GROUP BLUE MATHS NOTES, EXERCISES AND ASSIGNMENTS

TOPIC: LONGITUDES AND LATITUDES

Instructions

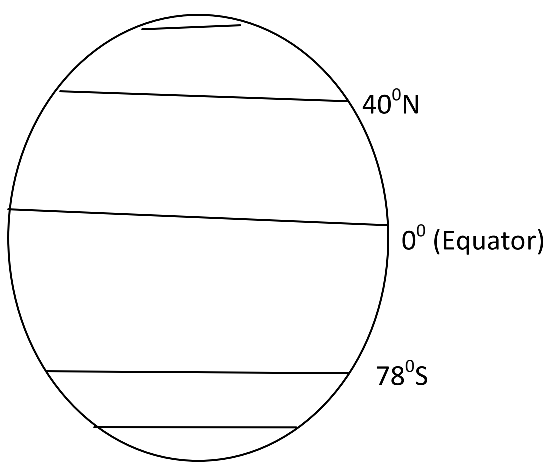
- Read the notes keenly
- Study the examples given carefully
- Sketching the question is very important
- In some worked examples, the working is displayed but the final answer **NOT** given. In such cases provide the answer.
- Attempt all the questions given after each subtopic.

LONGITUDES AND LATITUDES

- Longitudes and latitudes are imaginary lines drawn on the earth's surface.
- They are used to locate positions of places on the earth's surface.

LATITUDES

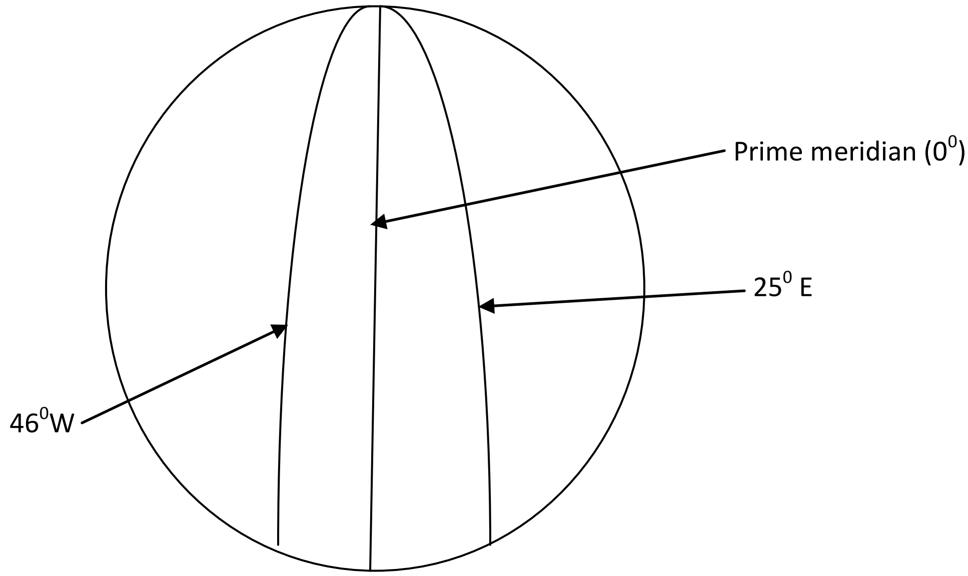
- These are imaginary lines drawn on the earth's surface.
- They run from West to East
- The **main** latitude is the Equator and is assigned 0^0 and is used as the reference latitude.
- All other latitudes are measured North or South of Equator.
- Latitudes run from 0^0 to 90^0 North and from 0^0 to 90^0 South of equator. e.g. the latitude 31^0 south of equator is written as 31^0S and the latitude 45^0 north of equator is written as 45^0N.



LONGITUDES (Meridians)

- These are imaginary lines drawn on the earth's surface.
- They run from North to South
- The **main** longitude is the Prime meridian or Greenwich Meridian and is assigned 0^0 and is used as the reference longitude.
- All other longitudes are measured East or West of Prime meridian.

- Longitudes run from 0^0 to 180^0East and from 0^0 to 180^0 West of Prime meridian. e.g. the longitude 71^0 East of Prime meridian is written as 71^0E and the longitude 105^0 West of Prime meridian is written as 105^0W

