surface. Such maps are called **topographic maps.** Topographic maps are maps that show elevation through the use of contour lines.

at 50° south latitude. A line from the center of Earth to the north or south pole forms a 90° angle with the plane of the equator. Therefore, the north and south poles are located at 90° north latitude and 90° south latitude, respectively.

Latitude also can be determined with reference to certain stars. In the northern hemisphere, Polaris (the North Star) is used as the reference point. As Figure 8-2 shows, Polaris lies almost directly above Earth's north pole. Therefore, a person standing at the north pole must look straight up—at an angle of 90° above the horizon—to see Polaris. Someone standing at 50° north latitude will find Polaris 50° above the northern horizon. Thus, the latitude of any point in the northern hemisphere is the same as the angle between Polaris and the northern horizon at that point. This angle is called the altitude of Polaris. Other stars are used as reference points for latitude in the southern hemisphere.

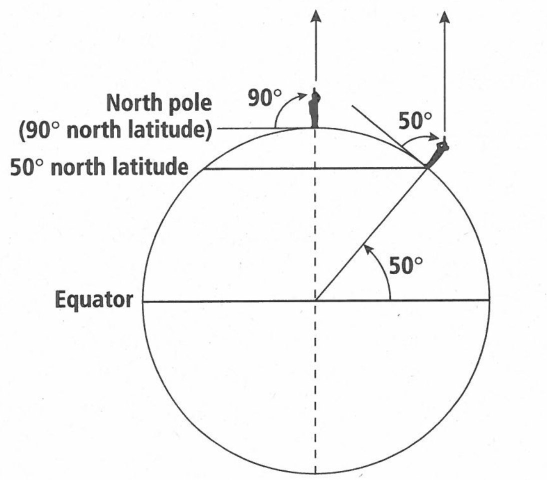


Figure 8-2 The latitude of any point in the northern hemisphere equals the angle between Polaris (the North Star) and the northern horizon.

Each degree of latitude represents about 111 km on Earth's surface. To see why, recall that Earth is almost a perfect sphere and has a circumference of about 40 000 km. A line drawn along Earth's surface from the equator to either pole would equal one-quarter of the circumference, or about 10 000 km, and cover 90° of latitude. Dividing 10 000 km by 90° gives 111 km per degree of latitude.

Longitude

Lines of latitude intersect with meridians, which are lines that span from pole to pole. The meridian that passes through Greenwich, England, is called the **prime meridian.** It serves as a reference line for **longitude,** the distance in degrees east or west of the prime meridian. The prime meridian has a longitude of 0°. Meridians are also known as lines of longitude.

The continuation of the prime meridian on the other side of Earth is the 180° meridian. These two meridians form a circle that divides Earth into the western hemisphere and the eastern hemisphere, as Figure 8-3A shows. Points in the western hemisphere have longitudes between 0° and 180° west, while points in the eastern hemisphere have longitudes between 0° and 180° east.

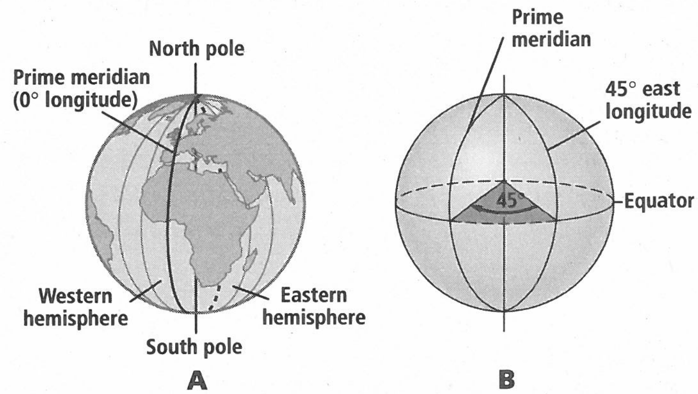


Figure 8-3 The prime meridian is the reference line for longitude. It and the 180° meridian divide Earth into the eastern and western hemispheres (A). The longitude of a point on Earth's surface equals the number of degrees in the angle between that point, the center of Earth, and the prime meridian (B).

Measuring Longitude

Figure 8-3B shows how longitude is measured. Imagine two lines that pass from the center of Earth to the surface. One line intersects with the prime meridian at the equator. The other line intersects with a point on the equator west of the prime meridian. The number of degrees in the angle between these two lines is the longitude of that point. In the example in Figure 8-3B, the angle measures 45°, so the point is located at 45° west longitude. All other points on the meridian that passes through that point are also located at 45° west longitude.

Because all meridians converge at the poles, meridians are not parallel to one another. They are farthest apart at the equator, where one degree of longitude represents about 111 km, the same as for latitude. As you move away from the equator, meridians get closer together. At a latitude of 60°, for example, each degree of longitude represents only about 56 km.

Locating Places with Coordinates

Every place on Earth's surface can be represented by a point that has a specific latitude and longitude. The latitude and longitude values are the coordinates of the location. For example, the coordinates of Madison, Wisconsin, are 43° north latitude and 89° west longitude, as Figure 8-4 shows. Coordinates are often abbreviated in this form: 43° N, 89° W. Note that latitude is always listed first in coordinates. Note also that coordinates must include a direction for both latitude (N or S) and longitude (E or W), except for points on the equator, the prime meridian, or the 180° meridian.

