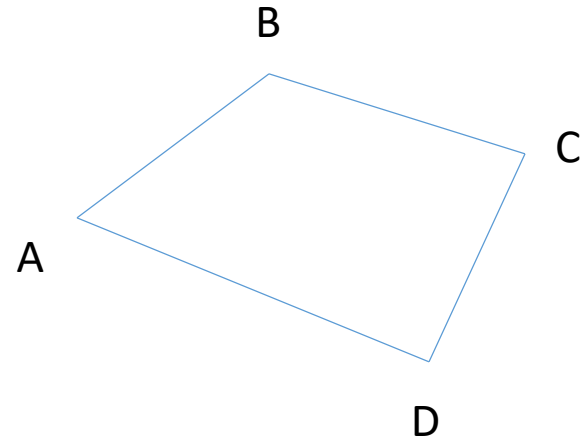
Traverse Survey/Traversing

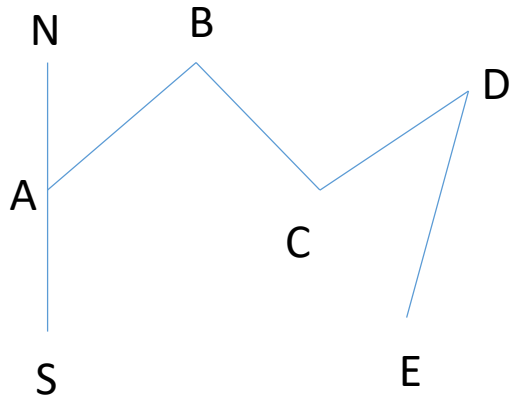
Definition: Traverse survey or Traversing is a type of survey in which **a number connected survey lines form the framework** and the **directions and lengths of survey lines are measured** with the help of an **angle measuring instrument** and a **chain or tape** respectively.



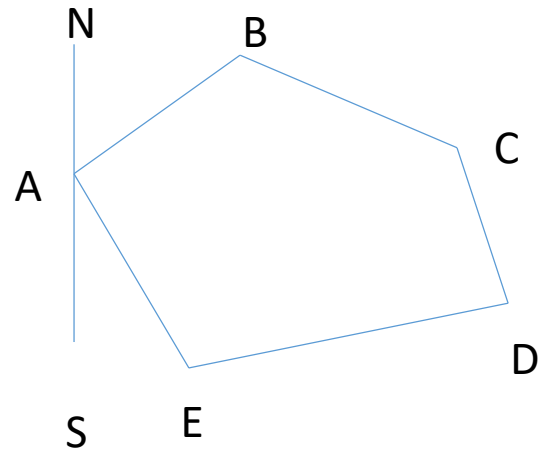
- With the **measurement of angular and linear measurements**, one can locate the positions of A, B, C, D.
- Polygon ABCD known as traverse.

Types of Traverse

- **Open Traverse**: In which end point of last line will not meet the starting point of first line i.e. Point E will not meet point A.



- **Closed Traverse**: In which a complete circuit is made i. e. Point E meet point A.



Bearing:

- **Bearing of a line is the angle**, which the **line makes with reference direction** in **the clockwise direction**.

Meridian:

- **Reference direction** with which **a line makes** an angle/bearing is known as meridian.

