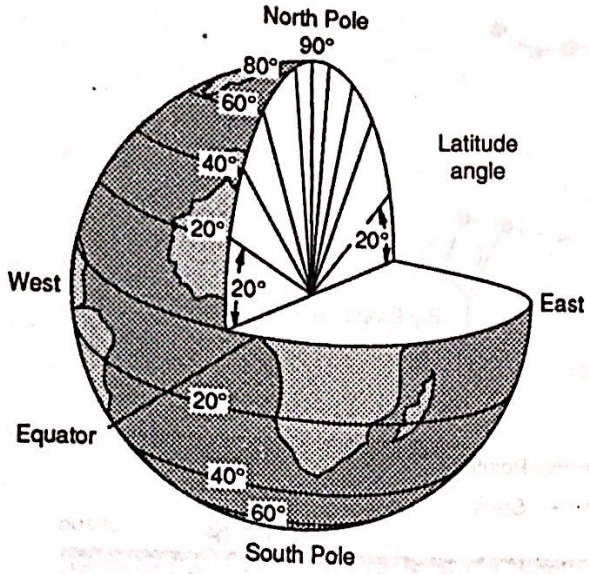


Figure 1-4. Latitude is the angular distance north or south of the equator.

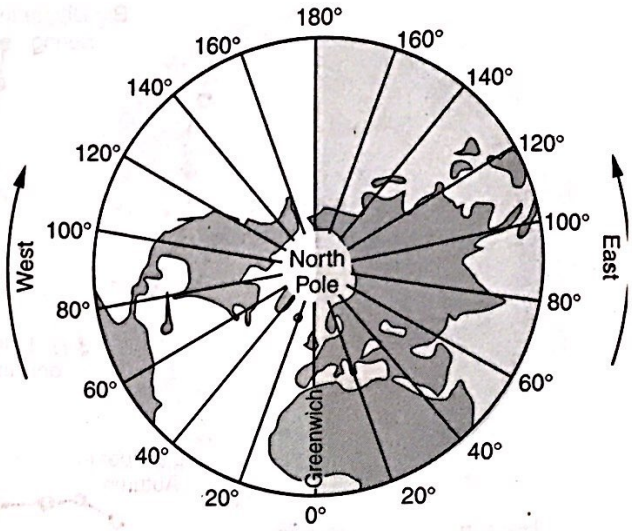


Figure 1-6. Earth is divided into the Eastern and Western hemispheres by the prime meridian and the 180° meridian. In this diagram, you are looking down from a position high above the North Pole.

world that is west of the prime meridian has west longitude. The half of the world that is east of the prime meridian has east longitude as illustrated in Figure 1-6. The Eastern and Western Hemispheres meet at 180° longitude. The International Date Line generally follows the 180° line of longitude.

Many students think of latitude as lines that circle Earth, parallel to the equator and longitude as lines that circle north and south. In this course, however, you will need a deeper understanding. Remember that latitude is the angle north or south of the equator, and longitude is the angle east or west of the prime meridian. Terrestrial coordinates are actually angles, not lines.

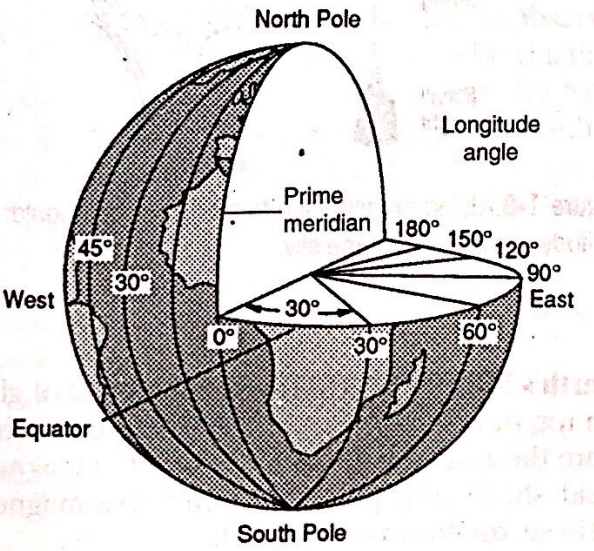


Figure 1-5. Longitude is the angular distance east or west of the prime meridian.

