Principles of Geoinformatics

COMPASS SURVEYING

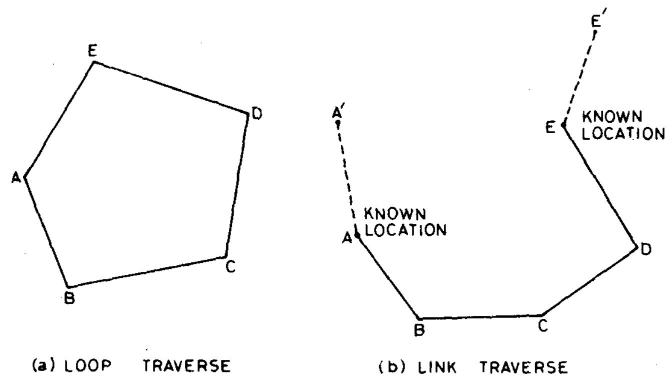
Compass Surveying

TRAVERSE

In traverse surveying the direction of survey lines are fixed by angular measurements and not by forming a network of triangles as is done in chain surveying. A traverse may be (a) Closed or (b) Unclosed.

Closed Traverse

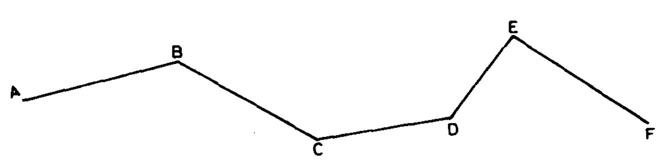
A traverse is said to be closed when a complete circuit is made, i.e. when it returns to the starting point forming a closed polygon as in (Fig. a), or when it begins and ends at points whose positions on plan are known (Fig. b).



It is particularly suitable for locating the boundaries of lakes, woods, etc, and for the survey of moderately large areas.

Unclosed or Open Traverse

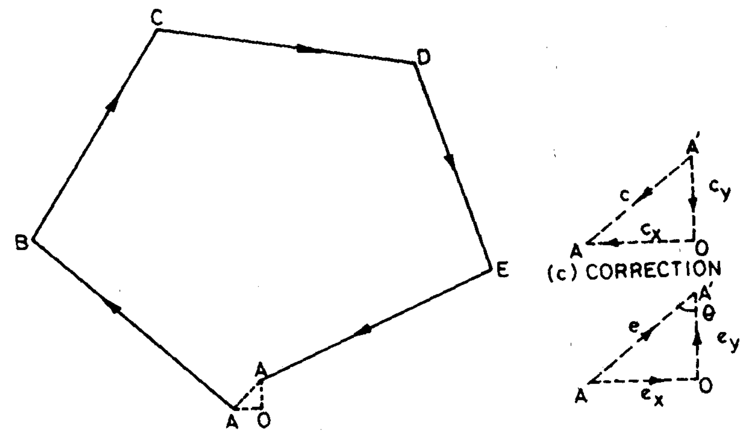
A traverse is said to be open or unclosed when it does not form a closed polygon. It consists of a series of lines extending in the same general direction and not returning to the starting point.



Similarly, it does not start and end at points whose positions on plan are known. It is most suitable for the survey of a long narrow strip of country, e.g. the valley of a river, the coast line etc.

Closing Error in a Traverse

If a closed traverse is plotted according to the field (procedure) measurements and if the end of traverse will not coincide exactly at the starting point. This discrepancy is due to the errors in the field observations i.e. magnetic bearings and linear distances. Such error is known as closing error.



The x and y components of the closing errors can be determined as

$$e_x = \sum D$$
$$e_y = \sum L$$

However in the case of link traverse

$$e_x = X' - X$$

and $$e_y = Y' - Y$$

where X' and Y' are computed coordinates of the final control point, and X and Y are the corresponding known coordinates.

The total closing error is given by

$$e = \sqrt{(e_x)^2 + (e_y)^2}$$

The direction of the closing error AA' is given by

$$\tan\theta = \frac{e_x}{e_y}$$

The signs of e_x and e_y will define the quadrant in which the closing error lies.

The signs of corrections c_x and c_y will be opposite to those of errors.

$$c_x = -e_x$$

and $$c_y = -e_y$$

INSTRUMENTS FOR MEASUREMENT OF ANGLES

In order to plot a survey line on paper, its length and direction must be known. The direction of a survey line may be defined either (i) by the horizontal angle between the line and the line adjacent to it, or (ii) by the angle called the bearing, between the fixed line of reference called the meridian, and the line.

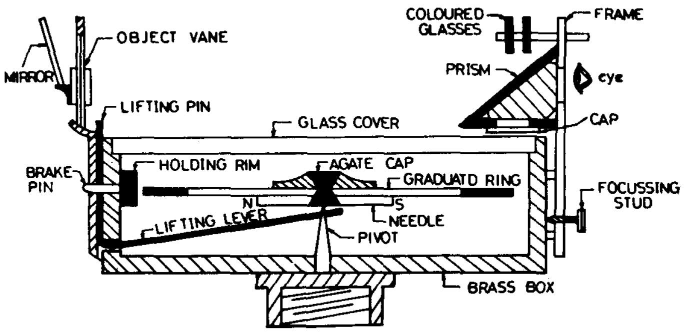
For measuring angles in survey work, the instruments commonly used are (i) the compass, and (ii) the theodolite.

Prismatic Compass

The construction of prismatic compass is illustrated in fig.3.

The compass needle is of broad form, and carries an *aluminum ring* of from 2 & 1/2 inch to 6 inch in diameter, graduated to half degrees. The special feature of the instrument lies in the construction of the *eye vane*, which carries a *reflecting prism* whereby a view of the compass ring is presented to an eye placed opposite the sighting slit. The observer, while sighting through the slit past the *object vane* wire or bar, sees the latter cutting the image at the required bearing, which is therefore read simultaneously with sighting. The compass ring is graduated from the S. End of the needle because the readings are taken at the end of the diameter remote from the object. The prism has both the horizontal and vertical faces convex, so that a magnified Image of the graduation is formed, and focusing to suit different observers is effected by moving the prism vertically by means of *stud*. To reduce excessive oscillation of the compass ring caused by unsteadiness of the hand, a light *spring*, carrying a *braking pin*, is fitted inside the compass box. On gently pressing the pin inwards, the spring is made to touch the ring and act as a brake.

