CHAPTER 5 LONGITUDES AND LATITUDES

Objectives

After studying this chapter, the student will be able to: (i) define the terms 'latitude' and 'longitude'.

(ii) identify similarities and differences between latitude and longitude.

(iii) describe the relationship between latitudes and major regions of the Earth.

(iv) locate the position of places on the earth's surface using longitude and latitudes.

(v) compute distances and local time using the concepts of longitude and latitude.

(vi) describe some concepts associated with longitude and time.

5.1 Latitudes

This is the angular distance of a place on the earth's surface measured in degrees from the centre of the Earth.

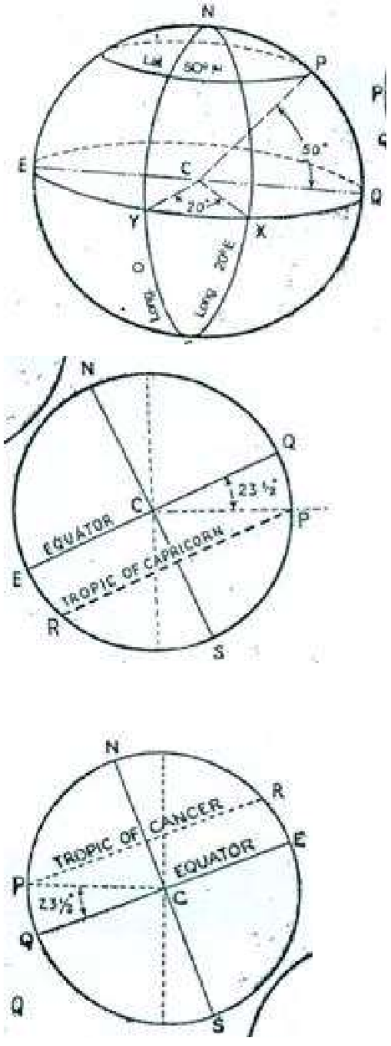

Fig 5.1: How Longitude and Latitude are measured from the Centre of Earth

Characteristics

1. Lines of latitude are otherwise known as PARALLELS.

2. Latitudes vary in length as their circumferences reduce as one moves from the Equator to the Poles.

3. Lines of latitude are parallel and do not meet or cross each other.

4. Latitudes are used to calculate distances from the Equator.

5. Each latitude is a complete circle of 360^0 (degrees).

6. Lines of latitude in addition to longitudes are used to determine the exact location on the globe. For example, Nigeria is located between latitude 4^0N and 14^0N of Equator and between longitudes 3^0E and 15^0E of the Greenwich Meridian.

Calculation of Distances Using Lines of Latitude

As mentioned earlier, latitudes are used in determining the distances of places on the Earth's surface. To calculate the distance of a place using latitudes, apply the following procedure: 1. Locate and identify the two places involved.

2. Obtain the latitude difference between the two places. If they are located in the same hemisphere (whether north or south), subtract the latitudes to obtain the difference, if they are located outside each hemisphere, that is, if one is the northern hemisphere and the other southern hemisphere, to obtain the difference, add the two latitudes.

3. Multiple the latitude difference by 111km.

***Example 1:** Calculate the distance between Kano Lat 12^0N and Amsterdam Lat 47^0N.*

Solution

(a) Locate the two places involved

Latitude of Kano = 12^0

Latitude of Egypt = 47^0

(b) The difference in latitude = $(47^0 - 12^0) = 35^0$ (because the towns are in the same hemisphere) (c) Since 1^0 of latitude = 111km

Therefore, 35^0 of latitude = (111 x 35) = 3885km

The distance between Equator and Amsterdam is 3885km

***Example 2:** Calculate the distance between South Africa Lat 30^0S and Egypt Lat 30^0N*

Solution

(a) Locate the two places involved

Latitude of South Africa = 30^0S

Latitude of Egypt = 30^0N

(b) Latitude difference = 30^0S + 30^0N = 60^0 (because they are in two different hemisphere) (c) Since 1^0 of latitude = 111km

Therefore, 60^0 = 111 x 60 = 6,660km

The distance between South Africa and Egypt = 6,660km

Example 3: If the distance between Bamako and Cairo (30^0N) is 1,665km, what latitude is Bamako, assuming that Cairo and Bamako are in the same hemisphere?

Solution

(a) Locate the places involved

Latitude of Cairo = 30^0N

Latitude of Bamako = ?