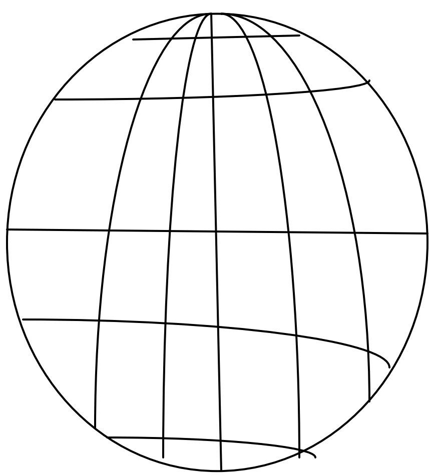


POSITION OF A PLACE ON THE EARTH'S SURFACE

- Any position on the earth's surface is defined by the intersection of its latitude and longitude.
- It is given by the ordered pair of coordinates (latitude, longitude) e.g. a town P is on latitude 37^0S and longitude 139^0East, its position is written as P(37^0S, 139^0E)

WORKED EXAMPLES AND EXERCISE

1. Use the figure below to give the position of the following points.
   a) A b)B c) C d)D e)E f) F g) G h) H



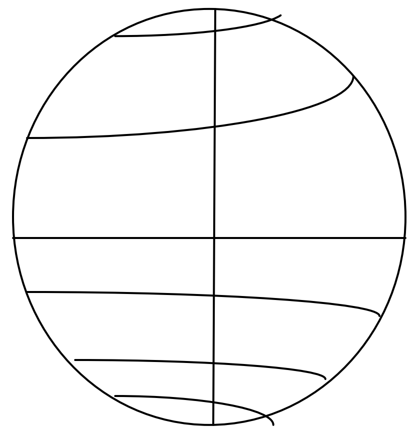
A(20^0N, 15^0W)

B(5^0S, 10^0E)

C(0^0, 100^0W)

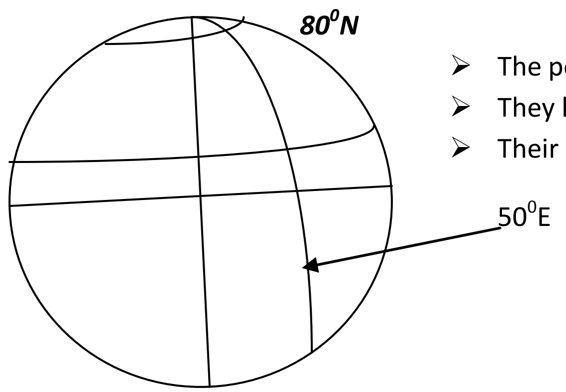
'Do the rest'

2. Using the sketch below of the earth's surface, locate the given points whose positions are given.
   A(45^0N, 20^0W), B(36^0S, 82^0E), C(0^0, 20^0W), D(45^0N, 82^0E), E(36^0S, 20^0W), F(45^0N, 0^0)



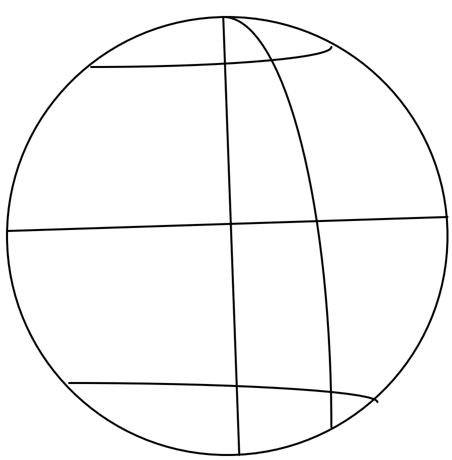
LATITUDE DIFFERENCE FOR POINTS ON THE SAME LONGITUDE

CASE 1



- The points P and Q lie on the same longitude (50^0E)
- They lie on the same side of equator i.e. North
- Their latitude difference is ($80^0 – 10^0$) = 70^0

CASE 2



- The points P and Q lie on the same longitude (72^0E)
- They lie on the opposite side of equator
- Their latitude difference is ($40^0 + 52^0$) = 92^0
- **NB**. If the points lie on the opposite sides of equator , latitude difference is the sum of the angles of the latitudes .

WORKED EXAMPLES AND EXERCISE

Complete the table below. Points A and B lie on the same longitude.

	Latitude of A	Latitude of B	Latitude difference
a)	43^0N	83^0N	$83 – 43 = 40^0$
b)	62^0S	14^0S	$62- 14 = 48^0$
c)	40^0N	36^0S	$40 + 36 = 76^0$
d)	13^0S	88^0S	
e)	60^0N	15^0N	
f)	53^0S	32^0N	
g)	25^0N	38^0S	

LONGITUDE DIFFERENCE FOR POINTS ON THE SAME LATITUDE

- Longitude difference is calculated the same way as latitude difference i.e. same as the two cases above

Complete the table below. P and Q lie on the same latitude.