Terrestrial Navigation

Navigation is the science of identifying your position on Earth. The identity of any location can be expressed as the measure of the angle north or south of the equator (latitude) and the measure of the angle east or west of the prime meridian (longitude). In other words, each place on Earth has its own unique coordinates of latitude and longitude. The latitude of any location north of the equator is basically equal to the angle of Polaris (altitude of the North Star) above the horizon. For example, the latitude of New York City's is 41°N, so the angle of Polaris above the horizon at New York City is 41°.

To find Polaris in the night sky, look for the Big Dipper. If you have a clear northern horizon, the Big Dipper will always be visible in the northern part of the sky. However, at times it may be tipped on its side or upside down. Figure 1-7 on page 22 illustrates how to locate Polaris in the Northern sky. The two stars at the end of the bowl of the dipper are known as the pointer stars. A line connecting the pointer stars always points to Polaris, no matter where the Big Dipper is in the sky. There are many stars brighter than Polaris.

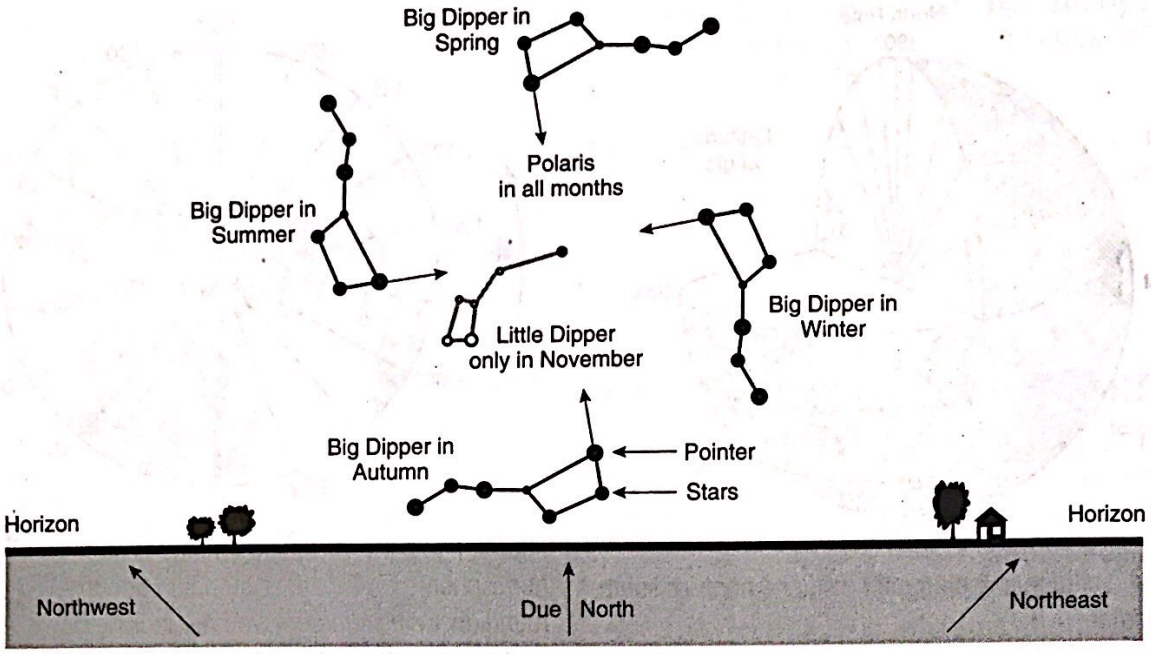


Figure 1-7. The easiest way to find Polaris is to locate the Big Dipper and follow the pointer stars at the end of the bowl as they point toward Polaris. This diagram shows the way the Big Dipper looks in the evening sky at the middle of each season. The Little Dipper also rotates around Polaris, but it is shown only in its autumn position.