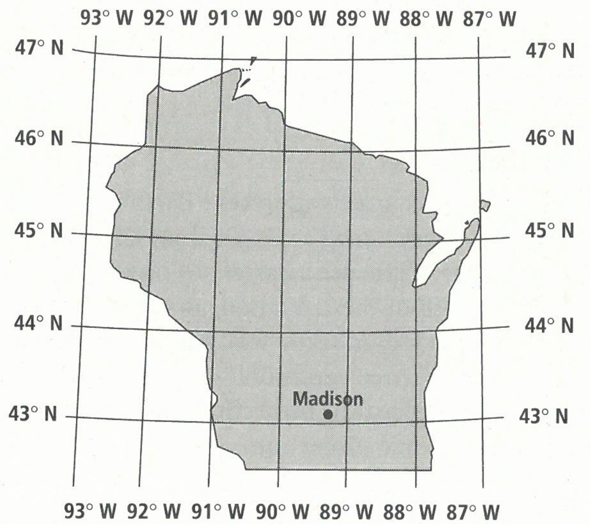


Figure 8-4 Every point on Earth's surface has a specific latitude and longitude, called coordinates. The coordinates of Madison, Wisconsin, are 43° N, 89° W.

To specify locations more precisely, cartographers divide each degree of latitude and longitude into 60 smaller units, called minutes. The symbol for a minute is ′. The more precise coordinates of Madison are 43°05′ N, 89°23′ W. For even greater precision, each minute of latitude and longitude can be further divided into 60 seconds. The symbol for a second is ″.

Relating Longitude and Time

Because Earth rotates on its axis from west to east at a constant rate, longitude and time are related. One complete rotation of Earth takes 24 hours, and one rotation equals 360° of longitude. Therefore, Earth rotates 15° every hour. This means that the Sun rises in Miami, Florida, one hour before it rises in Houston, Texas, which is 15° farther west.

As Figure 8-5 shows, Earth is divided into 24 time zones, each roughly 15° of longitude wide. The 15° width of each time zone is related to the fact that Earth rotates at a rate of 15 degrees per hour. This rotation provides a basis for local time and for Earth's 24 time zones. However, time zone boundaries do not follow meridians exactly. In many locations, the boundaries have been adjusted to follow physical features and political borders. All clocks in a time zone are set to the same time, which is generally one hour earlier than the time in the zone immediately to the east. There are six time zones in the United States.

Time in the 12 zones of the eastern hemisphere is ahead of the time at the prime meridian, which is called Greenwich Mean Time (GMT). Time in the western hemisphere's 12 zones is behind GMT. Because time changes by one hour in each time zone, there is a 24-hour difference that occurs at the 180° meridian. The 180° meridian is the basis for the **International Date Line,** an imaginary line that marks the place where each calendar day begins. People who cross the International Date Line by moving from east to west—from Alaska to Siberia, for example—must advance their calendar one day. People who cross in the opposite direction—moving from west to

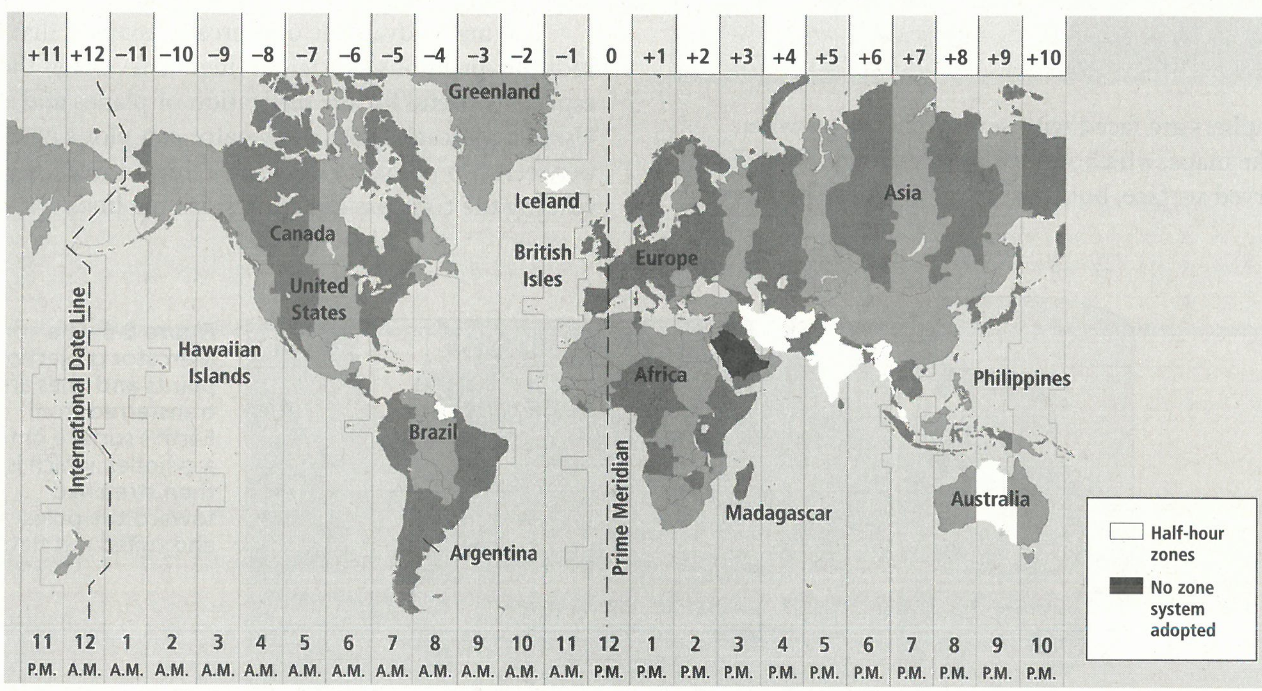


Figure 8-5 Earth is divided into 24 time zones. Each time zone represents a different hour and is roughly 15° of longitude wide.

east—must set their calendar back one day. As you can see in Figure 8-5, the International Date Line does not coincide exactly with the 180° meridian. It is bent in several places so that it does not pass through Siberia, the Aleutian Islands, or islands in the southern Pacific Ocean.