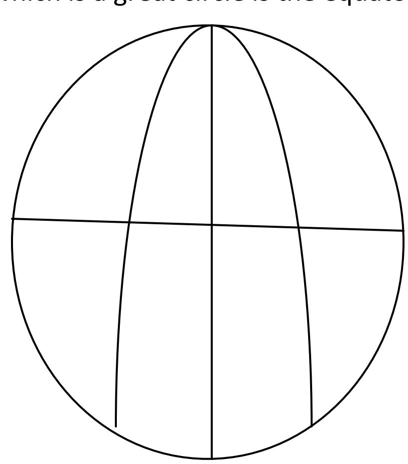
	Longitude of P	Longitude of Q	Longitude difference
a)	42^0	150^0	$150 – 42 = 108^0$
b)	100^0	172^0	$172 – 100 = 72^0$
c)	30^0	80^0	$80 + 30 = 110^0$
d)	136^0	20^0	
e)	10^0	38^0	
f)	90^0	12^0	
g)	14^0	83^0	

GREAT AND SMALL CIRCLES

- Longitudes and latitudes can be grouped as great and small circles.

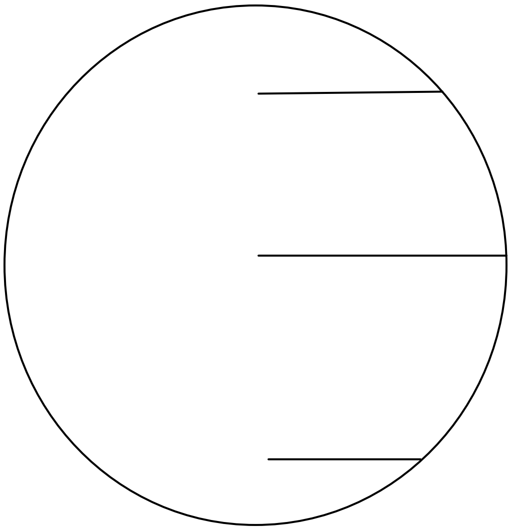
GREAT CIRCLE

- A great circle is a circle that has the same radius as that of the earth.
- All longitudes have the same radius as that of the earth.
- Equator has the same radius as that of the earth.
- Therefore all longitudes and equator are great circles.
- N.B. The only latitude which is a great circle is the equator



SMALL CIRCLES (CIRCLES OF LATITUDES)

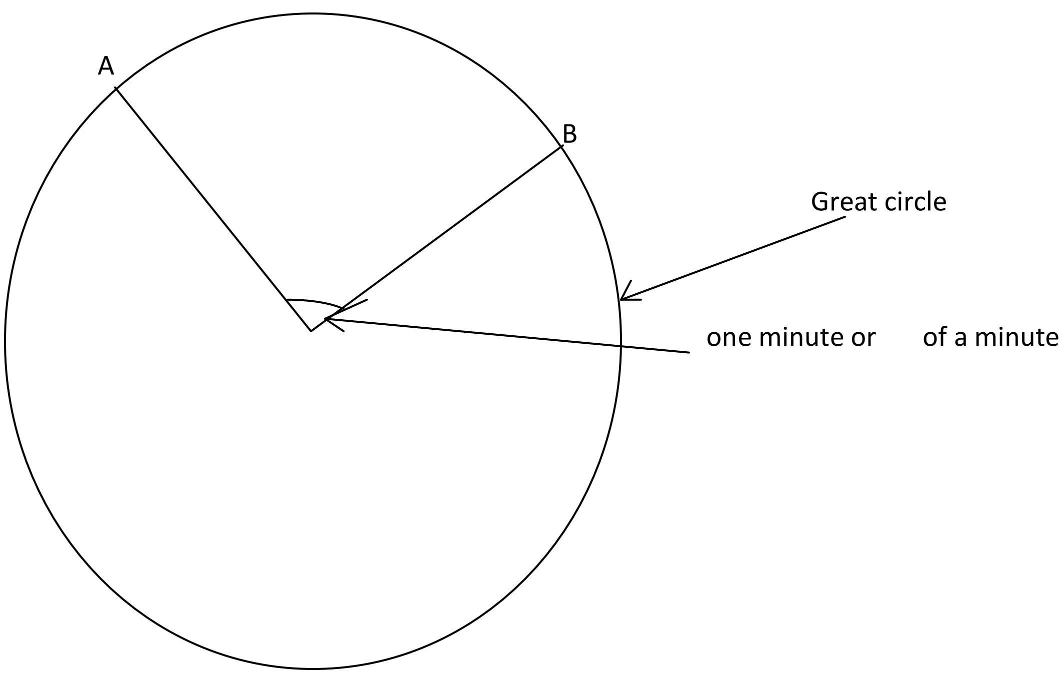
- A small circle or a circle of latitude is a circle whose radius is smaller than that of the earth.
- All latitudes except equator are small circles.