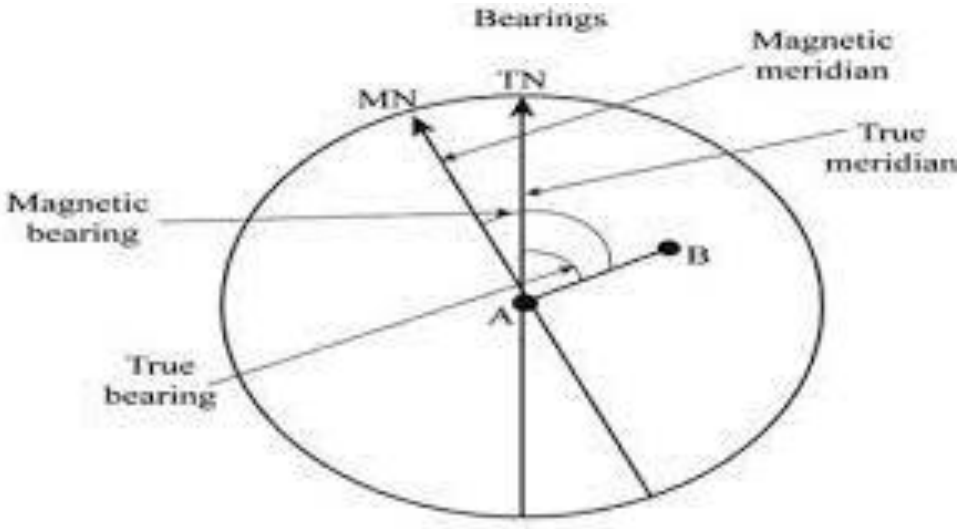
Types of Meridian

True meridian and True Bearing

- Also called **Geographical** meridian.
- Meridian passing through **a point** on the surface of the earth, is the line in which, the **plane passing through north and south poles**
- Angle between the true meridian and line is called true bearing.

Magnetic Meridian and Magnetic Bearing:

- Direction **indicated by a freely suspended magnetic needle** is called magnetic meridian.
- Angle which a line makes with the magnetic meridian is called magnetic bearing or **simply bearing** of the line.