However, it is one of the brighter stars in the Little Dipper, which seems to rotate around Polaris with the Big Dipper. Polaris is located at the end of the handle of the Little Dipper. You can use Figure 1-7 to help find the North Star in the night sky. You will probably need to look an hour or more after sunset from a dark location with a good view of the northern sky.

People living in the Northern Hemisphere are fortunate to have a bright star located almost exactly above Earth's North Pole. Residents of the Southern Hemisphere, however, are not as fortunate. They must use a number of stars to locate the South celestial Pole.

Finding the Altitude of a Star With an Astrolabe The **altitude** of an object in the sky is its angular height above the observer's horizon. The altitude of Polaris can be measured using an astrolabe. You can construct your own astrolabe by suspending a weight from a protractor as you see in Figure 1-8.

When you sight any star along the edge of the astrolabe, the weight hangs straight down toward Earth's center, or center of mass. Therefore, the string's position on the protractor indicates the angle of the star above the horizon.

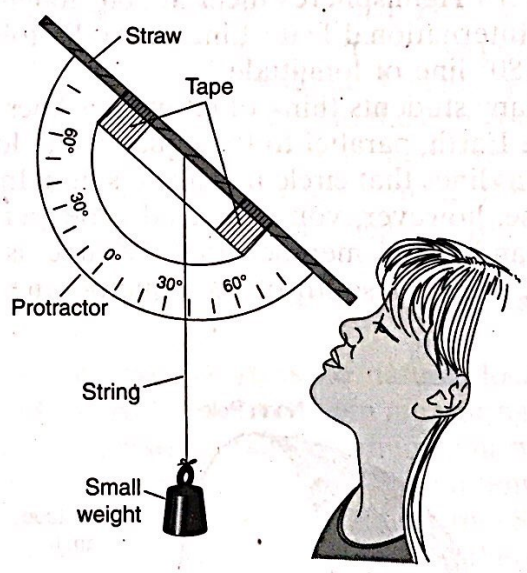


Figure 1-8. Using an astrolabe to measure the angular altitude of an object in the sky.

Earth's Magnetic Field If you lay a sheet of glass on top of a bar magnet and sprinkle iron filings onto the glass, the filings align with the magnetic field, showing its pattern. An invisible magnetic field surrounds every magnet.

Earth itself has a magnetic field that lines up within about 12° of Earth's spin axis. In that way,

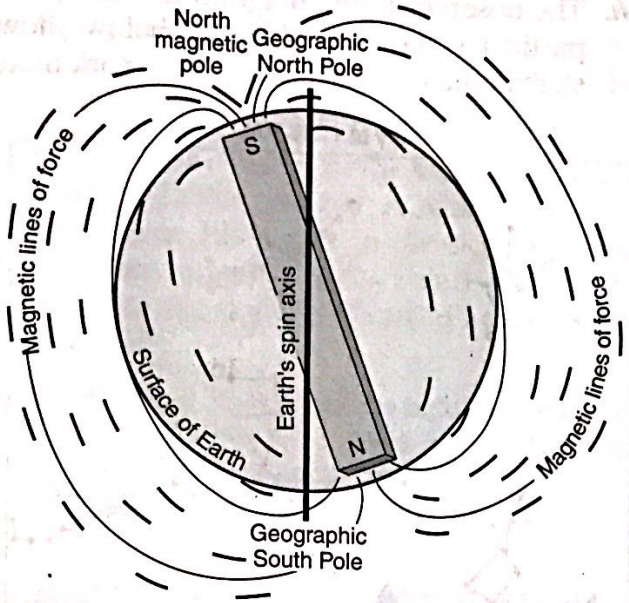


Figure 1-9. Our planet has a magnetic field. It is as if a giant bar magnet were at Earth's core. The magnet's north and south poles are reversed because the north-pointing end of a compass needle points to geographic north. (Opposite poles attract.)