$r < R$

NAUTICAL MILE (nm)

- A nautical mile(nm) is the SI unit for measuring distances covered by ships and aeroplanes.
- Consider the figure below.



- The arc AB subtends an angle of one minute(1') at the centre of a great circle.
- The arc length AB is equivalent to 1 nautical mile.
- Hence a nautical mile is the length of an arc of a great circle that subtends an angle of one minute (1') at the centre of the earth.

- **N.B** $1^0 = 60'$ (60 minutes) , hence 1^0 is subtended by an arc length of 60 nm

$$\boxed{1^0 = 60 \text{ nm}}$$

DISTANCE ALONG A GREAT CIRCLE IN NAUTICAL MILES (nm)

- To find the distance in nautical miles along a great circle, we use the formula
  l = 60a where a is;
  (i) Latitude difference if the points lie on the same longitude
  (ii) Longitude difference if the points lie on Equator

WORKED EXAMPLES AND EXERCISE

1. Calculate the distance in nautical miles between the following points

a) A(20^0S, 40^0E) and B(85^0S, 40^0E)

Soln;

Both points A and B lie on the same longitude (40^0E) which is a great circle

L = 60a

a = difference in latitudes

= 85 – 20

= 65^0

L = 60 x 65

= -------------- nm

b) P(0^0, 36^0E) and B(0^0, 113^0E)

Soln;

Both points P and Q lie on the same latitude (0^0) equator which is a great circle

L = 60a

a = difference in longitudes

= 113 – 36

= 77^0

L = 60 x 77

= -------------- nm

c) X(30^0N, 15^0W) and Y(72^0S, 15^0W)

Soln;

Both points X and Y lie on the same longitude (15^0W) which is a great circle

X and Y lie on the opposite sides of equator and hence latitude difference is the sum of latitudes

L = 60a

a = sum of angles of latitudes

= 72 +30

= 102^0

$L = 60 \times 102$

$= \text{--------------}$ nm

d) $K(0^0, 16^0E)$ and $L(0^0, 54^0W)$

Soln;

Both points K and L lie on Equator and on the opposite sides of Prime meridian. Hence longitude difference is the sum of longitudes

$L = 60a$

a = sum of angles of longitudes

$= 54 + 16$

$= 70^0$

$L = 60 \times 70$

$= \text{--------------}$ nm

2. A plane flew northwards from a base $V(20^0N, 50^0W)$ to a base W covering 1500 nm. Find the
   a) Latitude difference
   b) Position of W

Soln;

When a body moves northwards or southwards, it follows a great circle; hence the formula to apply is

$L = 60a$

a) $1500 = 60a$

$a = {}^{1500}/_{60}$

$a = 25^0$

b) Moving from 20^0N northwards, the angle of latitude increases by 25^0

New latitude $= 20 + 25$

$= 45^0N$

Position of W $(45^0N, 50^0W)$

3. A plane flew southwards from a base $H(10^0N, 30^0W)$ to a base J covering 3900 nm. Find the
   a) Latitude difference
   b) Position of J

Soln;

When a body moves northwards or southwards, it follows a great circle; hence the formula to apply is $l = 60a$

a) $L = 60a$

$3900 = 60a$

$a = {}^{3900}/_{60}$

$a = 65^0$

b)Since 65^0 is greater than 10^0 (latitude) then J is in South of equator

New latitude $= 65 - 10$

$= 55^0S$

Position of J $(55^0S, 30^0W)$

EXERCISE

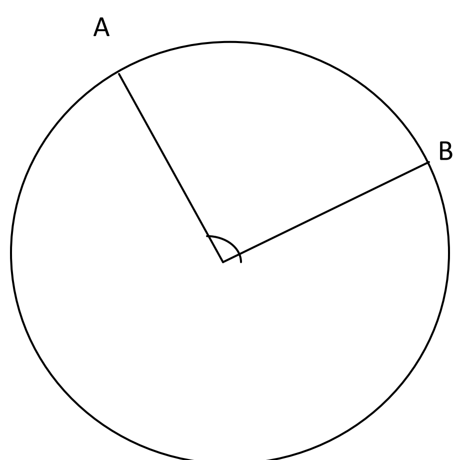
1. Calculate the distance in nautical miles between the following points.

	A	B
a)	(30^0N, 18^0W)	(70^0N, 18^0W)
b)	(14^0S, 10^0E)	(2^0S, 10^0E)
c)	(25^0N, 32^0W)	(16^0S, 32^0W)
d)	(0^0, 142^0W)	(0^0, 78^0W)
e)	(0^0, 58^0E)	(0^0, 96^0W)
f)	(25.6^0N, 140^0E)	(82^0N, 140^0E)

2. A plane flew northwards from a base situated at (70^0S, 10^0E) for a distance of 2160 nm to another base. Find its new
   a) Latitude
   b) Position
3. A ship sailed from a harbor H(15^0N, 36^0E) to another harbor J situated to the south of H. If it covered 2700 nm, find the position of J.
4. A jet flew northwards from a base P(30^0S, 100^0E) for 1800 nm to a base Q. From Q it flew westwards to another base R for a further distance of 9000 nm. Find the position of Q and R.