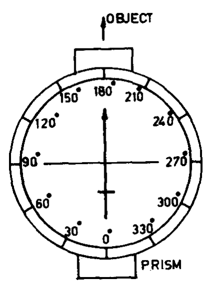
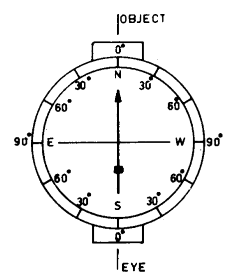
When the instrument is not in use, the object vane is folded down on the face of the glass cover, and presses against the *lifting pin*, which lifts the needle off the *pivot*. The vane folds outwards, and is held by the hinged strap, and a metal lid is placed over the *glass cover* and *object vane*.



Surveyor's Compass

The surveyor's compass was formerly much used in land surveying, but now it is little used.

Prismatic Compass vs. Surveyor's Compass

	Component	Prismatic Compass	Surveyor's Compass
1.	magnetic Needle	The needle is of broad based needle type. The needle does not act as index.	The needle is of 'edge bar type' and it acts as an index also.
2.	Graduated Ring	The graduated ring is attached with the magnetic needle and does not rotate alongwith the line of sight/compass box.	The graduated ring is attached to the compass box along its perimeter and rotates along with the line of sight. The ring is not attached to the magnetic needle and the needle moves independently.
3.	Graduations	The graduations are in whole circle bearing system having 0^0 at south end, 90^0 at west, 180^0 at north and 270^0 at east. 	The graduations are in the quadrantal bearing (Q.B.) system, having 0^0 at N and S ends;90^0 at East and West ends. East and West ends are interchanged. 
4.	Sighting Vanes	The eye vane consists of a small metal vane with slit. The object vane consists of a metal vane with a vertical hair in a wide slit.	The eye vane consists of a metal vane with a fine slit. The object vane consists of a metal vane with a vertical hair.
5.	Tripod	The tripod stand may or may not be provided. The instrument can be used even by holding suitably in hand.	The instrument must be used with a tripod stand or at least supported on a single pointed rod.
6.	Reading	(a) The reading is taken with the help of a prism provided at the eye slit. (b) Sighting of the object and reading of the graduated ring are	(a) The reading is taken by directly seeing through the top of the glass. (b) The observer has to sight the object first and then go round to

		done simultaneously from one position of the observer.	read the graduation on the ring pointed to by the north end of the needle with the naked eye.

BEARING OF LINES

The bearing of a line is the horizontal angle which the line makes with some reference direction or meridian. The reference direction employed in surveying may be (I) a true meridian (ii) a magnetic meridian or (iii) an arbitrary or assumed meridian. Magnetic meridian is used in plane surveys.

True Meridian

The true meridian passing through a point is the line in which the earth's surface is interested by a plane through the north and south poles and the given point.

Magnetic Meridian

The magnetic meridian of a place is the direction indicated there by a freely floating and properly balanced magnetic needle, uninfluenced by local attractive forces. Magnetic meridian does not coincide with true meridian except in certain localities, and the horizontal angle between the two directions is termed as Magnetic Declination of the needle.

Arbitrary Meridian

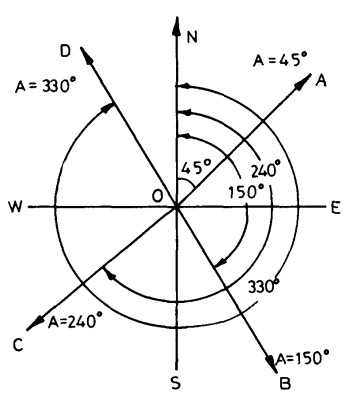
For small surveys, especially in mapped country, any convenient direction may be assumed as a meridian. This artificial meridian is usually the direction from a survey station either to same well defined and permanent point or to an adjoining station.

Designation of Bearings

The bearings are designated by the following two systems:

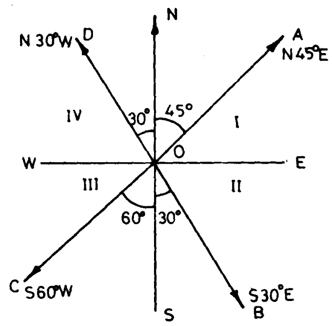
1. Whole circle system,
2. The quadrantal system

Whole Circle System. The bearing of lines, in this system, are measured from the *north* point towards the line in a *clockwise* direction. This is termed as the whole circle bearing of the line and expressed usually as W.C.B.



In this system, the whole circle bearing of a line may have any value from 0° to 360°. The letters N, S, E and W are not at all used to designed the bearing.

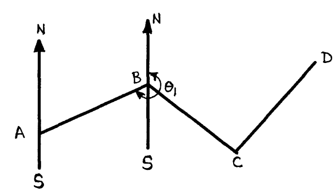
Quadrantal System. The bearing of a line is measured *clockwise or anticlockwise* from the *north and south* point whichever is nearer to the line towards the east or west. The plane around the station is divided into four quadrants.



QUADRANTAL BEARING

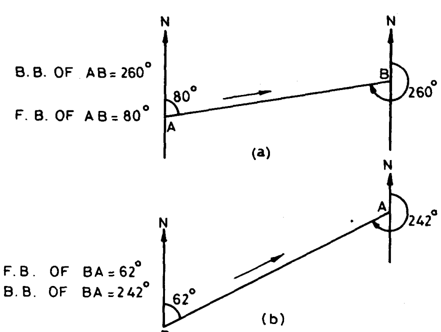
The first quadrant is denoted by NE, second by SE, third by SW and fourth by NW. The quadrantal bearing never exceeds 90°. The bearings obtained in surveyor's compass are the quadrantal bearings.

Fore and back Bearing



The bearings of a survey line in the direction of the survey is called "fore bearing" whereas its bearing in an opposite direction is known as its "back bearing".