(b) Difference in distance = 1,665km

(c) Difference in latitude = $\frac{1665}{111} = 15^0$

Since both towns are in the northern hemisphere, the latitude of Bamako = $30^0 - 15^0 = 15^0$N (since Cairo is ahead of Banako)

5.2 Longitudes

A longitude is an imaginary line drawn on the globe (the earth) running from north to south at right angle to the parallels. They are angular distances measured in degrees east and west of the Greenwich Meridian (0^0), which passes through London (Britain) and Accra (Ghana).

Characteristics

1. All longitudes divide the earth into two equal halves, that is, they are all great circles.
2. All longitudes have equal circumference.
3. Lines of longitude are otherwise known as MERIDIANS.
4. Lines of longitude meet and converge at the poles.
5. Longitudes are used to determine the time of places on the Earth's surface.
6. Each longitude is a semi circle of 180^0, making 360 lines in all, that is, 180 lines in each half, east or west of the Greenwich Meridian.

Important Lines of Latitude

Of the 180 lines of latitudes, there are some important or significant ones. They include:

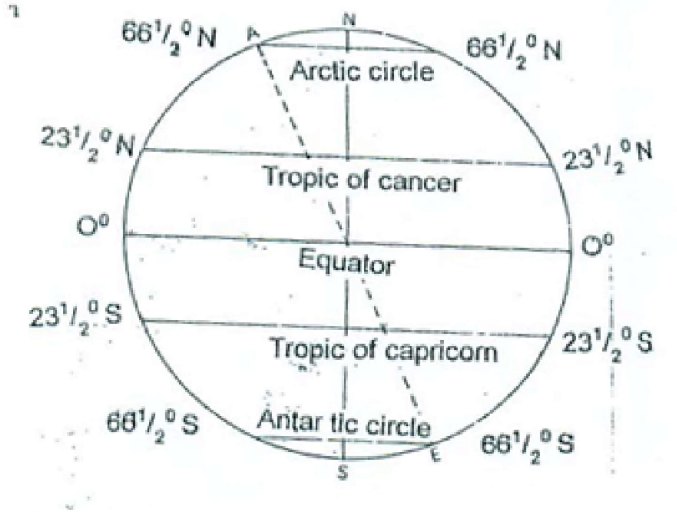

Fig. 5.2: Important Lines of Latitude

(i) Latitude 0^0 (the Equator)

(ii) Latitude 23½^{0}N (Tropic of Cancer)

(iii) Latitude 23½^{0}S (Tropic of Capricorn

(iv) Latitude 66½^{0}N (Arctic Circle)

(v) Latitude 66½^{0}S (Antarctic Circle)

(vi) Latitude 90^0N (North Pole)

(vii) Latitude 90^0S (South Pole)

Important Lines of Longitude

Just like latitudes, there are only two important lines of longitude and they are: (a) Longitude 0^0 (Greenwich or Prime Meridian)

(b) Longitude 180^0 (International Date Line)

Similarities between Lines of Longitude and Lines of latitude

1. *Both longitudes and latitudes are imaginary lines drawn on the earth's surface as they do not actually exist as lines on the Earth's surface.*
2. *Latitudes and longitudes are angular distances measured in degrees from the centre of the Earth.*
3. *Longitudes and latitudes are used to locate places on the Earth's surface. The intersection or meeting of the two lines determine the exact location of any place on the Earth's surface.*
4. *Both are shown on the globe or maps.*
5. *Both lines contain great circles.*

Differences between Lines of Longitude and Lines of Latitude

1. *Lines of latitude run from east to west while lines of longitude runs from north to south.*
2. *Latitudes are parallel to each other while longitudes are not parallel to each other but converge at the poles.*
3. *Latitudes get shorter towards the poles while longitudes are of the same length.*
4. *Of all the latitudes, the Equator is the only great circle while longitude has many great circles as any opposite pairs of lines make great circles.*
5. *Latitudes are otherwise called parallels while longitudes are called meridians.*
6. *Latitudes are used to measure distances while longitudes are not used to measure distances.*
7. *Latitudes are not used to measure or determine local time while longitudes are used to calculate local time.*
8. *Latitudes have the Equator as their reference point while longitudes are measured in reference to the Prime Meridian.*
9. *There are 180 lines of longitude, ninety (90) in each hemisphere while there are 360 lines of longitudes.*
10. *Latitudes decrease in length as they move towards the poles while all lines of longitudes are of the same length.*
11. *Latitudes increase in value from the equator towards the poles while lines of longitude increase in value eastwards and westwards of the Greenwich meridian.*
12. *Each longitude is a semi circle of 180^0 while each latitude is a complete circle of 360^0.*

Great Circles

A great circle is any line that divides the Earth into two equal halves or hemisphere. It has the following characteristics: 1. The centre of a great circle is also the centre of the Earth.