DISTANCE ALONG A GREAT CIRCLE IN KILOMETRES

- Consider the circle below of radius R.



- Arc AB subtends an angle of a^0 at the centre O.
- The length of the arc AB is given by the formula

$$L = {}^{a}/_{360} \times \text{circumference}$$

$$L = {}^{a}/_{360} \times 2\Pi R$$

- Similarly, if points A and B lie on a great circle and R is the radius of the earth, the distance along a great circle in kilometers is given by the formula

$L = {}^{a}/_{360} \times 2\Pi R$ where (i) R is the radius of the earth, R = 6370 km

(ii) a is the latitude difference or longitude difference (for points on the equator)

WORKED EXAMPLES

Take π = 22/7   and R = 6370 km

1. Find the distance in km between the given point

a) K(30^0N, 0^0), L(60^0N, 0^0)

Soln;

K and L lie on the same longitude 0^0, hence on a great circle

$L = {}^{a}/_{360} \times 2\Pi R$

a =latitude difference

= 60 – 30

=30^0

$L = {}^{30}/_{360} \times 2 \times {}^{22}/_{7} \times 6370$

L = …………………………… Km

b) F(20^0S,112^0W), G(25^0N, 112^0W)

Soln;

F and G lie on the same longitude 112^0W, hence on a great circle and on opposite sides of equator

$L = {}^{a}/_{360} \times 2\Pi R$

a =latitude difference (sum)

= 20 +25

=45^0

$L = {}^{45}/_{360} \times 2 \times {}^{22}/_{7} \times 6370$

L = …………………………… km

c) A(0^0, 50^0E), B(0^0, 100^0W)

Soln;

A and B lie on the Equator (great circle) and on opposite sides of Prime meridian

$L = {}^{a}/_{360} \times 2\Pi R$

a =longitude difference (sum)

= 50 +100

=150^0

$L = {}^{150}/_{360} \times 2 \times {}^{22}/_{7} \times 6370$

L = …………………………… Km

2. A ship sailed southwards from a port T(80^0N, 20^0E) to another port S 10010 km away. Find
   a) Its new latitude
   b) Position of S

   Soln

   The ship followed a great circle

   $L = {}^{a}/_{360} \times 2\Pi R$

   $a = \frac{360l}{2\pi R}$

   $a = \frac{360 \times 10010}{2 \times 22/7 \times 6370}$

   a = ……………………

   New latitude = ……………..

   b) Position of S =…………………

EXERCISE

In this exercise take π = 22/7 and radius of the earth R = 6370 km

1. Find the distance in km between the following points

	A	B
a)	(40^0N, 10^0E)	(86^0N, 10^0E)
b)	(0^0, 50^0W)	(0^0, 10^0W)
c)	(36^0S, 90^0E)	(54^0N, 90^0E)
d)	(0^0, 15^0W)	(0^0, 60^0E)
e)	(40^0S, 20^0W)	(78^0S, 20^0W)

2. A jet flew eastwards from a base P(0^0, 54^0W) to another base Q covering 20020 km. Find the
   a)longitude difference between P and Q.
   b) position of Q.

3. Two points X and Y lie on longitude 800W and they are 1280 km apart. If the position of X(6^0S, 80^0W), find

a) to 1 decimal place, the latitude difference

b) the latitude of Y and hence its position

DISTANCE ALONG A SMALL CIRCLE IN NAUTICAL MILES (nm)

- The distance along a small circle (circle of latitude)is given by the formula
  $L = 60a\cos\Theta$ where a = longitude difference and Θ = angle of latitude

WORKED EXAMPLES

1. Find the distance in nautical miles between the following points
   a) P(40^0N, 20^0E) Q(40^0N, 120^0E)

Soln;

P and Q lie on the same latitude 40^0N (small circle)

$L = 60a\cos\Theta$

a = longitude difference

= 120 – 20

= 100^0

$L = 60 \times 100 \times \cos 40^0$

L = ……………………….. nm

b)

U(60^0S, 10^0E) V(60^0S, 30^0W)

Soln;

Uand QVlie on the same latitude 60^0S (small circle) and on the opposite sides of [Prime meridian

