Latitude, Longitude, and Time Zone

Overview:

A coordinate system of lines known as latitude and longitude is used to locate any position on the Earth. Latitude lines are measured in degrees north or south from the equator. Longitude lines are measured in degrees east or west from the Prime Meridian. Each degree of latitude or longitude is subdivided into smaller units of minutes (') and seconds ("). Exact location of any position on Earth can be established once these coordinates are known. Latitude and longitude numbers are found on three maps within the reference tables.

Latitude:

Latitude lines are parallel to the equator and are frequently referred to as parallels. The longest of all latitude lines is the equator. It separates the Northern and Southern Hemispheres. At the poles, the latitude line is just an imaginary point. Degrees of latitude range from 0° at the equator to 90° at the poles. The uppermost northern border of New York State is halfway between the equator and the North Pole. Thus its latitude is 45° N (see the Generalized Bedrock Geology of NYS map – above Massena, page 53).

Latitude and the Angle of Polaris – Polaris, the North Star, is positioned almost directly over the North Pole. Due to this location, the latitude of any position in the Northern Hemisphere can be found by measuring the altitude (height) of Polaris above the northern horizon. An observer positioned at the North Pole would therefore view Polaris directly overhead, being 90° above the horizon, which is the latitude of the North Pole. At the equator, Polaris would be positioned on the horizon, having an altitude of 0°, which is the latitude of the equator. From these examples, it can be seen that, in the Northern Hemisphere, as one travels northward, the angle of Polaris would increase to a maximum of 90° at the North Pole. If one were to travel southward, the angle of Polaris would decrease to 0° at the equator. As one travels from the Northern Hemisphere to the Southern Hemisphere (crossing the equator), Polaris would disappear as it dips below the horizon.

Remember:

- The angle of Polaris, measured up from the northern horizon, is equal to the observer's latitude. *or* The latitude of an observer is equal to the angle of Polaris measured up from the northern horizon.
- The height of Polaris changes as an observer travels north or south in the Northern Hemisphere. But the height of Polaris remains the same when an observer travels along a line of latitude.

Longitude:

Longitude lines extend from pole to pole. The Prime Meridian, which runs through Greenwich, England, is the 0° longitude line. All longitude lines are measured east or west from the Prime Meridian. Halfway around the globe from the Prime Meridian, is the maximum longitude of 180°. Longitude lines become closer as they approach the poles, at which point they converge.

An observer's longitude can be determined if the time at the Prime Meridian is known when it is solar noon (when the Sun is at its highest altitude) for the observer. This will be explained in greater detail in the *Longitude and Time Zones* section found below.

Time Zones – The rotational speed of the Earth is 15° per hour. Because of this, the globe has been divided into 24 wedge-shape segments – representing time zones – each being 15° of longitude apart. Each time zone is one-hour different from adjacent time zones. Traveling westward, passing into different time zones, time becomes earlier, while traveling eastward time becomes later. On the mainland of United States there are 4 time zones. If it is 10 a.m. in NYS, being in the Eastern time zone, it would be 9 a.m. in the Central time zone, 8 a.m. in the Mountain time zone, and 7 a.m. in the Pacific time zone.

Longitude and Time Zones – Longitude can be calculated if you know the difference between your time and time at the Prime Meridian (referred to as Greenwich Mean Time – GMT) and knowing that each hour difference equals 15° of longitude. The following examples show how this works.

Remember: All positions on a longitude line will have the same solar time.

Example 1: What is your longitude if it is solar noon at your location and it is 7 p.m. at the Prime Meridian?

Since you are 7 time zones earlier than Greenwich Mean Time, your longitude must be 105° W ($7 \times 15° = 105°$). Since your time is earlier than GMT, you must be west of the Prime Meridian.

Example 2: If an observer's time is 3 p.m. while it is noon at the Prime Meridian, what is the observer's longitude?

There is a 3-hour difference of time, which equals 45° of separation of longitude ($3 \times 15° = 45°$). Since the observer's time is later than that of Greenwich time, the observer must be to the east of Prime Meridian, making the observer's longitude 45° E.

Minutes and Seconds of Latitude and Longitude – A degree of latitude and longitude can be subdivided into smaller units of minutes and seconds. By using these small units, very accurate positioning is possible. For our purpose, only minutes will be explained. Each degree of latitude and longitude is subdivided into 60 equal sections that are called minutes ('). Therefore, 30' is the halfway position between any two degrees. The illustration on the next page shows how this works with degrees of latitude.