SUBTOPIC B
TYPES OF MAPS

Covers National Science Content Standards UCP.1, UCP.2, UCP.3; E.1, E.2

Unifying Concepts and Processes

UCP.1	Systems, order, and organization
UCP.2	Evidence, models, and explanation
UCP.3	Change, constancy, and measurement

Science and Technology

E.1	Abilities of technological design
E.2	Understandings about science and technology

VOCABULARY

Mercator projection	contour interval
conic projection	hachure
gnomonic projection	gradient
topographic map	profile
contour line	map legend
isoline	map scale

Cartographers are faced with several challenges when they make maps, which model Earth's surface. First, Earth has a curved surface, but most maps are flat. Therefore, cartographers must find a way to make flat maps show the spatial relationship of places on Earth's surface. Second, some flat maps must also show how the elevation of landforms (valleys, hills, and mountains) varies over a given area. Finally, some maps must indicate where specific features, such as cities, highways, and political boundaries, are located and how far apart they are.

Map Projections

A flat map cannot accurately represent Earth's curved surface except over very small areas. To show large areas on a flat map, cartographers use a variety of methods called map projections. All of these methods distort the representation of Earth's surface in some way, but each method has certain advantages. Three commonly used types of map projections are the Mercator projection, the conic projection, and the gnomonic projection.

Mercator Projection

A **Mercator projection** is made by transferring points and lines from Earth's surface onto a cylinder and then stretching the cylinder toward the poles. When the cylinder is slit along a meridian and rolled out, it produces a flat map like that shown in Figure 8-6. Maps drawn by Mercator projection have parallel lines of latitude, like those on Earth's surface. However, these maps show lines of latitude near the equator as being closer together than those near the poles. They also show meridians as parallel lines that do not converge at the poles. As a result, the areas of landmasses are greatly distorted near the poles. For example, Greenland appears much larger than Australia on a Mercator map. In reality, Australia is more than three times as large as Greenland.

The main advantage of Mercator maps is that they indicate directions as straight lines. This makes these maps especially useful for the navigation of planes and ships. Using a Mercator map, a navigator can plot a course between two points by drawing a line between them and reading the compass direction from the line.

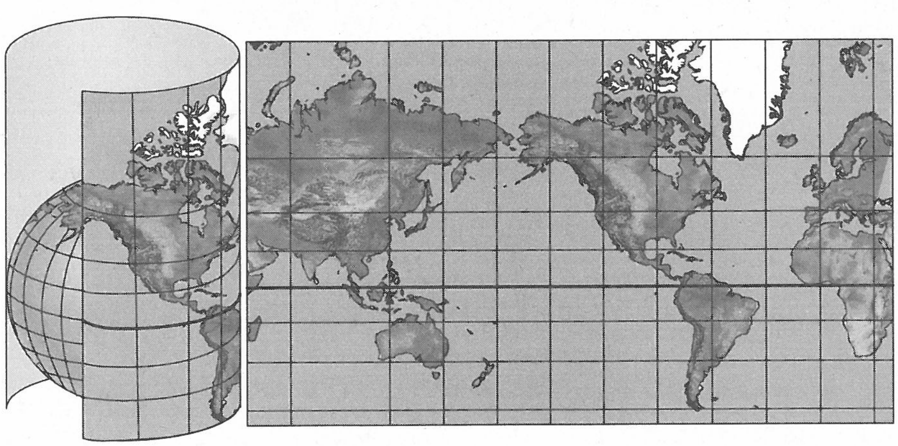
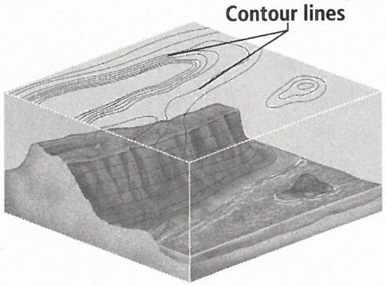


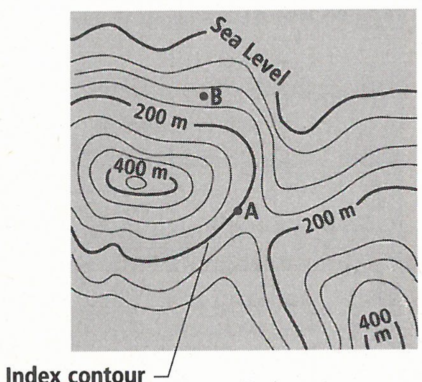
Figure 8-6 In a Mercator projection, points and lines are transferred from Earth's surface onto a cylinder, which is then stretched toward the poles and rolled out flat.