2. *The shortest distance between any two points on the Earth lies along the circumference of the great circle which passes these points.*
3. *Of all latitudes, Equator is the only one that is a great circle while several longitudes makes a great circle since two opposite lines of longitude normally make a great circle e.g. Greenwich Meridian (Long 0^0) and Long 180^0, Long 30^0E and Long 150^0W, Long 100^0W and Long 80^0.*
4. Great circles serve as routes for modern aircraft and vessels as it allows for speedy long-distance flights which help in cutting down flying time. This is however, limited by some factors such as difficulties encountered in linking numerous cities when using the routes, political consideration involved in the use of great circle routes as some countries may forbid the use of their air space and the dangers inherent in

flying over oceans in case of air accidents. In spite of these, great circle routes serve as the way out where long distances have to be covered over uninhabited regions, especially when crossing polar regions and by so doing help relieve air-traffic congestion.

Small Circles

These are lines that do not divide the earth into two equal halves or hemispheres. They have the following characteristics: 1. The centre of a small circle does not coincide with the centre of the Earth.

2. All lines of latitudes except the equator are small circles *e.g.* the Tropic of Capricorn $23\frac{1}{2}^0$S, Tropic of Cancer ($23\frac{1}{2}^0$N), Arctic circle ($66\frac{1}{2}^0$N), Antarctic circle ($66\frac{1}{2}^0$S), North pole (90^0N) and South Pole (90^0S) 3. Small circles serve as air routes that can only be used by aircrafts on a short journey.

5.3 Longitudes and Local Time

The idea of local time arose as an effect of the Earth's rotation as it determines the time of day or night at any place on the Earth's surface. Since the Earth rotates from west to east, as one moves through 360^0 of longitude in 24 hours or 15^0 in 1hour or 1^0 in 4 minutes. Hence, its longitude has its own local time which is acknowledged with reference to the Greenwich Meridian. The time at the Greenwich Meridian is called Greenwich Mean Time.

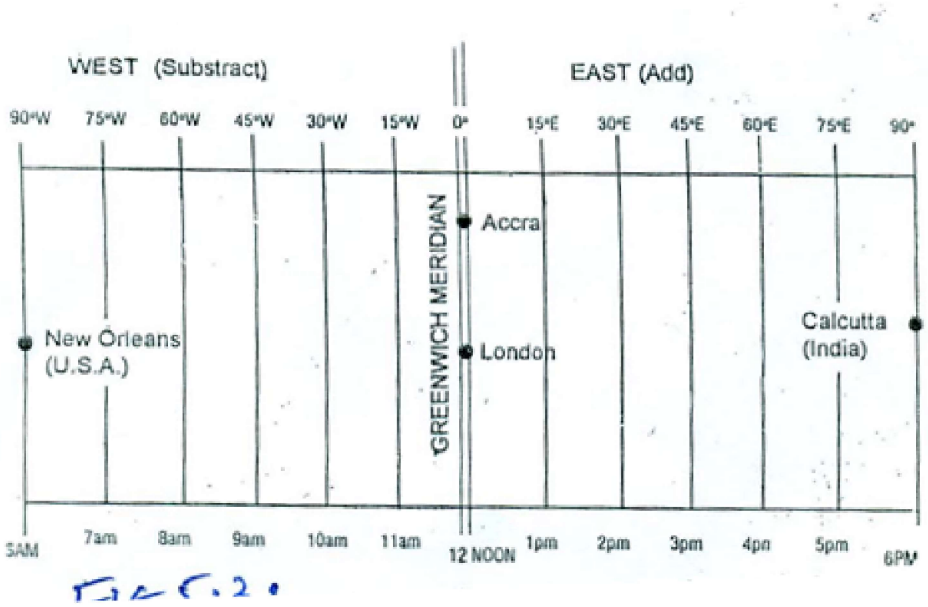

Fig. 5.3: How Time changes with Longitude

To the east of the Greenwich Meridian, the time increases by 4 minutes for every degree of longitude. To the west of the Greenwich, the time decreases by 4 minutes for every degree of longitude. For instance, if the time is 9.00 am in Greenwich, then it is 8.56 am local time on Long 1^0W and 9.04 am on Long 1^0E. In simple terms, local time is 4 minutes behind the Greenwich Mean Time (GMT) on 1^0W and 4 minutes ahead of GMT on 1^0E.