In given figure, the bearings of the line AB from the point A to the point B is termed as the fore bearing or simply the bearings of the line AB. The bearing from B to A is termed as back bearing of the line AB or the fore bearing of line BA. from the figure it is clear that the fore bearing of the line AB is θ and the back bearing of AB is θ_1 .

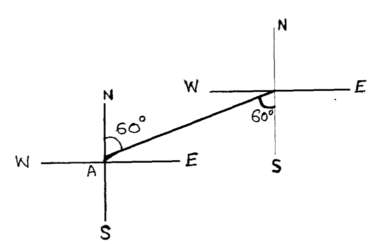


In the *whole circle system*, the back bearing of a line may be obtained by the fore bearing from the following relationship :

$$\text{Back bearing} = \text{fore bearing} \pm 180^0$$

Plus sign may be used when the fore bearing is less than 180^0 and minus sign may be used when the fore bearing is more than 180^0.

Following figures show a few examples.



In the *quadrantal system*, the fore and back bearing of a line will be numerically same but will be in the diametrically opposite quadrants, i.e. if the fore bearing of a line is N60^0E then its back bearing will be S60^0W. This is illustrated in Figure.

Therefore, the back bearing of a line may be obtained by simply interchanging N for S, or S for N, and E for W, or W for E.

Reduced Bearings (or Quadrantal Bearings)

For finding the values of the trigonometrical functions of whole circle bearings exceeding 90^0, reference has to be made to the tables to the corresponding angles which are less than 90^0 and which possess the same numerical values of the functions. This angle is called the **reduced bearing**. The following table may be referred to obtain the reduced bearings from the whole circle bearings.

No.	W.C.B.	Corresponding R.B.	Quadrant
1	0^0 and 90^0	W.C.B.	NE
2	90^0 and 180^0	180^0-W.C.B.	SE
3	180^0 and 270^0	W.C.B. - 180^0	SW
4	270^0 and 360^0	360^0 - W.C.B.	NW

Example

No.	W.C.B.	Corresponding R.B.
1	$75^0$42’	N $75^0$42’ E
2	$112^0$04’	S $67^0$56’ E
3	$259^0$32’	S 79^0 32’ W
4	$339^0$42’	N $20^0$18’ W

Example

No.	R.B.	Corresponding W.C.B.
1	N $10^0$20’ E	$10^0$20’
2	S $46^0$24’ E	$133^0$36’
3	S $25^0$47’ W	$205^0$47’
4	N $40^0$17’ W	$319^0$43’

Example

Find the back bearing of the line LM whose fore bearing. is $320^0$24’.

Solution

As the fore bearing of LM = N $24^0$12’ E

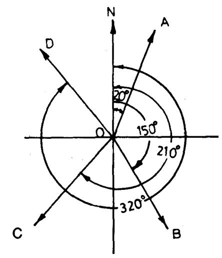
Back bearing of LM = S 24^0 12’ W

Example

Convert the following whole circle bearings to the quadrantal bearings: (i) 20^0; (ii) 150^0 (iii)210^0; and (iv) 320^0.

Solution

The lines OA, OB, OC and OD show the given directions. The required quadrantal bearings are:



Line OA	N 20^0 E
Line OB	S 30^0 E
Line OC	S 30^0 W
Line OD	N 40^0W

Problem

Convert the following whole circle bearings to reduced bearings (i) 65^0-30' (ii) 140^0-20' (iii) 255^0-10' (iv) 336^0-40'

Answer: N$65^0$30'E, S$39^0$40'E, S$75^0$10'W, N$23^0$20'W

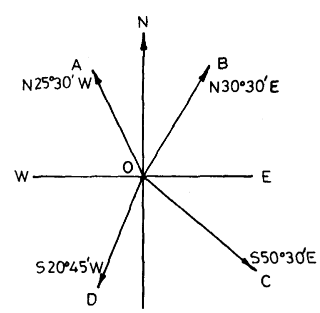
Example

Convert the following quadrantal bearings to the whole circle bearings: (i) N 25^0 $30'$ W; (ii) N 30^0 30' E; (iii) S 20^0 45' W; (iv) S 50^0 30' E

Solution

The lines OA, OB, OD and OC show the given lines.

The whole circle bearing can be written directly.



Line OA	$360^0 - 25^0\ 30' = 334^0\ 30'$
Line OB	$30^0\ 30'$
Line OD	$180^0 + 20^0\ 45' = 200^0\ 45'$
Line OC	$180^0 - 50^0\ 30 = 129^0\ 30'$

Problem

Convert the following reduced bearings to whole circle bearings (i) N$56^0$30'E (ii) S$32^0$15'E (iii) S$85^0$45'W (iv) N$15^0$10'W

Answer: $56^0$30', $147^0$45', $265^0$45', $344^0$50'

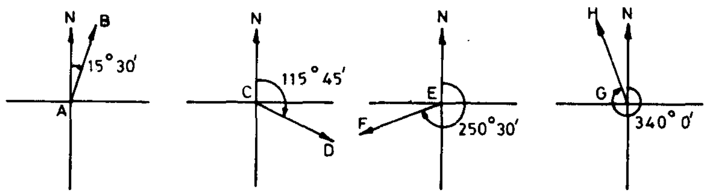
Example

The fore bearings of the four lines AB, CD, EF and GH are, respectively, as under: (i) 15^0 30' (ii) 115^0 45' (iii) 250^0 30' (iv) 340^0 0'

Determine the back bearings.

Solution

Given figures show the four lines.



The back bearings of lines AB and CD are obtained by adding 180^0 as the fore bearings are less than 180^0.

Line AB $15^0 30' + 180^0 = 195^0 30'$

Line CD $115^0 45^0 + 180^0 = 295^0 45'$

The back bearing of lines EF and GH are obtained by subtracting 180^0 as the fore bearings are greater than 180^0.

Line EF $250^0 30' - 180^0 = 70^0 30'$

Line GH $340^0 - 180^0 = 160^0 0'$

The reader should verify the back bearings obtained by reversing the directions of arrows.

Problem

Find back bearings of the following observed fore bearings of lines AB $63^0 30'$, BC $112^0 45'$, CD $203^0 45'$ and DE $320^0 30'$.