Contour Lines and Contour Intervals

As Figure 8-9A shows, points of equal elevation on a topographic map are connected by a line known as a **contour line.** Contour lines are a type of **isoline** (iso = equal), which is a line that connects points that have the same value. You may already have read about other types of isolines used on weather maps to show how air temperature or atmospheric pressure varies over an area. Like all isolines, contour lines never cross. If they did, it would mean that the point where the lines crossed had two elevations. On a topographic map, contour lines that cross a stream form a V shape that is pointed upstream.



A



B

Figure 8-9 On a topographic map, points of equal elevation are connected to form contour lines (A). Certain contour lines, called index contours, are labeled with the elevation they represent (B).

Not every elevation on a topographic map is represented by a contour line. Instead, cartographers draw contour lines only for elevations that differ by a set distance. This distance is called the **contour interval.** In Figure 8-9B, for example, the contour interval is 50 m, and contour lines are drawn to mark sea level, 50 m above sea level, 100 m above sea level, and so on. On this map, the elevation of point A is 200 m, and the elevation of point B can be estimated to be 125 m. On most topographic maps, every fourth or fifth contour line is thicker than the others and is labeled with the elevation it represents. Such a contour line is known as an index contour.

You can use index contours to calculate the contour interval on a topographic map. First, pick two index contours and subtract their elevations. Then divide the difference in elevation by the number of contour lines you touch when going from one index contour to the other. In Figure 8-9B, for example, you would touch four contour lines when going from the index contour at sea level (0 m) to the one at 200 m, so the contour interval equals (200 m − 0 m) ÷ 4, or 50 m.

Local depressions, such as dry lake beds and volcanic craters, are indicated on topographic maps by contour lines that have hachures. As Figure 8-10 shows, **hachures** are short lines that point from a contour line toward lower elevations. Hachures let you tell quickly that an area on a map represents a depression rather than a hill or mountain.

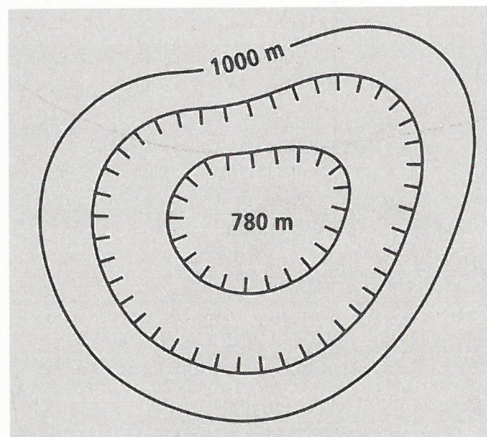


Figure 8-10 Hachures on a contour line point toward lower elevations.

Gradients

The steepness of terrain varies in different areas. Canyon walls are steeper than the sides of low hills. Another word for steepness is **gradient,** the change in elevation for a given change in horizontal distance. The equation for gradient can be found on the first page of the *Earth Science Tables and Charts.* Suppose you travel 10 km along a straight road that starts at an elevation of 200 m and ends at an elevation of 800 m. That road has an average gradient of 600 m over 10 km, or 60 m/km.

There are two methods for determining gradient using a topographic map. The first is to look at the spacing between the contour lines. In an area where the contour lines are very close together, there is a large change in elevation over a very small horizontal distance, so the gradient is large. Conversely, an area where the contour lines are far apart has a small gradient. You can see this relationship if you compare the map in Figure 8-9A with the diagram of the landform it represents.

The other method for determining gradients involves using the equation for gradient given on the first page of the *Earth Science Tables and Charts.* Pick two points on the map and read the contour lines to find the difference in elevation (referred to as "change in field value" in the *Earth Science Tables and Charts*) between the points. Then use a ruler to measure the horizontal distance between the points. Convert this map distance to actual distance—the distance between points on Earth's surface—by referring to the map scale, which is discussed at the end of this topic. Finally, divide the elevation difference by the actual distance to obtain the gradient.

Profiles

Imagine slicing through the landscape in an area. The slice would give you a side view of the land like that shown on the left side of Figure 8-9A. If you then traced the surface of the land along the slice, you would produce a profile of the topography, or physical features of the landscape. A **profile** is a graph showing how elevation changes along a straight line between two points. Unlike a gradient, which measures the average steepness of the terrain between two points, a profile reveals all of the rises and falls in elevation between the points. Figure 8-11 shows how to construct a profile from a topographic map.

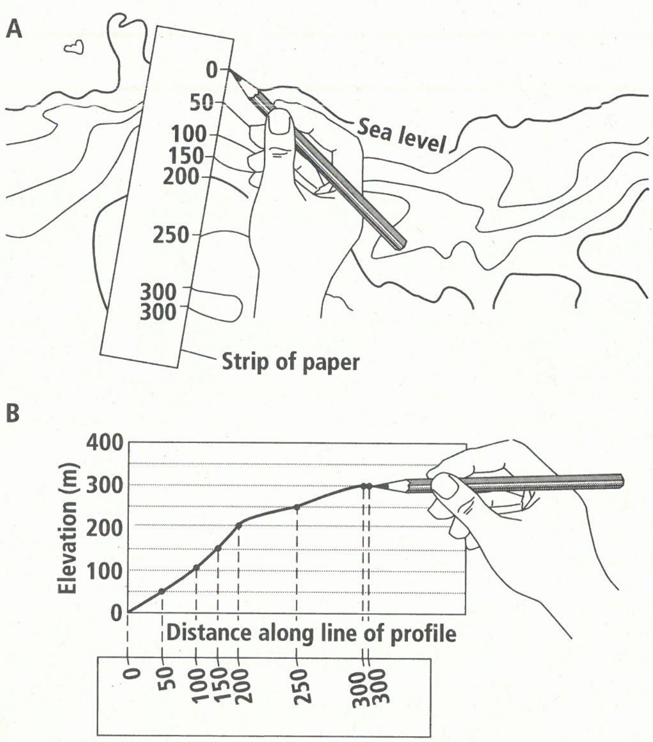


Figure 8-11 To construct a profile from a topographic map, place a strip of paper with a straight edge along a line between two points on the map. Make a mark on the edge of the paper wherever the edge crosses a contour line. Label each mark with its elevation (A). Lay the paper along the bottom of a sheet of lined paper, and draw a dot directly above each mark at the line corresponding to that altitude. Connect the dots with a smooth line (B).