39° N ——— e ——— 39° N The latitude of position **e** is 39° 00′ N

•

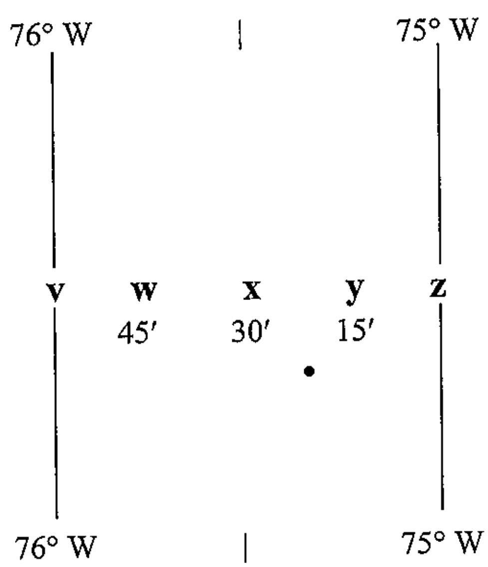
d = 45′ The latitude of position **d** is 38° 45′ N

– **c** = 30′ – The latitude of position **c** is 38° 30′ N
(Notice the dash halfway marks.)

b = 15′ The latitude of position **b** is 38°15′ N

38° N ——— **a** ——— 38° N The latitude of position **a** is 38° 00′ N

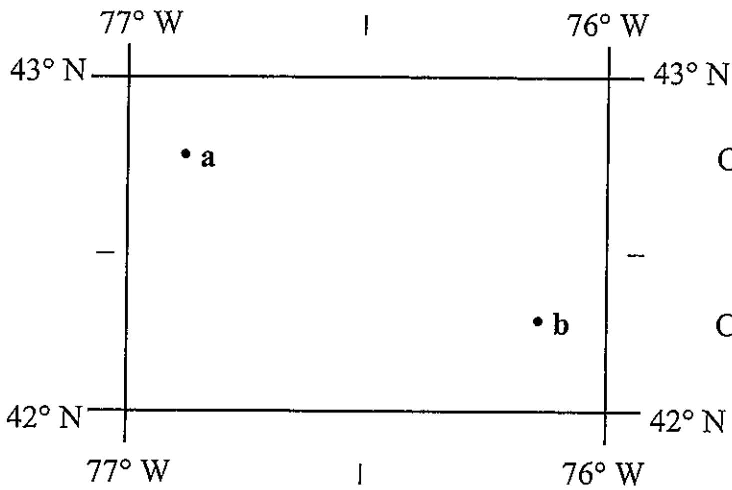
This example shows increments of 15′, but remember each degree is divided into 60 minutes. What would you estimate the latitude reading of the dot (•) shown above? A correct answer would be one that is close to a latitude reading of 38° 55′ N. The same system is used with longitude lines. The illustration below shows how this works with degrees of longitude.



The longitude of position **z** is 75° 00′ W.
The longitude of position **y** is 75° 15′ W.
The longitude of position **x** is 75° 30′ W.
(Notice the dash halfway marks.)
The longitude of position **w** is 75° 45′ W.
The longitude of position **v** is 76° 00′ W.

From the diagram above, what is the estimated longitude position of the dot (•)?
A correct answer would be 75° 20′ W.

Now let's see if you can estimate the full coordinates of a given position.
From the diagram below, what are the coordinates of dot **a** and dot **b**?



Coordinates of dot **a** = ______________

Coordinates of dot **b** = ______________

Answer: dot **a** = 42° 45′ N, 76° 50′ W
(Give yourself credit if your minutes are within ± 5′ for both readings.)

Explanation: Latitude readings are always given first. Dot **a** is higher than the halfway position as shown by the – symbol. Knowing that there are 60′ (minutes) in one degree, dot **a** is approximately at the 45′ position, giving an estimated latitude value of 42° 45′ N. For the longitude value, dot **a** is to the left of the 76° 30′ W position (notice the halfway position, represented by the | symbol), being approximately 50′. This gives a longitude reading of 76° 50′ W.

Answer: dot **b** = 42° 20′ N, 76° 10′ W
(Give yourself credit if your minutes are within ± 5′ for both readings.)

Explanation: Dot **b** is below the 42° 30′ N position, being close to 20′ position. This gives a latitude reading of 42° 20′ N. The longitude position of dot **b** is less than the halfway position, (76° 30′ W), being close to the 10′ position. This gives a longitude reading of 76° 10′ W.