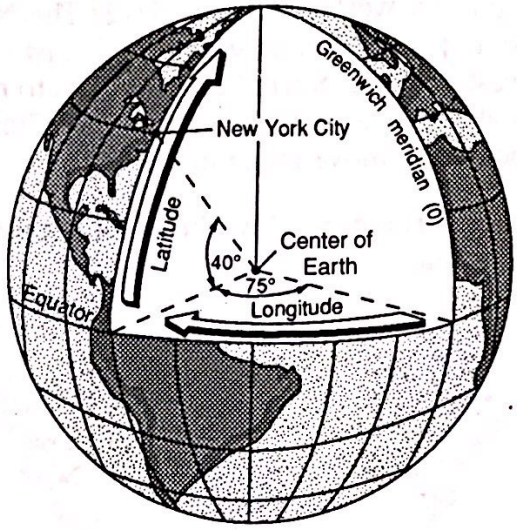


Figure 1-10. The parallels of latitude and the meridians of longitude allow us to locate positions. The position of New York City (approximate latitude 40°N, longitude 74°W) is illustrated here.

it is like Earth has an imaginary gigantic bar magnet at its core, as shown in Figure 1-9. The needle of a magnetic compass points toward the magnetic pole that is located relatively close to Earth's geographic North Pole. (You may recall that the geographic pole is where Earth's spin axis intercepts Earth's surface.) A magnetic compass is a convenient way to find directions if clouds cover the sun and stars.

Time Our system of time is based on observations of the sun. Noon can be defined as the time the sun reaches its highest point in the sky. Note that for all locations in the continental United States the noon sun is never directly overhead. For us in the Northern Hemisphere, it is always in the southern half of the sky. The day is divided into 24 divisions called hours. Each hour is further divided into 60 minutes, with each minute divided into 60 seconds.

You can calculate your approximate longitude if you know the present time along the prime meridian at Greenwich (**Greenwich Mean Time**) and your local time. (Greenwich is a suburb of London, England, where observations were made to establish the prime meridian.) To find longitude, you must first find the time difference, in hours, between local time and Greenwich time. This time difference multiplied by 15° per hour equals your longitude. (The rate at which the sun appears to move from east to west is 15° per hour.) If local time is earlier than Greenwich time, your position is west of the prime meridian or west longitude. If local time is later than Greenwich time, your position is east of the prime meridian or east longitude.

For example, there is a time difference of 5 hours between the time in Greenwich, which is located at 0° longitude, and the time in New York City. Multiplying 15° by 5 (hours), you get a difference of 75° of longitude. The fact that New York time is 5 hours earlier than Greenwich time indicates that New York is west of Greenwich. Therefore, the longitude of New York is approximately 75° west. See Figure 1-10.

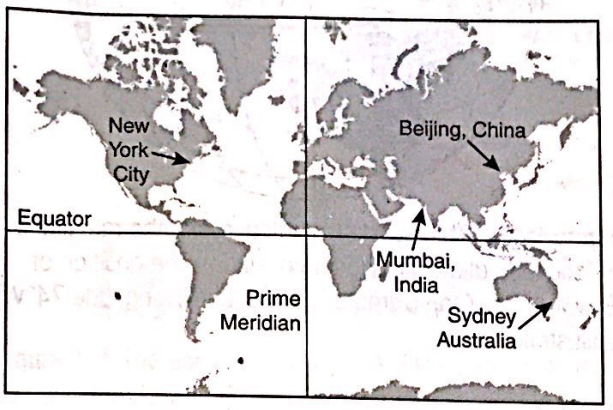
QUESTIONS

Part A

12. On a clear night, Ruby traveled from New York City 120 miles north to Albany, New York. She made observations of the North Star every 30 miles. How did the position of the North Star appear to change during her trip? (1) The North Star appeared to move

from the west to the east. (2) The North Star appeared to move from the east to the west. (3)The North Star appeared to move higher in the sky. (4) The North Star appeared to move lower in the sky.