Map Legends and Map Scales

Cartographers use a variety of symbols to identify the natural and human-made features that are represented on their maps. The meaning of some symbols is fairly obvious. For example, small drawings of airplanes and tents are often used to mark the locations of airports and campgrounds, respectively. It may be harder to guess the meaning of other symbols, however. Cartographers overcome this problem by including a **map legend,** a list of all symbols on the map and what they mean. An example of a map legend is shown in Figure 8-12. Map legends, which are sometimes called map keys, are usually placed near one of the corners of a map.

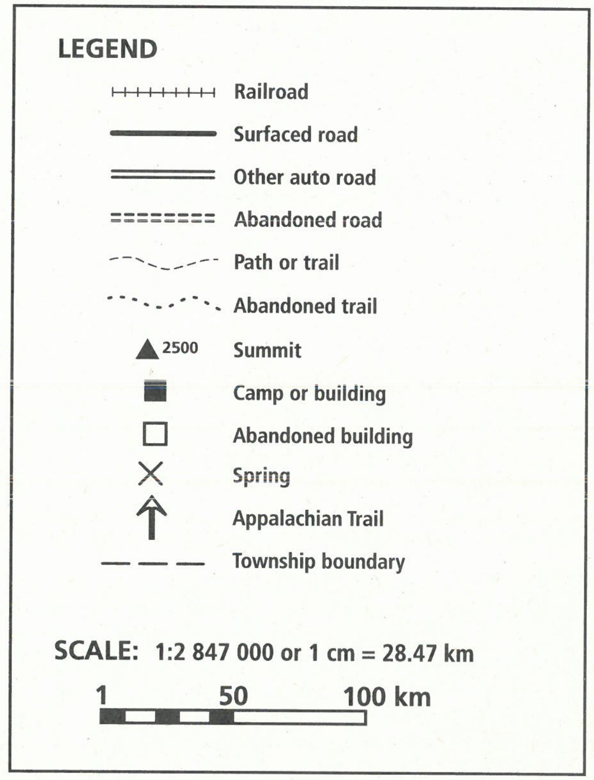


Figure 8-12 A map legend explains the meaning of the symbols on a map. Map scales show the relationship of distances on a map to distances on the surface of Earth.

A map is a reduced representation of Earth's surface, so distances on the map are much smaller than the actual distances they represent. To know how much smaller the distances on a map are requires a map scale. A **map scale** expresses the relationship between distances on a map and actual distances on the surface of Earth. There are three types of map scales: verbal, graphic, and fractional. All are illustrated at the bottom of the map legend in Figure 8-12.

A verbal scale is a statement, such as "one centimeter equals one kilometer" or "1 inch = 45 miles." The smaller distance (1 cm) on the map represents the larger distance (1 km) on Earth's surface.

A graphic scale, as shown in Figure 8-12, is a line that indicates a certain distance on Earth's surface, such as 50 km or 100 miles. To use a graphic scale, you compare the distance between two points on the map with the length of the scale. For example, a distance that is half as long as a 50-km graphic scale would represent 25 km on Earth's surface. Graphic scales are usually divided into segments, which make it easier to estimate smaller distances.

A fractional scale is a ratio, such as 1/500 000 or 1:100 000. The ratio means that one unit of distance on the map represents the second number of the same units on Earth's surface. For example, 1 cm on the map whose scale is depicted in Figure 8-12 represents 2 847 000 cm, or 28.47 km, on Earth's surface. A map with a large fractional scale, such as 1:1 000 000, covers a larger area and therefore shows less detail than a map with a small fractional scale, such as 1:1000.

QUESTIONS FOR SUBTOPIC A

Type A

Some questions may require the use of the *Earth Science Tables and Charts.*

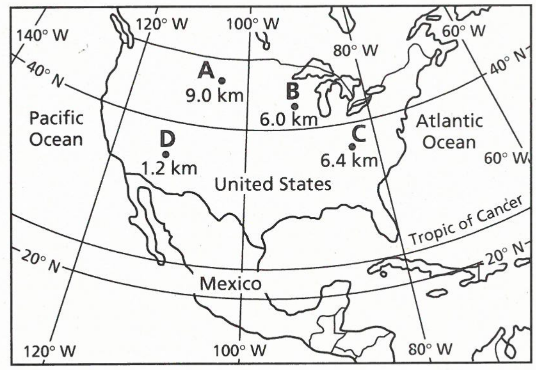
1. Which of the following lines does *not* pass through the north and south poles?
- **a.** prime meridian
- **b.** equator
- **c.** 90° west longitude
- **d.** International Date Line

2. An observer in Missouri finds the star Polaris 38° above the northern horizon. The observer is located at
- **a.** 38° north latitude.
- **b.** 38° west latitude.
- **c.** 38° east longitude.
- **d.** 38° west longitude.