$L = 60a\cos\Theta$

a = longitude difference

= 10 + 30

= 40^0

$L = 60 \times 40 \times \cos 60^0$

L = ……………………….. nm

2. Two points lying on the same latitude have a longitude difference of 80^0 and are 2400 nm apart. Find their latitude.

Soln

$L = 60a\cos\Theta$ $a = 80^0$

$\cos\Theta = l \div (60a)$

$\cos\Theta = 2400 \div (60 \times 80)$

$\cos\Theta = 0.5$

$\Theta = \cos^{-1}0.5$

$\Theta = 60^0$

Latitude is 60^0N or 60^0S

3. P and Q lie on the same latitude to the south of equator. P is on longitude 20^0E and Q is on 70^0E. If they are 2700 nm apart, find their latitude to the nearest tenth of a degree

Soln;

$L = 60a\cos\theta \qquad a = 70 - 20 = 50^0$

$\cos\theta = l \div (60a)$

$\cos\theta = 2700 \div (60 \times 50)$

$\cos\theta = 0.9$

$\theta = \cos^{-1}0.9$

$\theta = 25.84^0$

Latitude is 25.8^0S

EXERCISE

1. Calculate the distance in nautical miles between the following points.

	P	Q
a)	(20^0S, 40^0E)	(20^0S, 100^0E)
b)	(60^0N, 20^0W)	(60^0N, 70^0E)
c)	(10^0S, 100^0W)	(10^0S, 15^0W)
d)	(64^0N, 12^0W)	(64^0N, 88^0E)

2. Two points lying on the same latitude south of equator are 1500 nm apart. Their longitude difference is 800. Find their latitude to the nearest degree.

DISTANCE ALONG A SMALL CIRCLE IN KILOMETRES (KM)

- Distance along a small circle (circle of latitude) is given by the formula

$L = {}^{a}/_{360} \times 2\Pi R\cos\theta$

Where a = longitude difference

R = radius of the earth

θ = angle of latitude

WORKED EXAMPLES

Take $\pi = 22/7$, R = 6370 km

1. Calculate the distance in km between the following points.
   a) J(20^0N, 18^0E), L(20^0N, 115^0E)

   Soln;

   J and L lie on the same latitude 20^0N (small circle)

   $L = {}^{a}/_{360} \times 2\Pi R\cos\theta$

   a = longitude difference

   = 115 – 18

   = 97^0

   R = 6370 km

   $\theta = 20^0$

$L = {}^{97}/_{360} \times 2 \times 22/7 \times 6370 \times \cos 20^0$

L = ……………………………….. km

b) $C(35^0S, 25^0W)$, $D(35^0S, 90^0E)$

Soln;

Cand D lie on the same latitude 35^0S (small circle)

$L = {}^{a}/_{360} \times 2\Pi R \cos\Theta$

a = longitude difference

= 25 + 90

$= 115^0$

R = 6370 km

$\Theta = 35^0$

$L = {}^{115}/_{360} \times 2 \times 22/7 \times 6370 \times \cos 35^0$

L = ……………………………….. km

2. X and Y are two points on the same latitude north of equator. They are 3336.67 km apart and their longitude difference is 60^0. Find their latitude.

Soln;

$L = {}^{a}/_{360} \times 2\Pi R \cos\Theta$

$\cos\Theta = 360l \div (2a\Pi R)$

$= 360\ 3336.67 \div (2 \times 60 \times 22/7 \times 6370)$

$= 0.5$

$\Theta = \cos^{-1}0.5$

$\Theta = 60^0N$

EXERCISE

Find the distance in km between the following points. Take π = 22/7, R = 6370 km

	X	Y
a)	$(40^0S, 40^0E)$	$(40^0S, 160^0E)$
b)	$(27^0N, 20^0W)$	$(27^0N, 70^0E)$
c)	$(80^0S, 130^0W)$	$(80^0S, 15^0W)$
d)	$(64^0N, 12^0W)$	$(64^0N, 98^0E)$
e)	$(16^0S, 56^0E)$	$(16^0S, 27^0W)$

SHORTEST DISTANCE BETWEEN TWO POINTS ON THE EARTH'S SURFACE

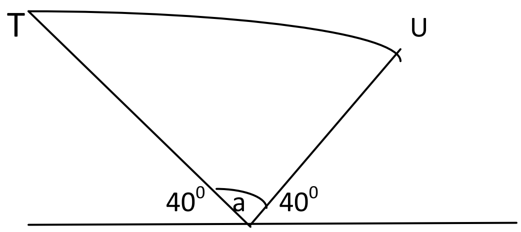
- If the sum of longitudes of two points is 180^0, the two points lie on the same great circle, e.g. P(60^0N, 125^0E), Q(34^0N, 55^0W)
- The sum of longitudes of A and B is $125^0 + 55^0 = 180^0$
- Therefore the two points lie on the same great circle
- The shortest distance between such points is along the great circle

WORKED EXAMPLES

1. The positions of T and U are T(40^0N, 84^0E) and U(40^0N, 96^0W). Calculate the shortest distance between them in nautical miles.