Reference Tables Showing Coordinates:

The Generalized Bedrock Geology of New York State map, the *Surface Ocean Currents* map and the *Tectonic Plates* map all show coordinate numbers. On the Generalized Bedrock map, the latitude and longitude numbers are shown for New York State. The 30′ reading is shown by the dashed lines halfway between the degrees. To get an accurate reading for the coordinates, use a straight edge that crosses the chart, aligning the same degree readings. Then estimate the correct minutes value for the given position. For example: What are the coordinates of Syracuse? Solution: Place a straight edge or a ruler on the map such that it passes through the 43° N latitude numbers on both sides of the chart. From this alignment, one can see that Syracuse's latitude is slightly higher than 43° N. A given latitude answer of 43° 05′ N would be a correct estimate. Next, place a straight edge extending through the 76° longitude reading. This shows that a correct longitude estimate would be 76° 10′ W. The full coordinates for Syracuse are 43° 05′ N, 76° 10′ W.

On the *Surface Ocean Currents* map, N and S latitude values are shown on the left side of the map. Although latitude goes up to 90°, the highest latitude reading shown is 80° N and S. Longitude values are given on the top and bottom of this map. Remember, the 0° longitude line is the Prime Meridian. To the left of the Prime Meridian are the W longitude values until 180° line is reach. The remaining numbers are the E longitude readings. The Surface Ocean Currents map has 5 additional lines that are explained below.

Tropic of Cancer, 23.5° N – Due to the Earth's tilt and motion of revolution, the Sun's direct rays (perpendicular to the Earth's surface) appear to move a total of 47° (23.5° N to 23.5° S) in six months, – spanning the tropics. When these direct rays reach the farthest northern position, striking the Tropic of Cancer (23.5° N), it is the summer solstice (on or close to June 21) – the first day of summer for the Northern Hemisphere. On this day, as viewed from New York State, the noon Sun has reached its highest altitude, producing the longest duration (length) of insolation (sunlight). For the next six months, the direct rays move south, and as viewed from New York State, the noon Sun continually decreases in altitude causing a decrease in the duration of insolation.

Tropic of Capricorn, 23.5° S – On the winter solstice (on or close to December 21), the Sun's direct rays have reached its southern most position – hitting the Tropic of Capricorn. On this day, as viewed from New York State, the noon Sun has reached its lowest altitude, producing the shortest duration of insolation. For the next six months, the direct rays move north, and as viewed from New York State, the noon Sun continually increases in altitude causing an increase in the duration of insolation.

Arctic Circle, 66.5° N – On the summer solstice, all positions on and north of this latitude line would experience 24 hours of sunlight, as the Sun circles above the horizon for 24 hours. On the winter solstice, all positions on and north of the Arctic Circle experience 24 hours of darkness, because the Sun remains below the horizon for 24 hours. At the Arctic Circle, there will be one full day per year of complete darkness (winter solstice) and on full day of sunlight (summer solstice). Moving north of the Arctic Circle, the number of days with full darkness or sunlight increases, until the North Pole is reach. Here, 6 months of 24 hours of darkness or 24 hours of daylight occurs, except at the equinoxes – the only time they have 12 hours of day and night.

Antarctic Circle, 66.5° S – The events and occurrences at the Antarctic circle are the same as the Arctic Circle (described above), except they take place during the Southern Hemisphere solstices. Remember, for the Southern Hemisphere, the seasons are opposite of our seasons. Periods of continuous day and night range from one day at the Antarctic Circle to six months at the South Pole.

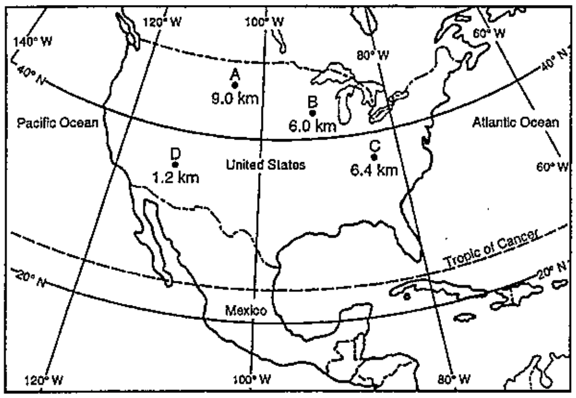
On the *Tectonic Plates* map, estimated coordinate readings are possible for mantle hot spots and locations of plate boundaries. On this chart, the highest latitude values shown are 70° N and S.

Note: All latitude and longitude questions dealing with these charts will be found in their respected sections.

Additional Information:

- To locate Polaris, the constellation The Big Dipper (Ursa Major) is used. The two "pointer stars," at the end of the bowl, direct a line of sight to the star Polaris.