3. As you move away from the equator, meridians
- **a.** remain separated by the same distance.
- **b.** get closer together.
- **c.** get farther apart.
- **d.** gradually become parallel.

4. Which coordinates represent a location on the continent of South America?
- **a.** 20° N, 60° W
- **b.** 20° N, 60° E
- **c.** 20° S, 60° W
- **d.** 20° S, 60° E

5. The map below shows the location and diameter, in kilometers, of four meteorite impact craters, A, B, C, and D.



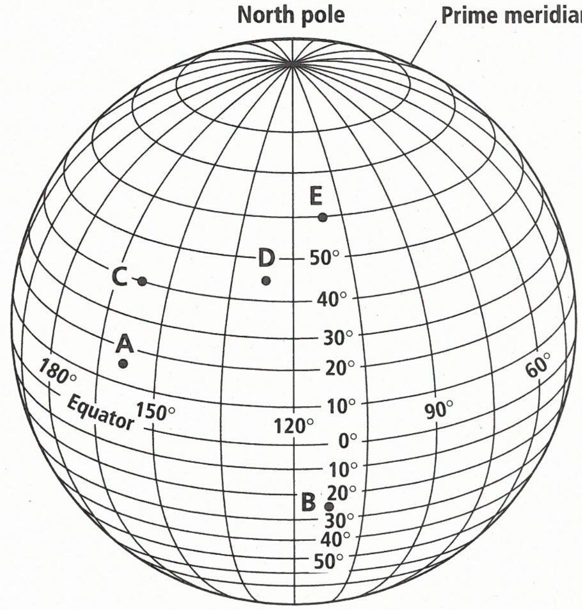
What is the approximate latitude and longitude of the largest crater?
- **a.** 35° N, 111° W
- **b.** 39° N, 83° W
- **c.** 44° N, 90° W
- **d.** 47° N, 104° W

6. The width of each time zone is roughly
- **a.** 15° of latitude.
- **b.** 24° of latitude.
- **c.** 15° of longitude.
- **d.** 24° of longitude.

7. When you cross the International Date Line from west to east, you must set your calendar
- **a.** back two days.
- **b.** back one day.
- **c.** ahead two days.
- **d.** ahead one day.

Type B

Base your answers to questions 8–10 on the next page on the diagram of Earth below.



8. What is the approximate latitude and longitude of location A?
   a. 160° N, 15° E
   b. 160° S, 15° W
   c. 15° N, 160° E
   d. 15° N, 160° W
9. When the local time at location C is 3 P.M., the local time at location D is likely to be
   a. 1 P.M.
   b. 3 P.M.
   c. 5 P.M.
   d. 3 P.M.
10. At which location would a person be unable to determine latitude by measuring the altitude of Polaris?
   a. A
   b. B
   c. C
   d. D
11. At what angle relative to the horizon does Polaris appear to an observer standing at the equator?
   a. 0°
   b. 45°
   c. 60°
   d. 90°

Base your answers to questions 12 and 13 on the table below.

Coordinates of Selected Cities

City	Coordinates
Johannesburg	26°08′ S, 27°54′ E
New York City	40°40′ N, 73°58′ W
Oslo	59°56′ N, 10°41′ E
Rio de Janeiro	22°50′ S, 43°20′ W
Sydney	33°55′ S, 151°17′ E
Tokyo	35°41′ N, 139°44′ E

12. List the cities in order of increasing distance from the equator.
13. List the cities in order of increasing distance, in degrees, from the prime meridian.

Type C

Base your answers to questions 14 and 15 on the newspaper article below.

Oil Tanker Runs Aground near Galápagos Islands

A tanker carrying more than a quarter million gallons of oil ran aground in shallow waters near the Galápagos Islands on January 16, releasing a portion of its cargo into the Pacific Ocean. An official for the company that owns the ship said it was impossible to determine at present how much oil was released.

He blamed navigational error for the accident, which occurred on the equator at 90° west longitude. Isabela Island, the largest of the Galápagos Islands, has coordinates of 0°, 92° W.

The oil spill could pose a threat to the fragile environment of the Galápagos Islands, which are populated by many species found nowhere else in the world. Organizers of the cleanup effort said there is a chance that winds and currents will carry the spilled oil away from the islands, avoiding a major environmental catastrophe.

14. If the winds and currents move from east to west, are they likely to carry the spilled oil toward or away from Isabela Island?
15. If all the oil evaporates or sinks within 150 km of the site of the accident, will the oil spill have a chance of reaching Isabela Island?

Base your answers to questions 16 and 17 on the table below.

Characteristics of Neptune

Circumference	155 000 km
Period of rotation about axis	16 hours

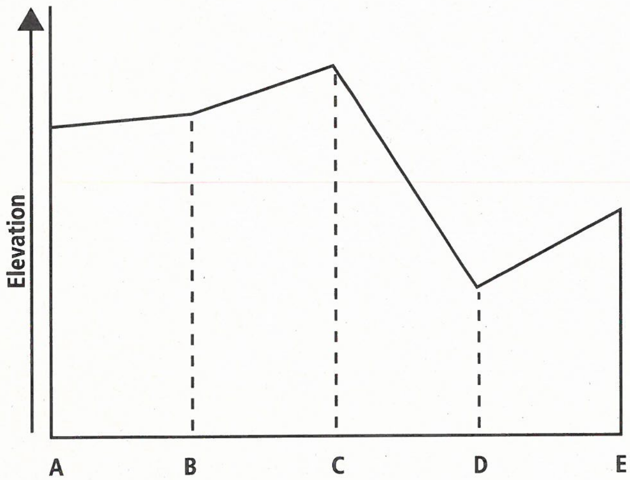
16. If Neptune had a grid of latitude and longitude lines like those on Earth, how many kilometers would each degree of latitude represent on Neptune?
17. If Neptune was divided into one-hour time zones, how many degrees of longitude would each time zone cover?