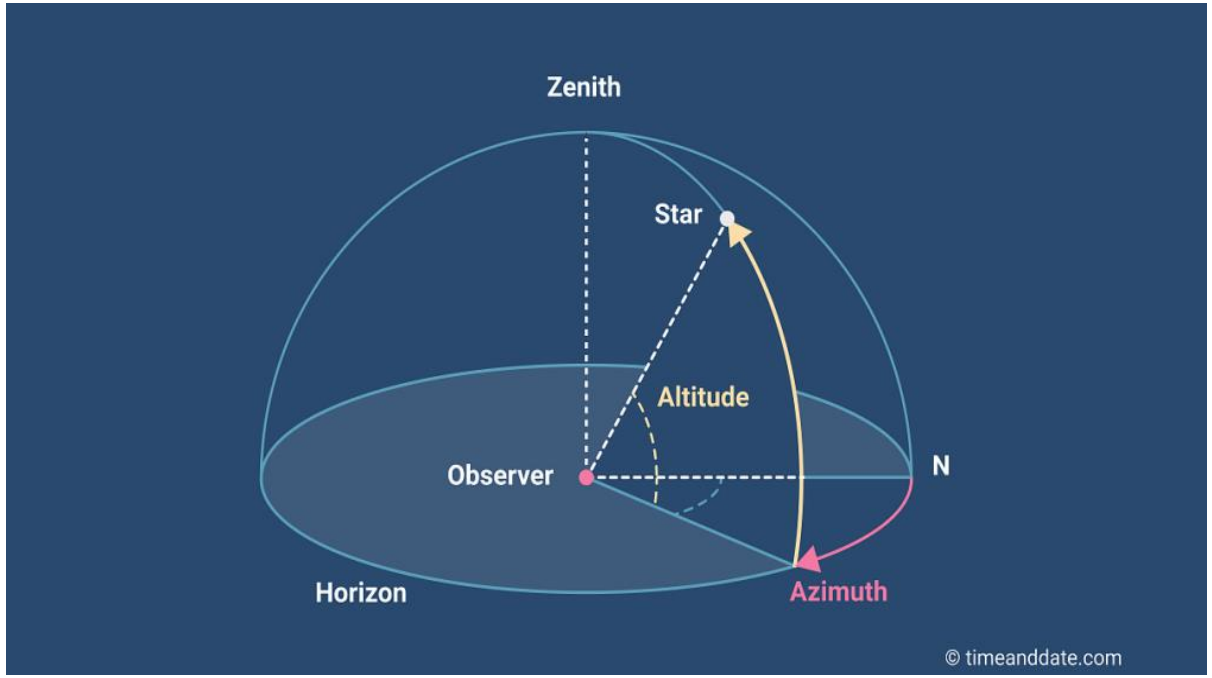


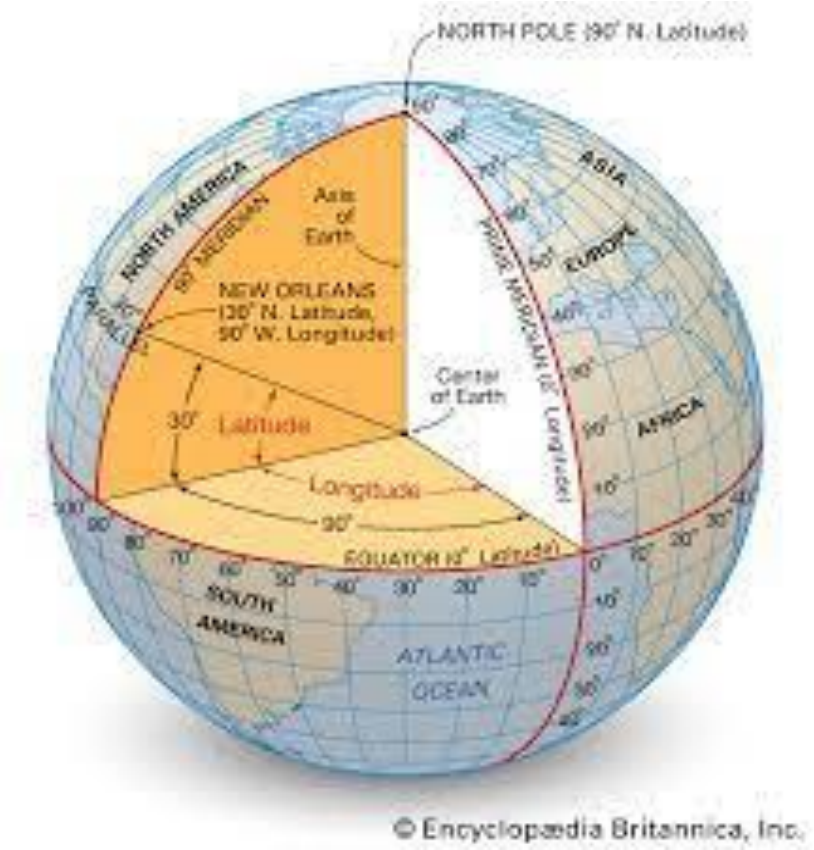
In **Plane surveying,** **Magnetic bearing** is taken, while in **geodetic surveying, true bearing** is taken.

Arbitrary Meridian:

- For **small survey work**, sometimes the **first line of the survey** or **any convenient direction** may be taken as a meridian, which is known as arbitrary meridian.
- Angle between this meridian and a line is known as **arbitrary bearing** of the line.

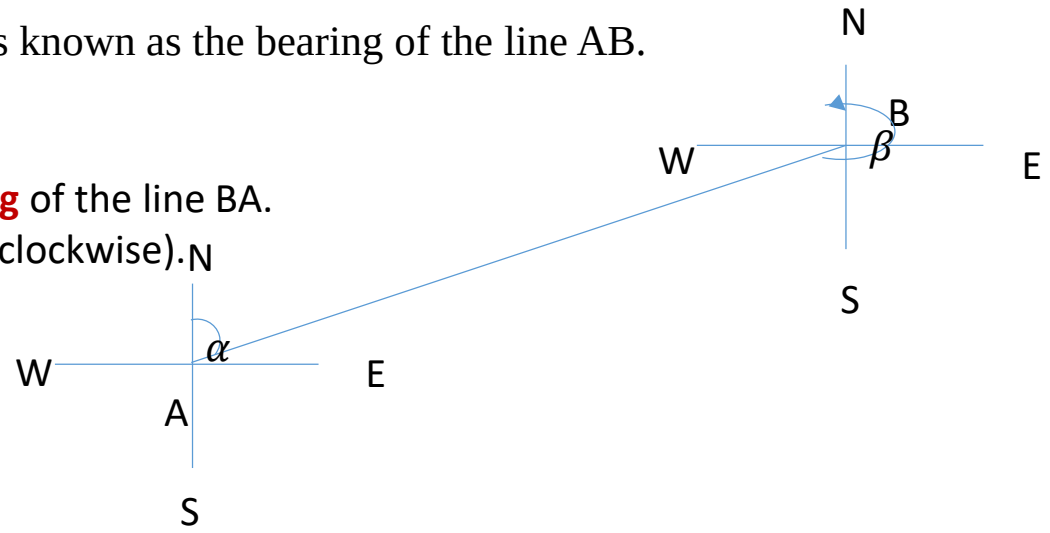
True meridian:





Bearings:

- Bearing of a line is the **angle which the line makes with fixed reference line** (Magnetic Meridian) and is always measured in **clockwise** direction.
- In the figure, N-S indicates **North-south line** which is a reference line.
- Angle α measured in clockwise direction from north line up to AB line, is known as the bearing of the line AB.



Forward Bearing (FB):

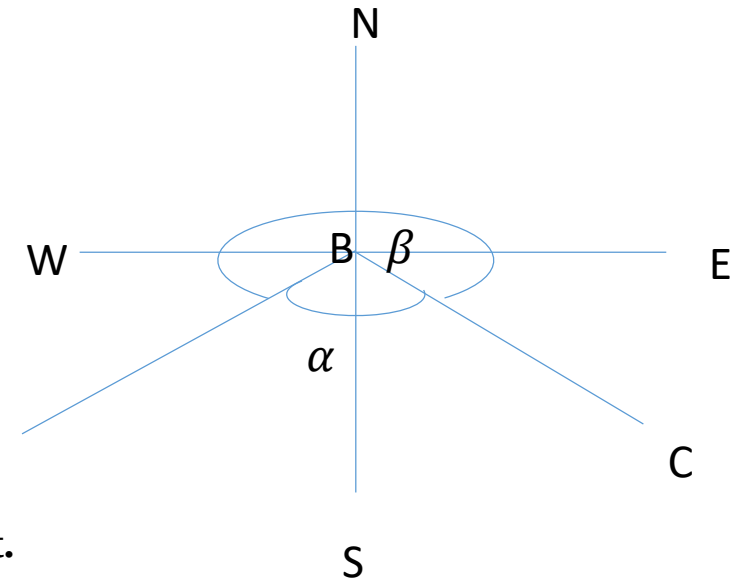
- Angle α **is called FB** of the line AB and the angle β **is the forward bearing** of the line BA.
- So, FB of a line is the **bearing in the direction of progress** of the survey (clockwise).

Back Bearing (BB):

- Angle β **is the BB of line AB** and angle α **is the BB of the line BA**.
- So, the BB of a line is the **bearing in the reverse direction** of the progress of the survey.

FB and BB of a line differ by 180°.

When the FB of a line is known, the BB of the same line can be obtained by the relation: **BB ~ FB = 180°**