1. The map below shows the location and diameter, in kilometers, of four meteorite impact craters, *A*, *B*, *C*, and *D*, found in the United States.



What is the approximate latitude and longitude of the largest crater?

(1) 35° N 111° W
(2) 39° N 83° W
(3) 44° N 90° W
(4) 47° N 104° W   1 ______

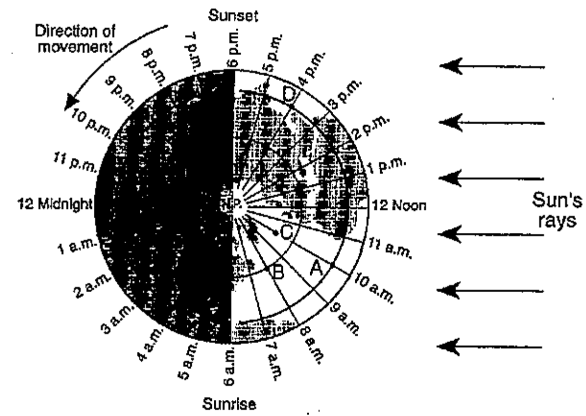
2. When the time of day for a certain ship at sea is 12 noon, the time of day at the Prime Meridian (0° longitude) is 5 p.m. What is the ship's longitude?

(1) 45° W   (3) 75° W
(2) 45° E   (4) 75° E   2 ______

3. Of the following choices, the maximum a longitude reading with its correct compass direction is

(1) 90° N   (3) 180° N
(2) 90° E   (4) 180° E   3 ______

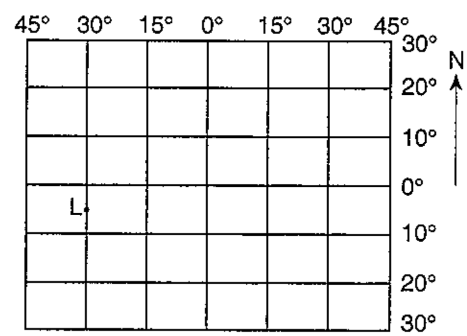
4. The map represents a view of the Earth looking down from above the North Pole, showing the Earth's 24 standard time zones. The Sun's rays are striking the Earth from the right. Points *A*, *B*, *C*, and *D* are locations on the Earth's surface.



Areas within a time zone generally keep the same standard clock time. In degrees of longitude, approximately how wide is one standard time zone?

(1) $7\frac{1}{2}$°   (3) $23\frac{1}{2}$°
(2) 15°   (4) 30°   4 ______

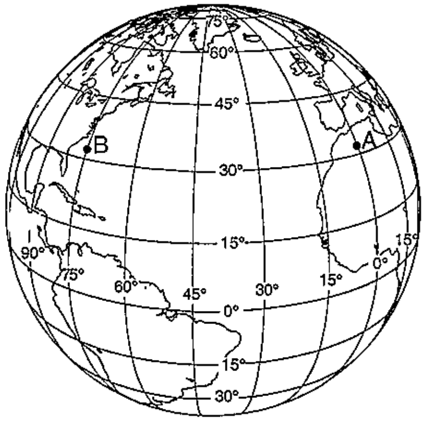
5. The diagram below represents part of Earth's latitude-longitude system.



What is the latitude and longitude of point L?

(1) 5° E 30° N   (3) 5° N 30° E
(2) 5° W 30° S   (4) 5° S 30° W   5 ______

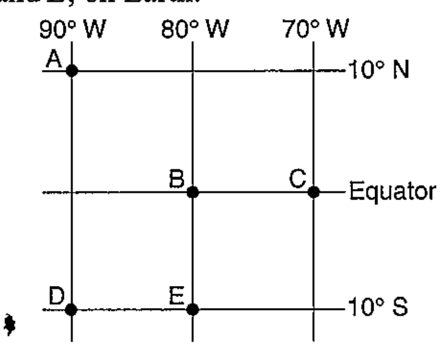
6. The diagram below shows the latitude-longitude grid on an Earth model. Points *A* and *B* are locations on the surface.



On Earth, the solar time difference between point *A* and point *B* would be

(1) 1 hour (3) 12 hours
(2) 5 hours (4) 24 hours 6 _______

7. *a*) The map below, shows the latitude and longitude of five observers, *A*, *B*, *C*, *D*, and *E*, on Earth.



What is the altitude of Polaris (the North Star) above the northern horizon for observer *A*?

(1) 0° (3) 80°
(2) 10° (4) 90° a _______

b) Which two observers would be experiencing the same apparent solar time?