QUESTIONS FOR SUBTOPIC B

Type A

18. On a topographic map, contour lines that are far apart indicate
- **a.** stable weather conditions.
- **b.** a slow change in atmospheric pressure.
- **c.** a gradual change in elevation.
- **d.** an abrupt change in elevation.

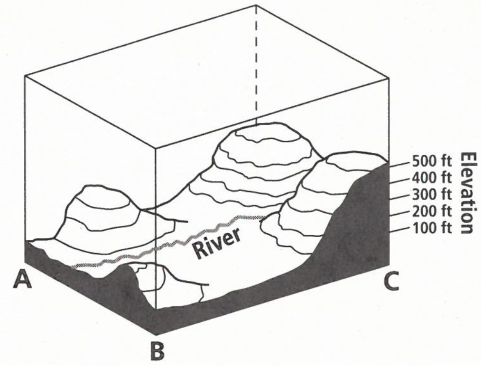
The profile below was constructed from a line passing through five points, A, B, C, D, and E, on a topographic map.



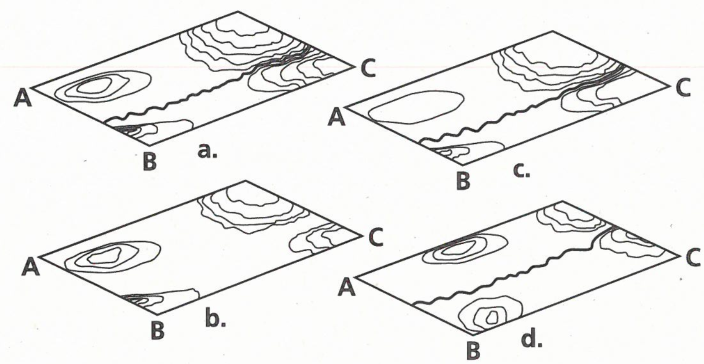
19. Which portion of the profile represents the terrain that has the largest gradient?
- **a.** between A and B
- **b.** between B and C
- **c.** between C and D
- **d.** between D and E

20. Which characteristics of Earth's surface can be determined by using a topographic map?
- **a.** hill slope and stream gradients
- **b.** bedrock erosion and stream velocity
- **c.** hilltop elevations and bedrock age
- **d.** soil thickness and benchmark movement

21. The diagram below is a three-dimensional model of a landscape region.



Which map view best represents the topography of this region?



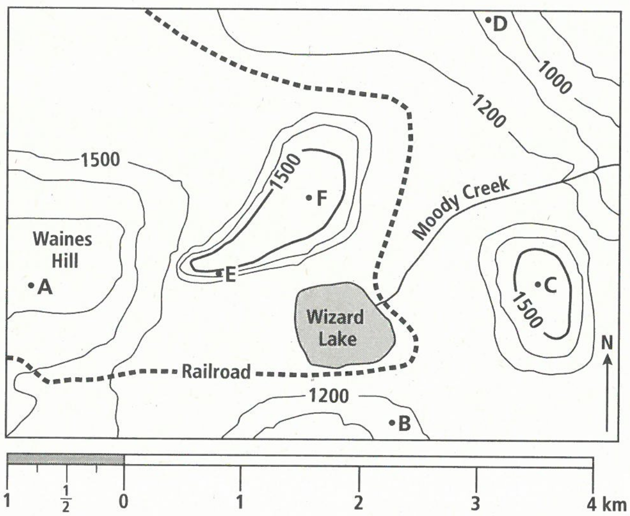
22. Hachures are used on topographic maps to show the locations of
- **a.** railroad tracks.
- **b.** depressions.
- **c.** rivers and streams.
- **d.** lakes.

23. Point A and point B are locations 0.24 mile apart on a ski slope in Colorado. Point A has an elevation of 1560 feet, and point B has an elevation of 1800 feet. What is the gradient between these points?
- **a.** 60 ft/mi
- **b.** 240 ft/mi
- **c.** 500 ft/mi
- **d.** 1000 ft/mi

24. Point X and point Y are 1.7 cm apart on a map. The scale of the map is 1:10 000. How far apart are the locations that X and Y represent on Earth's surface?
- **a.** 0.17 km
- **b.** 1.7 km
- **c.** 170 km
- **d.** 17 000 km

Type B

Base your answers to questions 25–29 on the topographic map below. Elevations shown on the map are in meters.