Procedures for Computing the Local Time of a Place

To calculate the local time for a given longitude with respect to another, take the following steps: (i) Calculate the difference in degrees of longitude between the two longitudes. In this step, there are three possible cases, namely: ***Case 1:*** *When the given longitude is with respect to the Greenwich Meridian, the difference in longitude is computed by subtracting zero (longitude of the GMT) from the given longitude.*

Case 2: *When the two longitudes are on the same side (east or west) of the GMT, subtract the value of the longitude with the smaller figure from that with the bigger figure.*

Case 3: *When one longitude is on the east and one is on the west of the GMT, add the values of the two longitudes together.*

(ii) Calculate the difference in time between the longitudes by multiplying the difference in degrees by 4 minutes.

(iii) Calculate the required time of the longitude given with respect to another. In this respect, there are two possible cases.

Case 1: *When the station whose time is required lies to the* ***east*** *of the reference station, add the time in step (ii) to the given time for the reference station.*

Case 2: *When the station whose time is required lies to the* ***west*** *of the reference station, subtract the time in step (II) from the given time for the reference station.*

Example 1: What is the local time in longitude 30^0E when the time is 11am on GMT?

Solution

Difference in longitude (in degrees) = $(30^0 - 0^0) = 30^0$

Difference in time = (30 x 4) minutes = 120 minutes

Since longitude 30^0E lies to the east of the GMT, the time at longitude 30^0E = 11am + 120mins = 13.00 hours or 1.00pm

Example 2: What will be the time in Barbados (45^0W) when it is noon in London (0^0)?

Solution

Difference in longitude = $(45 + 0^0)$ since long 45^0W comes before longitude 0^0 because the longitude increases westward from 0^0 to 180^0W

Convert longitude difference to time

15^0 of long = 1 hour

$\therefore$ 45 of long = $\frac{45}{15}$ = 3 hours

Since longitude 45^0W lies to the west of the GMT, time at Barbados

= (12.00hrs – 3hrs) = 9.00am

Example 3: A football match during a world cup competition between Nigeria (15^0E) and Brazil (40^0W) was played in Lagos (15^0E) on Saturday 12 June 2010 at 4pm. At what time and date should viewer tune their TV sets for the start of commentaries at (i) Vancouver (120^0W); (ii) Cairo (30^0E) and (iii) Tokyo (140^0E)

Solution

Vancouver (120^0W)

(i) Longitude difference = $(120^0$W + 15^0E) since the two locations are in two different locations with the Greenwich Meridian = 135^0

(ii) Convert the longitude difference to time

15^0 of longitude = 1hr

135^0 of longitude = $\frac{135}{15}$ = 9 hours

(iii) Time at Vancouver = (4pm – 9 hours)

(16 – 9) hours = 7am on Saturday 12 June Cairo (30^0E) (i) Longitude difference = $(30^0 - 15^0) = 15^0$ as the two locations are to the east of the Greenwich Meridian.

(ii) Convert the longitude difference to time.

15^0 of longitude = 1hour

(iii) Time at Cairo = (4pm + 1hr) = 5pm on Saturday 12 June

Tokyo (140^0E)

(i) Longitude difference = ($140^0 - 15^0$) = 125^0 as the two locations are to the east of the Greenwich Meridian.

(ii) Convert the longitude difference to time

15^0 of longitude = 1hour 125^0 of longitude = $\frac{125}{15} = 8\frac{1}{3}$ hours

= 8hours 20minutes

(iii) Time at Tokyo = (4pm + 8hrs 20mins) = 12.20 am on Sunday 13th June

Calculation of the Longitude of a Place

There may be the need to calculate the longitude of a place. The same procedure as that of the calculation of local time is followed except that the operations are reversed.

Procedure

(i) Locate the places involved by identifying their given local time.

(ii) Obtain the difference in time in terms of hours of the day by dividing the difference in time.

(iii) Multiply the time difference, computed in hours by 15degrees. This is because, for every difference in time of one hour, there is a difference of 15 degrees.