Answer: $243^0 30'$, $292^0 45'$, $23^0 45'$ and $140^0 30'$

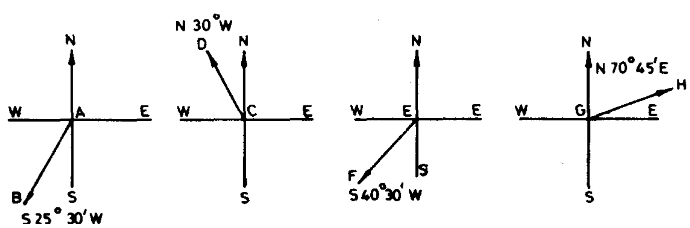
Example

The fore bearings of the four lines AB, CD, EF and GH are, respectively, as under: (i) S 25^0 30' W; (ii) N 30^0 W; (iii) S 40^0 30' W; (iv) N 70^0 45'E

Determine the back bearings.

Solution

Given figures show the four lines.



The back bearings are obtained by interchanging the letters S and N and also by interchanging E and W.

Line AB	N 25^0 30' E
Line CD	N 30^0 0' E
Line EF	N 40^0 30' E
Line GH	N 70^0 45' W

Problem

The following are the fore bearings of lines. Find their back bearings.

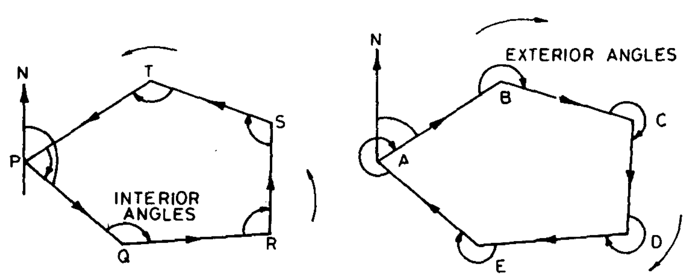
Line	*F.B.*
AB	*N$28^0$30'E*
BC	*S$45^0$10'E*
CD	*S$16^0$15'W*
DE	*N$63^0$45'W*

Answer: S$28^0$30'W, N$45^0$10'W, N$16^0$15'E, S$63^0$45'E

CALCULATIONS OF BEARINGS FROM INCLUDED ANGLES

In a traverse, sometimes the included angles are measured directly with a theodolite, If the bearing of anyone line (generally, the first line) is also measured in the field, the bearings of all other lines can be calculated from the observed bearing of one line and the included angles.

When two lines meet at a point, they form an *interior* angle and an *exterior* angle, An interior angle is the one which is on the inner side of the traverse, It is generally the smaller of the two angles formed, but sometimes it can be the larger of the two angles, A sketch should be drawn to determine whether the interior angle is smaller than the exterior angle or not.



(a) Counter clockwise traverse (b) Clockwise traverse

The clockwise angles will be the interior angles if the traverse is run in the counter-clockwise direction (see figure "a").

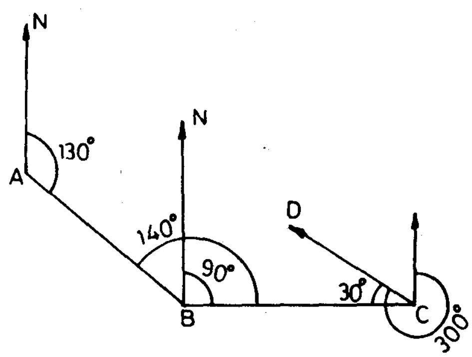
However, the clockwise angles will be exterior angles if the traverse is run in the clockwise direction (see figure "b").

In the case of a traverse in which the included angles have been measured, the bearing of a line is determined by applying the following rule:

Bearing of any line = Bearing of the preceding line + included angle.

If the sum of the terms on R.H.S. is greater than 360^0, deduct 360^0,

For example, in following figure, the bearing of the line BA is 310^0, and the included angle is 140^0.



Bearing of line BC= Bearing of BA + included angle

Bearing of line BC = $310^0 + 140^0 = 450^0$

Deduct 360^0 as the sum is greater than 360^0.

Therefore, bearing of line BC = $450^0 - 360^0 = 90^0$.

Similarly, the bearing of line CD can be found.

Bearing of line CD = bearing of CB + included angle = $270^0 + 30^0 = 300^0$

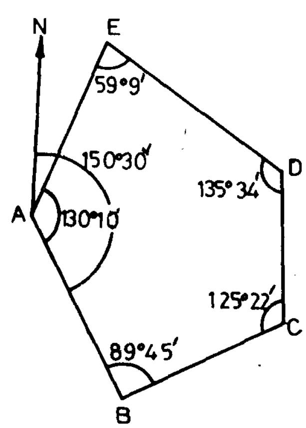
Example

In a closed traverse ABCDE, the bearings of the line AB was measured as $150^0 30'$. The included angles were measured as under: $\angle A = 130^0 10'$, $\angle B = 89^0 45'$, $\angle C = 125^0 22'$, $\angle D = 135^0 34'$, $\angle E = 59^0 9'$.

Calculate the bearings of all other lines.

Solution

See following figure.



Bearing of BC = Bearing of A + angle ABC = $(150^0 30' + 180^0) + 89^0 45' = 420^0 15' = 60^0 15'$

Bearing of CD = Bearing of CB + angle BCD = $(60^0 15' + 180^0) + 125^0 22' = 365^0 37' = 5^0 37'$

Bearing of DE = Bearing of DC + angle CDE = $(5^0 37' + 180^0) + 135^0 34' = 321^0 11'$

Bearing of EA = Bearing of ED + angle DEA = $(321^0 11' – 180^0) + 59^0 9' = 200^0 20'$

Check: *For checking the calculations, it is advisable to calculate the bearing of the first line from bearings of the last line.*

Bearing of AB = Bearing of AE + angle EAB = $(200^0 20' – 180^0) + 130^0 10' = 150^0 30'$ Hence O.K.