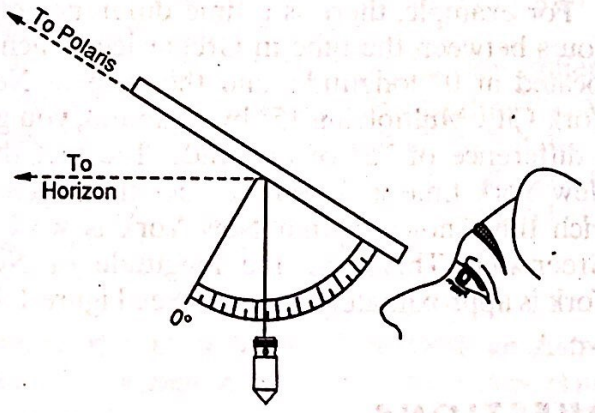
13. The world map below shows the location of four major cities.



Polaris is never visible for observers in

(1) New York City (3) Beijing, China
(2) Mumbai, India (4) Sydney, Australia

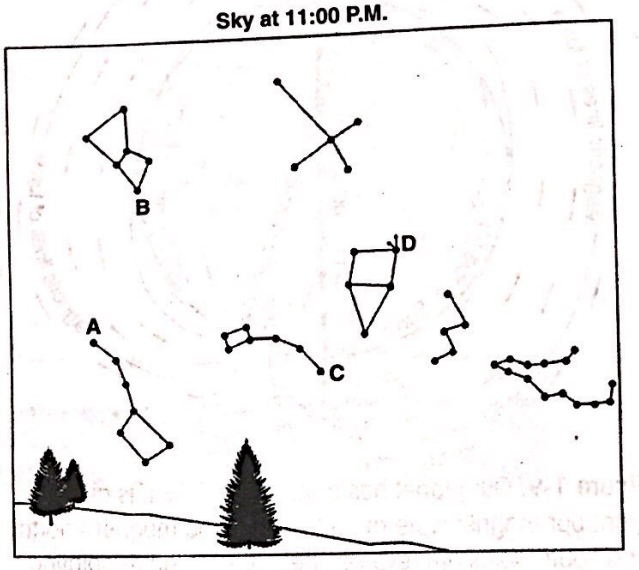
Base your answers to questions 14 through 16 on the picture below, which shows a person using an astrolabe.



14. What is the position of the person? (1) 34° west longitude 2) 60° west longitude (3) 34° north latitude (4) 60° north latitude

15. The person in this diagram is making an observation to find his angular distance along Earth's surface from (1) the equator (2) the Prime Meridian (3) Polaris (4) the North Star

16. The observer in the diagram is looking at a particular star. The diagram below shows stars in the northern sky in New York State.

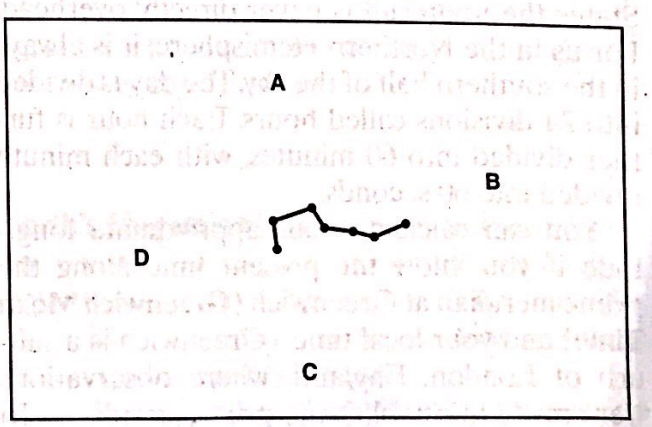


At which star on the figure above is this observer looking? (1) *A* (2) *B* (3) *C* (4) *D*

17. A compass used to find directions on Earth's surface does not point northward in some locations. Where would this problem most likely occur? (1) over a geologic deposit of magnetic iron (2) where strong winds always blow from the same direction (3) a region that has not been explored and mapped (4) at the South Pole

18. What is the longitude of the Yellowstone Hot Spot? (Hint: Use the *Earth Science Reference Tables*.) (1) 120° east (2) 120° west (3) 45° north (4) 45° south

19. The diagram below shows the Big Dipper in the evening in spring. What is the correct position of Polaris?



(1) *A* (2) *B* (3) *C* (4) *D*

20. On a clear night, observers in Albany, New York, and Buffalo, New York, attempt to measure the altitude of Polaris. How do their observations compare?