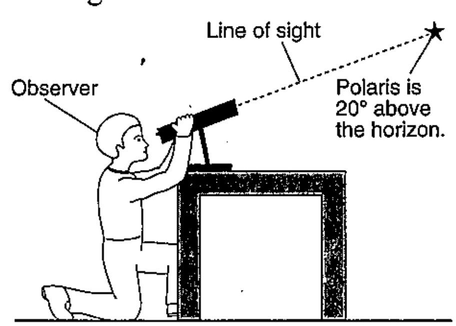
(1) *A* and *C* (3) *B* and *E*
(2) *B* and *C* (4) *D* and *E* b _______

8. The dashed line on the map below shows a ship's route from Long Island, New York, to Florida. As the ship travels south, the star Polaris appears lower in the northern sky each night.

Showing the map of the Eastern part of the United States, the best explanation for this observation is that Polaris

(1) rises and sets at different locations each day
(2) has an elliptical orbit around Earth
(3) is located directly over Earth's Equator
(4) is located directly over Earth's North Pole 8 _______

9. The diagram below shows an observer measuring the altitude of Polaris.

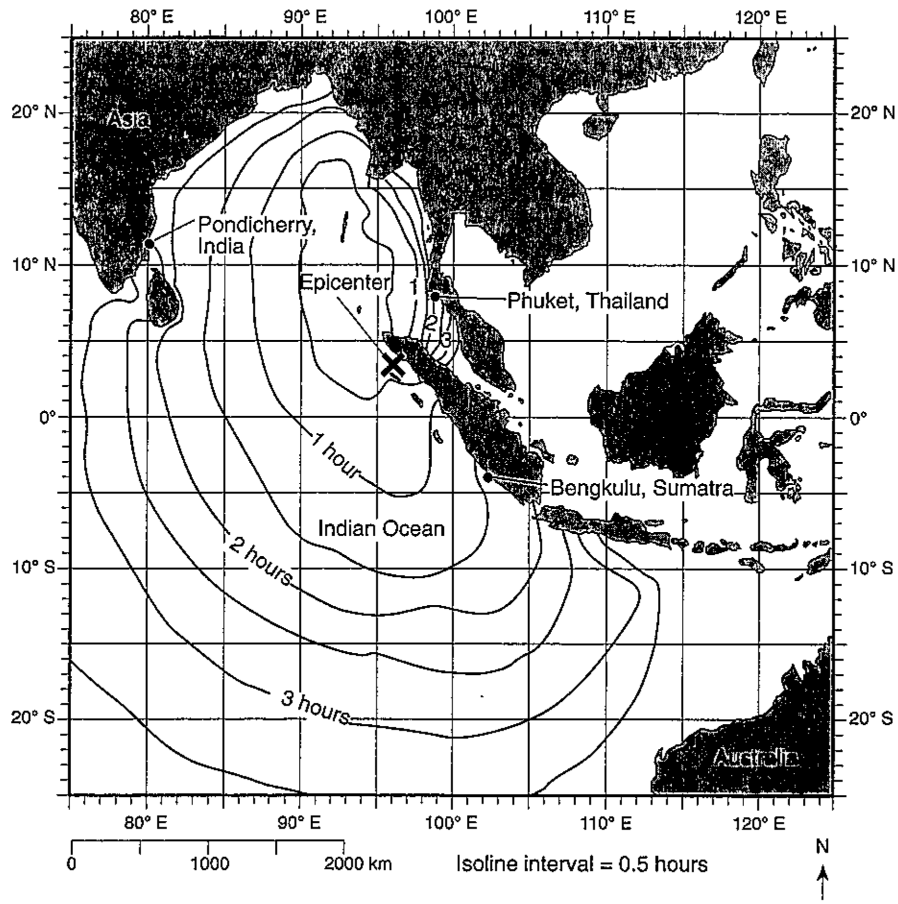


(Not drawn to scale)

What is the latitude of the observer?

(1) 20° N (3) 70° N
(2) 20° S (4) 70° S 9 _______

Base your answer to question 10 on the map below. The map shows a portion of the Indian Ocean and surrounding landmasses. The location of the epicenter of a large undersea earthquake that occurred on December 26, 2004, is shown by an **X**. The isolines surrounding the epicenter show the approximate location of the first tsunami wave produced by this earthquake in half-hour intervals after the initial earthquake.



10. State the latitude and longitude of the epicenter of this earthquake. Include the units and compass directions in your answer.

____

11. On the accompanying diagram, mark with a dot the position of Polaris as viewed by the observer. Label this dot "Polaris."