Example

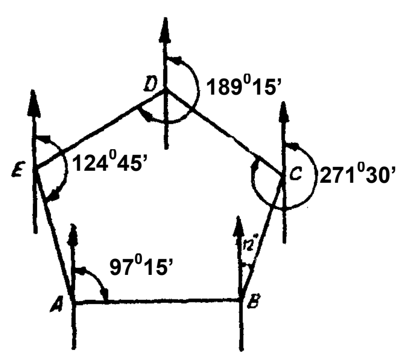
The bearing of the sides of a traverse ABCDE are as follows:

Side	***F.B.***	***B.B.***
AB	*$97^0 15'$*	*$277^0 15'$*
BC	*$12^0 0'$*	*$192^0 0'$*
CD	*$271^0 30'$*	*$91^0 30'$*
DE	*$189^0 15'$*	*$9^0 15'$*
EA	*$124^0 45'$*	*$304^0 45'$*

Calculate the interior angles of the traverse.

Solution

See figure.



Bearing of AE = B.B. of EA – F.B. of AB = $304^0 45' – 97^0 15' = 207^0 30'$ (exterior angle)

∴ Interior $\angle A = 360^0 – 207^0 30' = 152^0 30'$

Bearing of BA = B.B. of AB – F.B. of BC = $277^0 15' – 12^0 0' = 265^0 15'$ (exterior angle)

∴ Interior $\angle B = 360^0 – 265^0 15' = 94^0 45'$

Bearing of CB = B.B. of BC – F.B. of CD = $192^0 0' – 271^0 30' = 79^0 30'$

∴ $\angle C = 79^0 30'$

Bearing of DC = B.B. of CD – F.B. of DE = $91^0 30' – 189^0 15' = 97^0 45'$

∴ $\angle D = 97^0 45'$

Bearing of ED = B.B. of DE – F.B. of EA = $9^0 15' - 124^0 45' = 115^0 30'$

∴ $\angle E = 115^0 30'$

Check: *The sum of the interior angles of a polygon must be equal to (2n – 4) right angles, where n is the number of sides of the polygon. In this case, the sum of the angles must equal* $(2 \times 5 - 4) \times 90^0 = 540^0$.

$\angle A + \angle B + \angle C + \angle D + \angle E = 152^0 30' + 94^0 45' + 79^0 30' + 97^0 45' + 115^0 30' = 540^0 0'$ *O.K.*

Problem

The following were the interior angles of a closed traverse ABCD:

$\angle A = 78^0 36'$, $\angle B = 101^0 24'$, $\angle C = 96^0 45'$, $\angle D = 83^0 15'$

If the fore bearing of the line BC is $135^0 15'$*, find the bearings of all the remaining sides, assuming the work done in a clock-wise direction.*

Answer: Bearing of CD = $218^0 30'$*; of DA =* $315^0 15'$*; of AB =* $56^0 39'$

Problem

The following are the bearings of the lines of a closed traverse ABCD:

Line	F.B.
AB	$N56^0 10'E$
BC	$S50^0 40'E$
CD	$S19^0 50'W$
DA	$N70^0 40'W$

Calculate the interior angles of the traverse.

Answer: $\angle A = 53^0 10'$, $\angle B = 106^0 50'$, $\angle C = 109^0 30'$, $\angle D = 90^0 30'$

LOCAL ATTRACTION

The magnetic needle does not record the direction of magnetic meridian when it is under the influence of attractive bodies in its surroundings such as steel structures, electric cables carrying current etc. Such a disturbing influence is called ***local attraction.*** Local attraction causes deflection of compass needle.

Detection of Local Attraction

Unless the local attraction at a place is found out and corrected, the bearings taken from a compass can not be regarded as correct. To test for local attraction, it is necessary to observe the bearing of each line from both its ends. If the fore bearing and back bearing of a line differ by 180^0, it may be taken for granted that no local attraction exists at either station, provided the compass is free from the instrumental error. If the back and fore bearings of a line do not differ by 180^0 then the deviation may be due to observational error or the local attraction. The reading should be again taken and verified. If they do not agree then the local attraction may be at one or both the stations. The observed bearings of the lines may be corrected for local attraction by finding out the amount of error and its nature and applying the same to affected bearings of sides.

Rule: *If at a station, observed bearing of a line is more than that of its correct one, then the error at the station is +ve and the correction is –ve and vice versa.*

Example

A closed compass traverse ABCDE was run and the observed bearings of the lines are as follows :

Line	*Observed bearing*
AE	$319^0 00'$
AB	$72^0 45'$
BA	$252^0 00'$
BC	$349^0 00'$
CB	$167^0 15'$
CD	$298^0 30'$
DC	$118^0 30'$
DE	$229^0 00'$
ED	$48^0 00'$
EA	$135^0 30'$

Correct the bearings for local attraction.

Solution

By inspecting the values of the fore and back bearings of the lines, it is clear that the observed fore and back bearings of the line CD(i.e. bearings of CD and DC) exactly differ by 180^0. Therefore, both the stations C and D are free from local attractions and therefore the bearings observed from these stations should be correct bearings. Therefore, the bearings of the line DE should be correct bearing.

Therefore, bearing of ED(back bearing of DE) = $229^0 - 180^0 = 49^0$. But the observed bearing of the line ED = 48^0, i.e. the station E is affected by local attraction. To bring the observed, incorrect bearing of the lines at the station E, to its corrected value 1^0 should be added. Therefore, the error at the station E is said to be $+1^0$, i.e. to correct the values of bearings observed at the station E, $+1^0$, should be added to the observed bearings, therefore, the correct bearings of lines ED and EA are 49^0 and $136^0 30'$ respectively. From the correct bearing of the line EA, the station A may be corrected as follows : Bearing of AE(back bearing of EA) =

$136^0 30'$(bearing of EA) + 180^0 = $316^0 30'$. But the observed bearing of the line AE is 319^0. Therefore, the station A is affected by local attraction. To correct the bearing of AE, observed from station A, $2^0 30'$ should be deducted. Therefore, the correction for local attraction = - $2^0 30'$. The correct bearings of AE and AB are, therefore, $316^0 30'$ and $70^0 15'$ respectively. Therefore the correct bearing of BA(back bearing of AB) = $70^0 15'$(bearing of AB) + 180^0 = $250^0 15'$. But the observed bearing of BA is 252^0. Therefore, the station B is affected by local attraction. The correction for local attraction is 1^0 45'. Therefore, the correct bearings of BA and BC are $250^0 15'$ and $347^0 15'$ respectively.