(1) They see Polaris at the same angular altitude. (2) The observer in Albany sees Polaris about 10° higher in the sky (3) The observer in Buffalo sees Polaris about 10° higher in the sky. (4) Polaris is never visible in Buffalo.

21. Which New York location below would see the sun rise earlier in the morning than the other three locations? (1) Watertown (2) Albany (3) Elmira (4) Buffalo

Part B

22. The antipode of any location on Earth is the point on the opposite side of the planet. So the antipode of New York City is in the Indian Ocean off Perth, Western Australia. What are the terrestrial coordinates of this Indian Ocean location? (1) 41° north, 74° west (2) 41° north, 74° east (3) 41° south, 74° west (4) 41° south, 74° east

23. London, England, is on the prime meridian. Massena, New York, is located at approximately 45° north latitude, 75° west longitude. If it is noon in London, what time is it in Massena? (1) 7 A.M (2) 9 A.M (3) 3 P.M (4) 5 P.M.

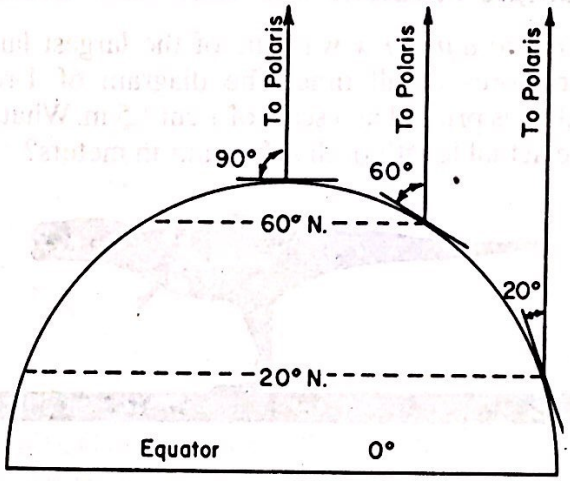
24. At which location would Polaris be visible on the horizon? (1) North Pole (2) New York State (3) equator (4) South Pole

25. Longitude is best determined experimentally by (1) observations of the North Star (2) comparing local times (3) recording times of sunrise (4) using a magnetic compass

26. New York City is at 41° north latitude, 74° west longitude. Osomo is a city in Chile (South America) that is located at approximately 41° south latitude, 74° west longitude. At New York City and Osomo (1) Polaris is at the same angle above the horizon. (2) The calendars are six months apart. (3) The time is the same. (4) The moon is never visible at the same time.

27. St. Louis, Missouri, is 90° west. Calcutta, India is 90° east. When the sun is just setting in St. Louis, in Calcutta (1) it is midnight (2) the sun is just rising (3) it is noon (4) the sun is also setting.

28. The diagram below indicates the altitude of Polaris as measured at three locations on Earth's Northern Hemisphere.



These observations could lead to the inference that Earth (1) rotates 15° per hour (2) has an elliptical orbit (3) has a curved surface (4) revolves around the sun

USING SCALE

Physical models are usually made to **scale**. That is, the dimensions of the real object are related to the model by a specific ratio. A scale is usually based on linear measurement. For example, a one-to-eight (1:8) model of a truck would mean that the real vehicle is 8 times longer than the scale model. So the model would probably be about 1 meter long, because the truck is about 8 meters long.

The United States Geological Survey (USGS) publishes maps at many scales, but the 1:24 000 maps are popular with hikers and others who enjoy the outdoors. So places about 240 m (24,000 cm) apart would be 1 cm apart on the map. If no scale is specified for a particular model, sometimes it can be determined by making measurements of length on the model and the length of the object.

Some models are smaller than the real object, for example a road map. Others are larger,