Soln;

Sum of longitudes = 84 + 96 = 180^0, hence the two points lie on the same great circle.



$a = 180 - (40 + 40)$

$= 100^0$

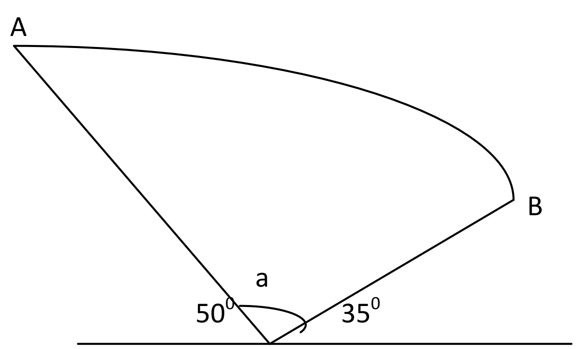
$L = 60a$

$= 60 \times 100$

$= 6000$ nm

2. Find the shortest distance between the following points A(35^0S, 60^0W) and B (50^0S, 120^0E)

Soln.



Sum of longitudes = 60 + 120

= 180

$a = 180 - (35 + 50)$

$= 95^0$

$L = 60a$

$= 60 \times 95$

=…………………….. nm

3. The positions of G and H are G(50^0N, 102^0E) and H(50^0N, 78^0W). Calculate the shortest distance between them in nautical miles,
   a) Along the parallel of latitude
   b) Along the great circle.

   Soln

   a) $L = 60a\cos\theta$

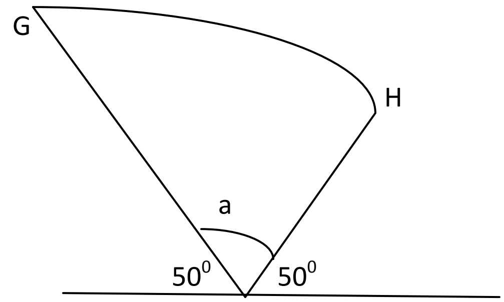
   $a = 102 + 78 = 180$

$\Theta = 50^0$

$L = 60 \times 180 \times \cos 50^0$

L = ……………………. Nm

b)



$a = 180 - (50 + 50)$

$= 80^0$

$l = 60a$

$= 60 \times 80$

= ………………………. Nm

EXERCISE

1. Find the shortest distance in nautical miles between the following points
   a) $A(63^0N, 100^0E)$ and $B(63^0N, 80^0W)$.
   b) $C(25^0S, 115^0W)$ and $D(50^0S, 65^0E)$.
   c) $E(10^0N, 45^0W)$ and $F(10^0N, 135^0ES)$.
   d) $G(75^0S, 86^0E)$ and $H(20^0S, 94^0W)$.

2. Two points P and Q lie on the latitude 25^0N. The sum of their longitudes is 180^0.Find in nautical miles the distance between them
   a) Along the parallel of latitude
   b) Along the great circle.

SPEED IN KNOTS

- A knot is a unit of speed used by airmen and sailors.
- A speed of one nautical mile per hour is called a knot
- Speed (knots) = $\frac{\text{distance in nautical miles}}{\text{Time taken in hours}}$

N.B. Distance in nautical miles = Speed in knots x Time in hours

WORKED EXAMPLES

1. A plane covered 1800 nm in 9 hours. Find its speed in knots.

Soln;

$S = \frac{D}{T}$

$= \frac{1800 \text{ nm}}{9 \text{ hr}}$

$= 200$ knots

2. A ship covered a certain distance in 4 hours at a speed of 35.8 knots. Find the distance covered.
   Soln;

   $D = S \times T$

   $= 35.8 \times 4$

   = ……………… nm

EXERCISE

1. Find the speed in knots in each of the following cases.

	Distance (nm)	Time (hrs)	Speed (knots)
a)	100	2	
b)	50	0.5	
c)	9840	7	
d)	0.5	0.25	

2. Find the distance covered in nautical miles.

	Speed (knots)	Time(hours)	Distance
a)	20	6	
b)	150	8	
c)	40.6	10	
d)	85	11	

LONGITUDE AND TIME

- The earth rotates through 3600 in every 24 hours.
- This means in 360^0 change in longitude, there is a change of 1440 minutes.
- In short for 1^0 change in longitude, there is a change in time of 4 minutes.
- This means if two longitudes differ by 1^0, there is a time difference of 4 minutes.
- This is equivalent to a time difference of 1 hour between two longitudes 15^0 apart.
- All places on the same longitude have the same local time.
- The local time on Greenwich meridian is known as Greenwich Mean Time(GMT)
- All longitudes to the west of Greenwich meridian lag behind in time
- Likewise, all meridians to the east of Greenwich meridian are ahead in time.