The readings may be tabulated as under:

Line	Observed bearing	Correction	Corrected bearing
AE	$319^0 00'$	$-2^0 30'$	$316^0 30'$
AB	$72^0 45'$	$-2^0 30'$	$70^0 15'$
BA	$252^0 00'$	$-1^0 45'$	$250^0 15'$
BC	$349^0 00'$	$-1^0 45'$	$347^0 15'$
CB	$167^0 15'$	$0^0 00'$	$167^0 15'$
CD	$298^0 30'$	$0^0 00'$	$298^0 30'$
DC	$118^0 30'$	$0^0 00'$	$118^0 30'$
DE	229^0 00'	$0^0 00'$	$249^0 00'$
ED	$48^0 00'$	$+1^0$ 00'	49^0 00'
EA	135^0 30'	+ 1^0 00'	136^0 30'

Example (AMIE Summer 95)

The following bearings were observed where local attraction was suspected. Calculate the actual bearings:

Line	*Fore bearing*	*Back Bearing*
AB	*S $40^0 30'$ W*	*N 41^0 15' E*
BC	*S 80^0 45 ' W*	*N 79^0 30' E*
CD	*N 19^0 30' E*	*S 20^0 00' W*
DA	*S 80^0 00' E*	*N 80^0 00' W*

Solution

Since the numerical value of fore and back bearings of line DA is the same, therefore, there is no local attraction at stations D and A. Consequently, bearings taken at D and A are correct.

Therefore, Fore and back bearing of DA are correct.

Also F.B. of AB = S 40^0 30' W (correct)

Correct B.B. of AB = N 40^0 30' E

But observed B.B. of AB = N 41^0 15' E

Difference = 0^0 45' the error at E

Observed F.B. of BC = S 80^0 45' W

Correction at B = -0^0 45'

Correct F.B. of BC = S 80^0 00' W

Correct B.B. of BC = N 80^0 00' E

But observed B.B. of B.C. = N 79^0 30' E

Difference = $0^0$30' the error at C

Observed F.B. of CD = N $19^0$30' E

Corrected at DC = + 0^0 30'

Correct F.B. of CD = N 20^0 00' E

Example

Following is the data regarding a closed compass traverse PQRS taken in a clockwise direction:

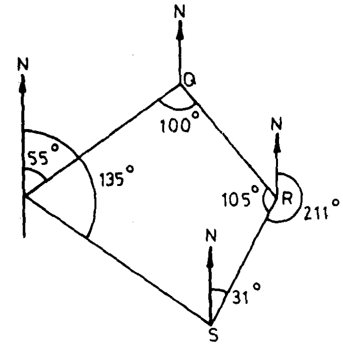
- *(i) Fore bearing and back bearing at station P = 55^0 and 135^0, respectively*
- *(ii) Fore bearing and back bearing of line RS = 211^0 and 31^0, respectively*
- *(iii) Included angles ∠Q = 100^0 ∠R = 105^0*
- *(iv) Local attraction at station R = 2^0W*
- *(v) All the observations were free from all the errors except local attraction.*

From the above data

- *(i) Calculate the local attraction at station P and S.*
- *(ii) Calculate the corrected bearings of all the lines and tabulate the same.*

Solution

Given figure shows the traverse with the given data. As FB and BB of the line RS differ by 180^0, stations R and S are either free from local attraction or affected by it equally. As the station R is affected, the station S is also affected. Therefore, the local attraction at S is also 2^0W. In other words, all the bearing at R and S are increased by 2^0 due to local attraction.



Therefore, corrected FB of RS = $211^0 - 2^0 = 209^0$

Angle QPS = $135^0 - 55^0 = 80^0$

$\angle PSR = 360^0 - (80^0 + 100^0 + 105^0) = 75^0$

The bearings of all the lines can be determined from the included angles and the corrected bearing of the line RS equal to 209^0.

BB of RS = $209^0 - 180^0 = 29^0$

FB of SP = $29^0 + (360^0 - 75^0) = 314^0$

BB of SP = $314^0 - 180^0 = 134^0$

FB of PQ = $134^0 - 80^0 = 54^0$

BB of PQ = $54^0 + 180^0 = 234^0$

FB of QR = $234^0 - 100^0 = 134^0$

BB of QR $134^0 + 180^0 = 314^0$

FB of RS $314^0 - 105^0 = 209^0$ (O.K.)

Problem (AMIE Summer 94)

The following fore and back bearings were observed in traversing with a compass. Correct for local attraction:

Line	*Fore bearing*	*Back Bearing*
AB	44^0 30'	226^0 30'
BC	124^0 30'	303^0 15'
CD	181^0 0'	1^0 0'
DA	289^0 30'	108^0 45'

Answer : Stations C and D are free from local attraction.

Problem

The bearing of a line AB was found to be N79^0E. There was local attraction at A. In order to determine the correct bearing of the line, a point O was selected at which there was no local attraction. The bearing of the line AO was S$53^0$45'E and that of OA was N$57^0$30'W. Determine the correct bearing of the line AB.

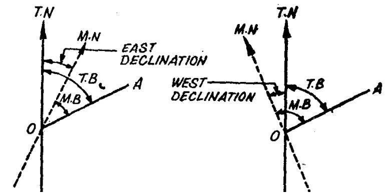
Answer: N$75^0$15'E

Problem

A compass was set on the station A and the bearing of AB was observed $309^0$15'. Then the same instrument was shifted to station B and the bearing of BA was found to be $129^0$15'. Is there any local attraction at the station A, or at station B? Can you give a precise answer? State your comments and support it with rational arguments.

Answer: Both stations are either free from local attraction or equally affected.

MAGNETIC DECLINATION



The magnetic meridian at a place does not coincide with the true meridian at that place except in few places. The horizontal angle which the magnetic meridian makes with the true or geographical meridian is knows as the *magnetic declination*.