(iv) Add or subtract the difference in degrees to the longitude of the known location depending on whether the reference location is to the east or west of the known location.

Example 4: The captain of a ship on the high seas listening to BBC news learnt that the time was 12.00 noon GMT. He observed his watch and found that the local time was 6 pm. What was the longitude of the ship?

Solution

(i) Locate the time of the two places involved. 10am is 10 hours while 6pm is 18hours.

(ii) Obtain the time difference which is (18 – 10) hours = 8hours (iii) Convert the time difference to longitude

1hour = 15^0 of longitude

8hours = $(15 \times 8)^0 = 120^0$

(iv) Since 6.00 pm is ahead of 10.00am at London (0^0), then the longitude of the ship is 120^0E.

Concepts Associated with Longitude and Local Time

Over the years, some concepts have evolved which are often used when local time is discussed. They include:

(i) Time Zone

(ii) Standard Time

(iii) The International Date Line

Time Zone

Every location on the Earth's surface ought to have its own local time and its own longitude. In reality, this is not so as it will be cumbersome and complex for several times to be kept. In order to avoid confusion that will arise if every place were to keep different times for the different locations, the idea of a time zone was conceived. Since there are 24 hours in a day, with every hour coinciding with 15^0 of longitude, it was decided that a time zone should coincide with the passage or within the confines of an hour.

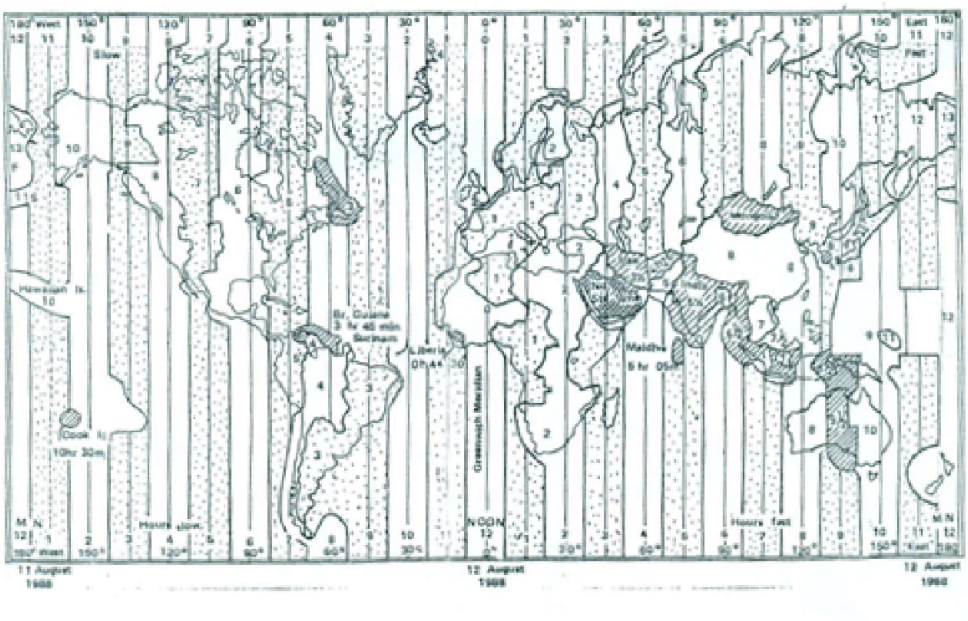

Fig. 5.4: The World Time Zones

Hence, there are twenty-four time zones in the world. In essence each time zone differs from the next zone by 1hour or 15^0 of longitude. All places located on the same time zone observe the same time. In essence, every movement of 15^0 towards the west of the Greenwich Meridian means that one hour is lost while every movement of 15^0 to the east of the Greenwich Meridian infers that an hour is gained. In spite of this arrangement, there are some countries that do not adhere strictly to it due to their large and irregular physical size such as North America where five time zones are observed. Former USSR has eleven time zones due to her great east-west stretch of almost 165^0 of longitude. The implication of this is that travelers will have to adjust their watches to meet up with the time kept in each zone.

Standard Time

This is the time that is associated with every central meridian that passes through countries of the world. For instance, the Nigerian government has adopted the time associated with the meridian of 15^0E that passes through it. This time is one hour ahead of the Greenwich Mean Time. Neighbouring time zones thus have a difference of 1hour.