WORKED EXAMPLES

1. The local time of a town A(63^0N, 40^0E) is 11.30 am. What is the local time of the following towns.
   a) Town B(34^0N, 82^0E).
   b) town C(55^0S, 10^0W)

   Soln;

   a) longitude difference = 82 – 40
      $= 42^0$
      Time difference = 42 x 4
      =168 minutes
      = 2hrs 48 minutes
      Town B is to the east of town A, hence ahead of local time of town A. Therefore add
      Local time of town B = 11.30
      + 2.48
      13. 78
      1 - 60
      1418
      Local time of town B is 1418h or 2.18 pm

   b) longitude difference = 40 + 10
      $= 50^0$
      Time difference = 50 x 4
      =200 minutes
      = 3hrs 20 minutes
      Town C is to the West of town A, hence lag behind local time of town A. Therefore subtract
      Local time of town C = 11.30

$$\begin{array}{r} -\ \underline{3.\ 20} \\ 8.\ 10 \end{array}$$

Local time of town C is 8.10 am.

EXERCISE

1. Given that the local time of a city P A(0^0, 30^0W) is 12.00 pm. What is the local time of the following cities.
   a) Q(10^0S, 60^0W)
   b) R(24^0N, 10^0W)
   c) S(33^0S, 20^0E)
   d) T(81^0N, 81^0 W)

2. Three towns X, Y and Z have positions X(42^0S, 15^0E), Y(8^0N, 15^0E) and Z(10^0S, 60^0E). A jet left town X at 10.00 am for town Y moving at a speed of 600 knots. What was the local time of town Z when the jet landed at town Y.

SUMMARY OF FORMULAE

1. L = 60a (distance along a great circle in nautical miles)
2. L = 60aCosΘ (distance along a small circle in nautical miles)
3. L = $^a/_{360}$ x 2ΠR (distance along a great circle in kilometres)
4. L = $^a/_{360}$ x 2ΠR cosΘ (distance along a small circle in kilometres)
5. r = R cosΘ (radius of a circle of latitude, R is the radius of the earth and Θ is the angle of latitude)

REVISION QUESTIONS

1. A passenger plane takes off from airport A(60^oN,5^oE) and flies directly to another airport B(60^oN,17^oE) and then flies due North for 600 nautical miles (nm) another airport C

(a) Find the position of airport C (3mks)

(b) Find the distance between airport A and B in nautical miles (3mks)

(c) If the plane at an average speed of 300knots, find total flight time (2mks)

(d)Given that the plane left air port A at 9.20am. Find the local time of arrival at airport C (2mks)

2. A plane take of from airport P at (0°, 40°W) and flies 1800 nautical miles due East to Q then 1800 nautical miles due South to R and finally 1800 nautical miles due West before landing at S.

(a) Find to the nearest degree the latitudes and longitudes of Q, R and S. (4mks)

(b) If the total flight time is 16 hours, find the average speed in knots for the whole journey. (3mks)

(c) Find the time taken to fly from R to S, given that this was two hours shorter than the time taken from P to Q to R. (3mks)

3. Calculate the shortest distance in nautical miles between M(45°N, 38°E) and N(45°N, I42°W).(3mks)

4. A plane leaves an airport P (10^0S, 62^0E) and flies due north at 800km/h.

(a) Find its position after 2 hours (3 Marks)

(b) The plane turns and flies at the same speed due west. It reaches longitude Q, 12^0W.

(i) Find the distance it has traveled in nautical miles. (3 Marks)

(ii) Find the time it has taken (Take $\pi = \frac{22}{7}$, the radius of the earth to be 6370km and 1 nautical mile to be 1.853km) (2 Marks)

(c) If the local time at P was 1300 hours when it reached Q, find the local time at Q when it landed at Q (2 Marks)

5. An aircraft leaves A (60^0N, 13^0W) at 1300 hours and arrives at B (60^0N, 47^0E) at 1700 hrs

(a) Calculate the average speed of the aircraft in knots (3 Marks)

(b)Town C (60^0N, 133^0N) has a helipad. Two helicopters S and T leaves B at the same time. S moves due West to C while T moves due North to C. If the two helicopters are moving at 600ots.Find

(i) The time taken by S to reach C (2 Marks)

(ii) The time taken by T to reach C (2 Marks)

(c)The local time at a town D (23^0N, 5^0W) is 1000 hours. What is the local time at B.(3 Marks)