When the north end of the needle points to the east of the true meridian, the declination is said to be east(n^0 E); when the north end of the needle points to the west, of the true meridian, the declination is said to be west(n^0 W).

Determination of True Bearing.

True bearing of a line = magnetic bearing of the line ± declination

Use + sign when declination is *east,* and minus sign when it is *west.*

This rule is applicable to W.C.B.

Determination of Magnetic bearing

Magnetic bearing of a line = true bearing of the line minus/plus magnetic declination.

Use the minus sign when the declination is *east*, and plus sign when it is *west.*

This rule is applicable to W.C.B.

Example

The magnetic bearing of a line is 197^0. Find its true bearing if the magnetic declination is 3^0 W.

Solution

Since the magnetic meridian is deflected towards west of the true meridian, true bearing of the line will be magnetic bearing – declination = 197 – 3 = 194^0.

Example

If the magnetic bearing of a line is N 37^0 W and the magnetic declination is 2^0 E, find true bearing.

Solution

True bearing = magnetic bearing – declination = N (37 – 2) W = N 35^0 W

Note: In this problem it is advisable to draw a figure indicating given magnetic bearing and declination and then find true bearing. Because here, above given rules will not be applicable as these rules are applicable to W.C.B.

Problem (AMIE Winter 93)

The following fore and back bearings were observed in traversing with compass where local attraction is suspected.

Line	F.B.	B.B.
AB	$65^0 30'$	$245^0 30'$
CD	$43^0 45'$	$226^0 30'$
BC	$104^0 15'$	$283^0 0'$
DE	$326^0 15'$	$144^0 45'$

Determine the corrected FB ,BB and true bearing of the lines assuming magnetic declination to be 5^0 20' W.

Answer

Line	FB	BB	True Bearing
AB	$65^0 30'$	$245^0 30'$	$65^0 30' - 5^0 20' = 60^0 10^0$ (*)
CD	$45^0 00'$	$225^0 00'$	$39^0 40'$
BC	$104^0 15'$	$284^0 15'$	$98^0 55'$
DE	$324^0 45'$	$144^0 45'$	$319^0 25'$

** Correction for all the magnetic bearings is - $5^0 20'$ as the declination is WEST.*

Problem

The magnetic bearing of a line AB is S 32^0 E. Magnetic declination is 8^0 16' E. What is the true bearing of the line ?

Answer : S 23^0 44' E

Example

Find the magnetic declination, if the magnetic bearing of the sun at noon is (a) 186^0 30' (b) 356^0 42'

Solution

(a) At noon the sun is exactly on the geographical meridian. Since the magnetic bearing of the sun is 186^0 30', it is at the south pole. The magnetic bearing of the south pole is therefore 186^0 30'. Hence the magnetic bearing of the north pole is 6^0 30'. It therefore follows that the magnetic meridian is 6^0 30 ' to the west of the true or geographical meridian.

$\therefore$ Magnetic declination = 6^0 30' W

(b) The magnetic bearing of the sun at noon being 356^0 42', the magnetic bearing of the north pole is 356^0 42'. The magnetic meridian is, therefore, $360^0 - 356^0 42' = 3^0 18'$ to the east of the true meridian.

$\therefore$ Magnetic declination = 3^0 18' E

Problem

The magnetic bearings of a line AB is $88^0 45'$. Calculate the true bearing if (a) the magnetic declination is $5^0 30'$ east (b) the magnetic declination is $4^0 45'$ W.

Answer: $94^0 15'$, 84^0

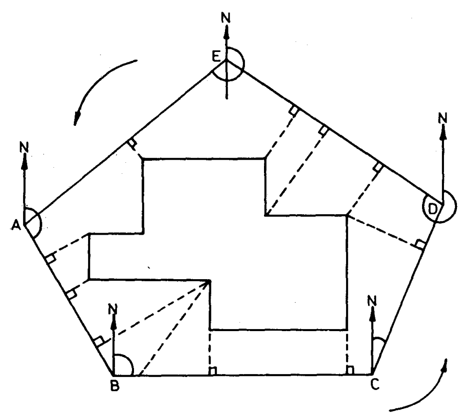
Problem

The true bearing of a tower as observed from a station A is $350^0 30'$, and the magnetic bearing of the tower is $2^0 30'$. The back bearing of the line AB when measured with a prismatic compass was found to be $330^0 30'$. What is the true bearing of the line AB?

Answer: $138^0 30'$

Traversing with the Chain and Compass

To run a compass traverse ABCDEA (see figure), the compass is centred over the starting station A and levelled. The ranging rap at E is sighted and the back bearing of the line EA is measured. Then the ranging rod at B is sighted and the fore bearing of the line AB is taken.



The traverse line AB is ranged as in chain surveying, and its length is measured with a chain or a tape. The offsets to the objects (details) on either side of the traverse line AB are also taken as in chain surveying.

The compass is then shifted to the station B, centred and levelled. The back .. bearing of the line AB and the fore bearing of the line BC are measured. The traverse line BC is then ranged and chained, and offsets are taken.

The compass is then shifted to the station C, D and E, respectively, and the processes of taking bearings, ranging, chaining and offsetting are repeated. Thus the traverse is completed.

ASSIGNMENT

Q.1. (AMIE W06, 6 marks): Draw a neat sketch of prismatic compass and label its parts. Differentiate between prismatic and surveyor's compass.

Q. 2. (AMIE S06, W07, 5 marks): What is meant by local attraction? How is it detected and how are the observed bearings corrected for local attraction?

Q. 3. (AMIE S06, 5 marks): Following are the bearings taken in a closed traverse:

Line	Fore bearing	back bearing
AB	S37^{0}30'E	N37^{0}30'W
BC	S43^{0}15'W	N44^{0}15'E
CD	N73^{0}00'W	S72^{0}15'E
DE	N12^{0}45'E	S13^{0}15'W
EA	N60^{0}00'E	S59^{0}00'W

Compute the interior angles and correct them for observational errors.