In order to avoid confusion and to accommodate several countries, the boundaries of time zones are usually adjusted to conform to political boundaries. The need for standard times now becomes clear which is to eliminate differences in local time between one town and others within the same country. In the case of Nigeria, all towns and cities conform to the standard time of longitude 15^0E which is one hour ahead of the Greenwich Mean Time and they all observe the standard time accordingly. In all, the idea of standard time is a political arrangement and applies strictly to the time adopted by countries of the world. It differs from one country to the other. By this arrangement a standard time relates to a central meridian which occurs at an interval of 15^0 of longitude. In reality however, the boundaries of time zones do not often follow the lines of longitude except on the oceans so as not to cut countries or landmarks off and necessary adjustments are made to take account of this situation.

The International Date Line

The International Date Line is a product of an international agreement that came out of the International Meridian Conference held in 1884 in Washington D.C, USA. The line is an imaginary line that coincides with the

longitude 180^0. The date changes by exactly one day (24 hours) when it is crossed. There is a difference of one whole day (24 hours) on both sides of the longitude 180^0.

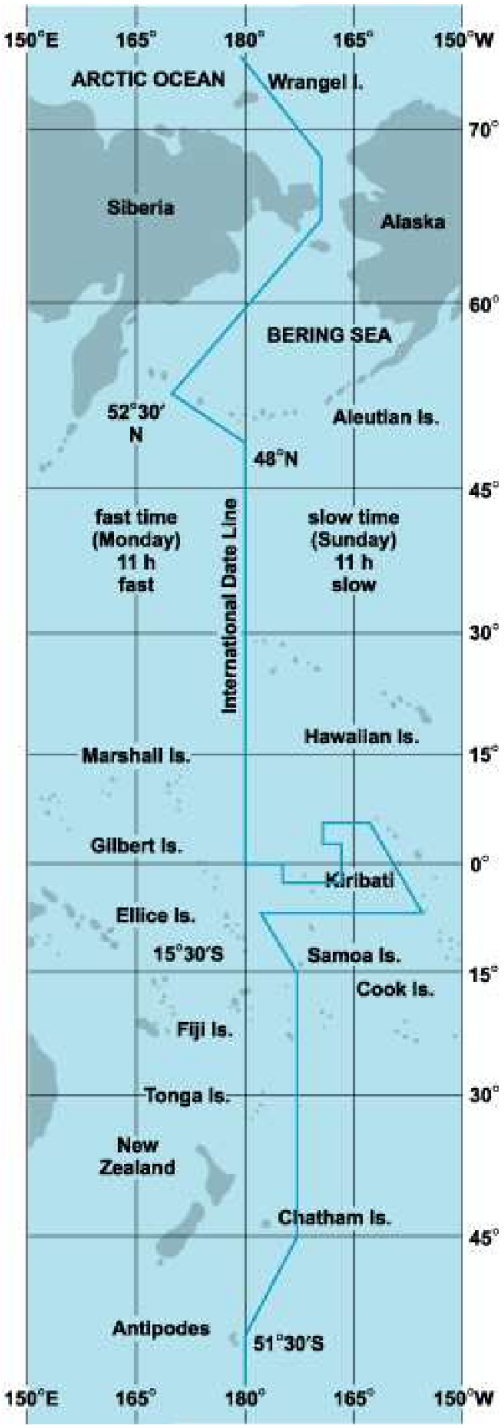

Fig. 5.5: The International Date Line

In essence, the longitude 180^0 theoretically represents a date line. A traveler crossing the date line from east to west ***loses*** a whole day (due to the loss in time he has experienced); and while crossing the date line from west to east he ***gains*** a day (because of the gain in time he encountered). The longitude 180^0 by nature is an odd meridian because it lies either east or west of the Greenwich meridian. On crossing it, travelers will have to adjust their calendar either ahead or behind. The International Date Line, is not a straight line as it deviates westward and eastwards to allow certain land areas and groups of islands to have the same calendar day. For instance, it deviates so that Islands of Fiji and the Aleutian Islands may observe the same calendar. Similarly, the line deviates so that the eastern Siberia may have the same time as the rest of former USSR. The deviation in the date line is particularly obvious in the mid-Pacific especially at the Bering Strait, Tonga and other Islands to

prevent confusion of day and date in some of the Islands groups that are cut through the meridian. For this reason, some of them keep Asiatic standard time while other prefer to follow the American date and time.