25. What is the contour interval of this map?

a. 10 m **c.** 100 m
b. 50 m **d.** 150 m

26. Which of the following locations has the lowest elevation?

a. A **c.** D
b. C **d.** E

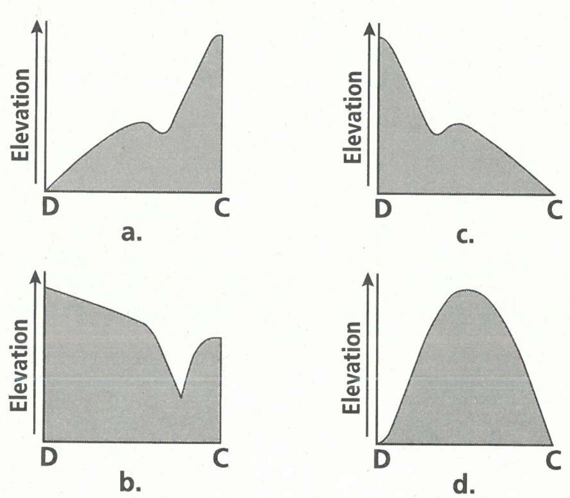
27. Which of the following points is located on the steepest slope?

a. A **c.** D
b. B **d.** E

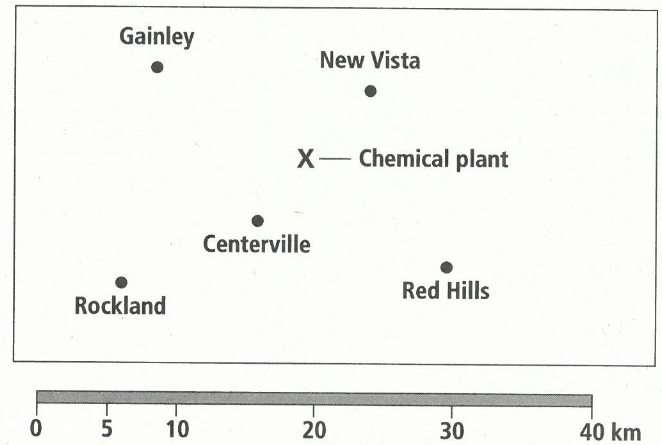
28. What is the approximate length of the railroad tracks shown on the map?

a. 4 km **c.** 12 km
b. 8 km **d.** 15 km

29. Which diagram best represents the profile along a straight line from point D to point C?



30. The map below shows the locations of several communities in the vicinity of a chemical manufacturing plant. Operators of the plant are required to notify all communities within 10 km of the plant if an accident at the plant releases chemicals.

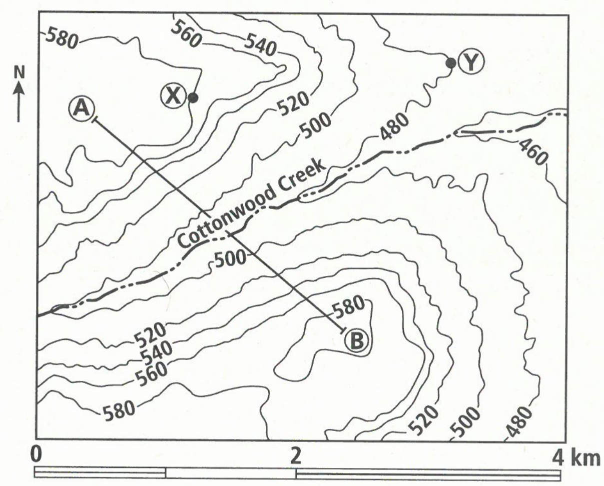


Which communities will have to be notified in the event of an accident at the chemical plant?

Type C

Some questions may require the use of the *Earth Science Tables and Charts.*

Base your answers to questions 31–34 on the topographic map shown below.



Contour interval = 20 meters

31. State the highest possible elevation, to the nearest meter, for point B on the map.

32. State the general direction in which Cottonwood Creek is flowing.

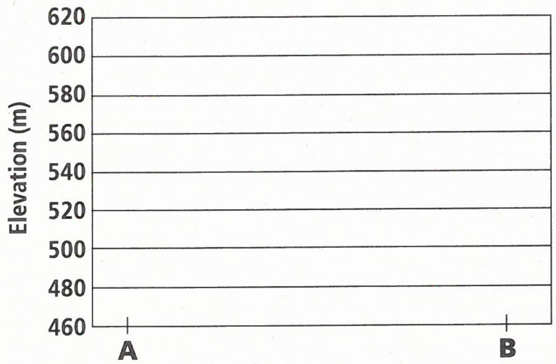
33. Follow the directions below to calculate the gradient between points X and Y on the map.

a Write the equation for gradient.

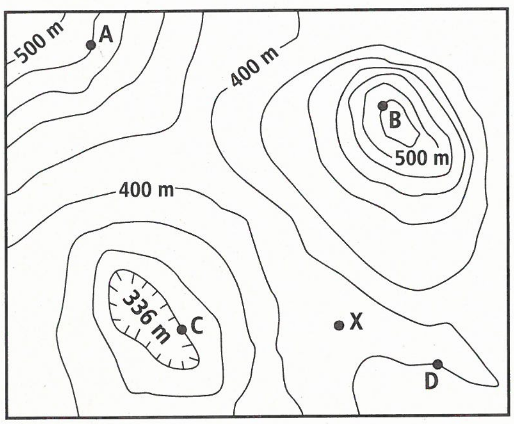
b Substitute data from the map into the equation.

c Calculate the gradient and label it with the proper units.

34. In the space below, draw a profile of the topography along line AB shown on the map in the second column on page 177.



35. The topographic map below shows the proposed location of a sewage treatment plant, which is marked by X on the map.



If there is a sewage spill at the plant, which of the other labeled points on the map is most likely to be affected by the spill?