Answer: Corrected FB are: S37^{0}30'E, S43^{0}15'W, N72^{0}00'W, N13^{0}00'E, N60^{0}15'E. Corrected BB are: N37^{0}30'W, N43^{0}15'E, S72^{0}00'E, S13^{0}00'W, S60^{0}15'W

Q.4. (AMIE W07, 10 marks): Following are the observed bearings of a closed compass traverse. Assuming the bearings of line CD be free from any error, compute corrected bearings of the traverse.

Line	Fore Bearing	Back Bearing
AB	110^{0}30'	290^{0}00'
BC	227^{0}00'	47^{0}30'
CD	323^{0}30'	143^{0}30'
DA	38^{0}00'	217^{0}00'

Answer: Corrected FB are 110^{0}30', 227^{0}30', 323^{0}30', 38^{0}00'. Corrected BB are 290^{0}30', 47^{0}30', 143^{0}30', 218^{0}00'

Q.5. (AMIE W08, 13 marks): Adjust the bearings of a clockwise running closed compass traverse. Assume the bearing of line AE to be free from error. Given data are:

Line	Fore Bearing	Back Bearing
AB	11^{0}30'	192^{0}00'
BC	84^{0}00'	265^{0}00'
CD	137^{0}30'	317^{0}00'
DE	215^{0}00'	36^{0}00'
EA	287^{0}30'	108^{0}00'

Answer: Corrected FB are 11^{0}30', 84^{0}30', 137^{0}00', 215^{0}00', 288^{0}30'. Corrected BB are 191^{0}30', 264^{0}30', 317^{0}00', 35^{0}00', 108^{0}30'

Q.6. (AMIE W09, 10 marks): A compass traverse ABCDEA was run anti-clockwise and the following bearings were taken where local attraction was suspected:

Line	FB	BB
AB	150^{0}0'	329^{0}45'
BC	77^{0}30'	256^{0}0'
CD	41^{0}30'	222^{0}45'

DE	$314^0 15'$	$134^0 45'$
EA	$220^0 15'$	$40^0 15'$

Determine the local attraction at stations and the correct bearings of lines.

Answer: E and A are free from local attraction. Corrected FB are $150^0 00'$, $77^0 45'$, $43^0 15'$, $314^0 45'$, $220^0 15'$. Corrected BB are $330^0 00'$, $257^0 45'$, $223^0 15'$, 13445', $40^0 15'$.

Q.7. (AMIE S10, 5 marks): Following bearings of the lines of a traverse are measured. Find stations affected by local attraction:

Line	FB	BB
AB	$191^0 45'$	13^0
BC	$39^0 30'$	$222^0 30'$
CD	$22^0 15'$	$200^0 30'$
DE	$242^0 45'$	$62^0 45'$
EA	$330^0 15'$	$147^0 45'$

Answer: D and E are free from local attraction. Corrected FB are $194^0 15'$, $40^0 45'$, $20^0 30'$, $242^0 45'$, $330^0 15'$. Corrected B are $14^0 15'$, $220^0 45'$, $200^0 30'$, $62^0 45'$, $150^0 15'$

Q.8. (AMIE S09, 10 marks): A five sided compass traverse has the following fore and back bearings (sides are nearly equal): AB = $161^0 30'$, 342^0; BC = 90^0, 270^0; CD = 19^0, $199^0 30'$; DE = $306^0 30'$, 126^0; EA = 235^0, $54^0 30'$

Compute the internal angles and express the correct fore bearings in "reduced" bearing system.

Answer: $\angle A = 107^0$; $\angle B = 108^0$; $\angle C = 109^0$; $\angle D = 107^0$; $\angle E = 109^0$. Corrected FB are $S18^0E$, $N90^0E$, $N19^0E$, $S54^0W$, $S55^0W$

Q.9. (AMIE S11, 10 marks): A compass traverse ABCDEA was run anti-clockwise and the following bearings were taken where local attraction were suspected. Determine the included angles:

Line	Fore Bearing	Back Bearing
AB	$150^0 30'$	$329^0 45'$
BC	$78^0 00'$	$256^0 30'$
CD	$42^0 30'$	$223^0 45'$
DE	$315^0 45'$	$134^0 15'$
EA	$220^0 15'$	$40^0 15'$

Answer: $\angle A = 110^0 15'$; $\angle B = 251^0 45'$; $\angle C = 214^0 00'$; $\angle D = 89^0 30'$; $\angle E = 86^0 00'$

Q.10. (AMIE W11, 10 marks): Following bearings were observed for a closed traverse ABCDEA:

Line	Bearing
AB	$140^0 30'$
BC	$80^0 30'$
CD	$340^0 0'$
DE	$290^0 30'$
EA	$230^0 30'$

Calculate the included angles.

Answer: $\angle A = 90^0 00'$; $\angle B = 240^0 00'$; $\angle C = 79^0 30'$; $\angle D = 130^0 30'$; $\angle E = 120^0 00'$

Q.11. (AMIE W06, 8 marks): A and B are two main stations whose coordinates are given below:

Station	N	E

A	1056.9	585.1
B	1426.5	992.7

from a line AC, 154.4 m long, is run on a bearing of $132^0$18' and from C a line CD of length 544 m is run parallel to AB. Find length and bearing of BD.

Answer: 154.43 m, $45^0$24' SE

Q.12. (AMIE S07, 10 marks): What is meant by magnetic declination? An open traverse has the following fore and back bearings:

PQ = $22^0$0', $203^0$0'; QR = $314^0$30', $135^0$0'; RS = $203^0$30', $23^0$30'; ST = $298^0$0', $117^0$30'

Check and correct the values.

Answer: Corrected FB are $23^0$30', $315^0$00', $203^0$30', $298^0$00'. Corrected BB are $203^0$30', $135^0$00', $23^0$30', $118^0$00'

Q.13. (AMIE W10, 10 marks): Magnetic bearings of an open traverse are AB = 71^0, BA = 250^0, BC = 110^0, CB = 292^0, CD = 161^0, DC = 341^0, DE = 219^0, ED = 40^0. Express correct fore bearings in quadrantal system, if declination is $1^0$15'W.

Answer: N$70^0$15'E, S$71^0$15'E, S$20^0$15'E, S$40^0$15'W