Grid Reference

The grid reference is a system or collection or network of horizontal and vertical lines which combine to form squares of a uniform size on a chart or a map. The north-south lines are usually numbers from West to East (horizontal lines) and are called EASTINGS while the west-east lines are numbers from south to west, that is, vertical lines are called NORTHINGS. Each line has a two figure number. The spaces between one line and the other are further subdivided into ten subdivisions to enable exact reference to be map. Like lines of longitudes and latitudes, grid references are imaginary lines and are mostly employed on maps to fix or locate the positions of places on the Earth's surface. A grid reference consists of an even number of figures. Examples include 4 to 6 grid references as the case may be. In stating grid references, the first half of figures are the eastings while the second are the northings. It should be noted that the greater the number of figures in the grid reference, the greater the degree of accuracy in specifying a location.

Summary

- Latitudes are angular distances of places on the Earth's surface measured in degrees from the centre of the Earth.
- Latitudes are used in measuring the distances of places on the Earth surface.
- Longitudes are angular distances of places on the Earth's surface measured in degrees east and west of the Greenwich Meridian (0^0).
- Latitudes and longitudes are imaginary lines drawn on the globe and used in showing the position of places on the Earth's surface.
- Longitudes are used in determining the local time of places on the Earth's surface.
- Great circles are lines that divide the Earth into two equal halves or hemispheres.
- Small circles are lines that do not divide the Earth into two equal halves and their centres do not coincide with the Earth's centre.
- Local time is the time for a specific place on the Earth's surface.
- Time zones are the time that coincides with every 15^0 of longitude.
- Standard time is a specific time zone chosen by countries of the world.
- The international date line is that line that coincides with longitude 180^0 for which a traveller going to the east from the west gaining a day and losing a day when crossing the line by moving from the west to the east.
- Grid references is a network of two sets of straight lines (horizontal and vertical) used on maps in determining the location of a place.

Revision Questions

Objective Questions

1. Which of the following is the best definition of latitudes?
   A. Distance from the equator
   B. Angular distance north or south of equator
   C. A line on a map
   D. Lines to show places

2. The longest latitude is

A. any great circle.

B. the Equator.

D. the North Pole.

D. the Tropic of Cancer.

3. The length of 1^0 of latitude on the earth's surface is

A. 32km B. 76km C. 98.5km D. about 11km

4. The shortest latitude is

A. the North or South Pole

B. Lat 70^0N

C. the Equator

D. Arctic Circle

5. The latitude of the Tropic of Cancer is

A. 90^0N B. 55^0N C. 45^0N D. $23\frac{1}{2}^0$N

6. $66\frac{1}{2}^0$N is to the Arctic circle as $66\frac{1}{2}^0$S is to

A. the Equator

B. the Tropic of Cancer

C. the South Pole

D. the Antarctic Circle

7. The name given to the 0^0 line of longitude is

A. the Equator.

B. the Great Circle.

C. the International Date Line.

D. Greenwich Meridian.

8. What is the time at 75^0W if it is midnight at 120^0W?

A. 9 pm B. 3 pm C. 9 am D. 3 am

9. When the time is 10 pm at 90^0E, what time is it as 15^0E?

A. 5 pm B. Midday C. 2 am D. 3 am

10. By crossing the International Date Line from East to West, the traveller A. gains a day.

B. loses a day.

C. loses 2hours.

D. gains 1hour.

Answers

1. B 2. B 3. D 4. A 5. D 6. D 7. D 8. A 9. A 10. B

Essay Questions

1a. Write explanatory notes on

(i) Longitude (ii) Latitude (iii) Local time

(iv) Greenwich Meridian

b. Describe two differences between a great circle and small circle

2a.State three similarities and three differences between latitudes and longitudes.

b. When it is 10.00 am in Berlin, Germany (Long 10^0E), what will be the time in Bangalore, India (Long 95^0E)?

3a.Distinguish between (i) great circles and small circles; (ii) standard time and time zones.

b. If the time at town X (long 85^0W) is 2.00 pm on Friday, what will be the time and day at town B (long 125^0E)?

4a.Describe the International Date Line.

b. Calculate the approximate distance in a straight line between Kumasi (Latitude 8^0N) and Paris (Lat 50^0N).

5a. Give four similarities between latitudes and longitudes.

b. A football match is to be played on Saturday in Australia long 120^0E between the host country and Egypt (30^0E). If the match is to be televised live, at what time should Egyptians tune in their television to watch the kick-off scheduled for 4.00pm in Australia?