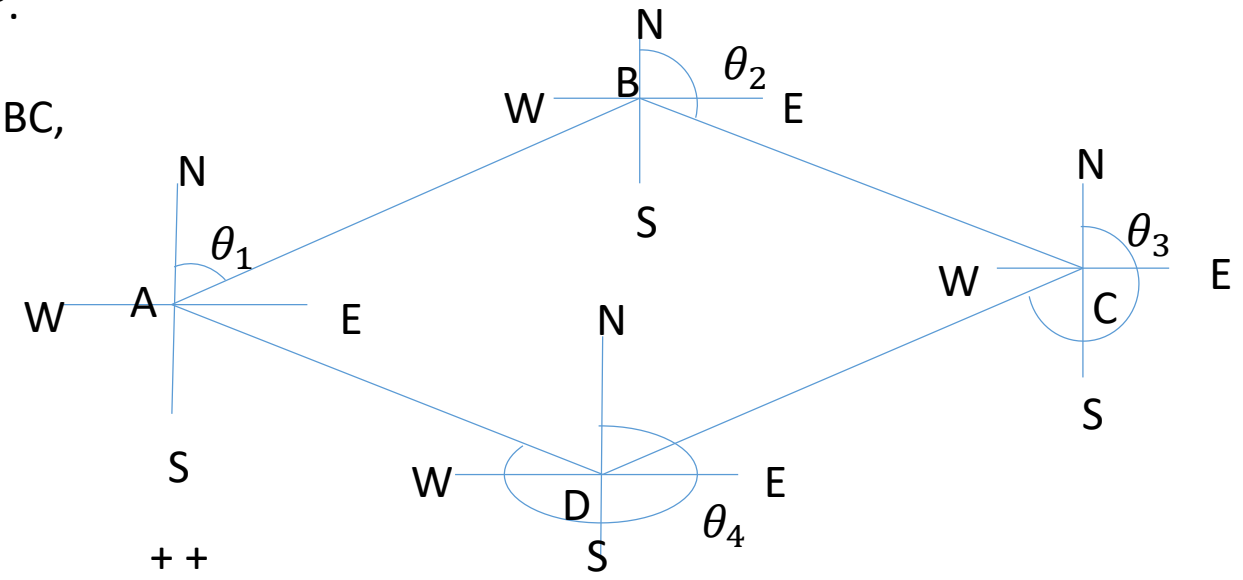
- If the FB is **less than 180°**, + sign to be used.
- If the **FB exceeds 180°**, - sign should be used.
- Difference of the bearings of two lines at a station is the angle between them {included (α) or excluded angle (β) }
- Similarly, the bearing of the line BA is β.
- **In surveying, the line AB is not same as the line BA, because the directions are different.**

Whole circle Bearing (WCB):

- **Angle between the magnetic meridian and the line**, is called WCB.
- May have value between **0° - 360°**.
- Bearing of a line, observed in the field is the WCB.
- WCB of a line **coincides with the magnetic meridian** is 0°.
- In the figure, θ_1, θ_2, θ_3, and θ_4 are the WCB of lines AB, BC, CD and DA respectively.

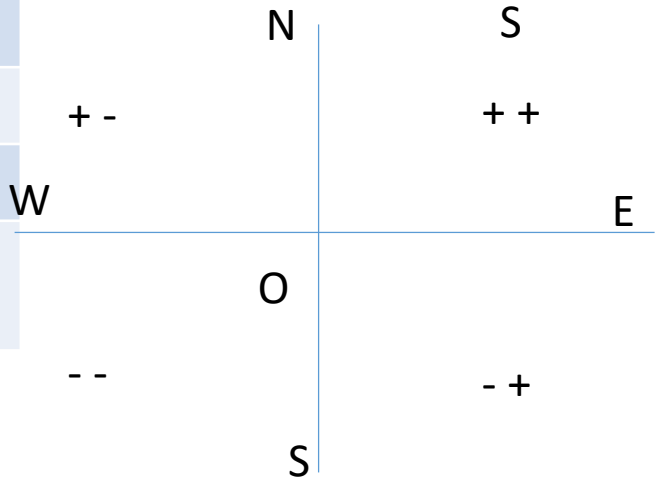
Reduced Bearing (RB):

- If the **WCB of a line** is **greater than 90°**, it is **reduced to a corresponding angle less 90°**, which has same value of trigonometrical functions.
- Corresponding reduced angle is known as RB.
- Quadrant or cardinal direction.



Procedure to obtain RB from WCB:

WCB between	RB	Quadrant
0° - 90°	Same as WCB	NE
90° - 180°	180° - WCB	SE
180° - 270°	WCB- 180°	SW
270° - 360°	360° - WCB	NW



Errors in Measured Angle with Traverse Compass:

- If the **difference between FB and BB of a line is not 180^{o}**, then there are errors in the measured angles. The errors may be due to:

  -**Local attraction**,

  -**Observation** and

  -**Faulty instrument**

Local Attraction:

- Magnetic needle will be deviated from the magnetic meridian due to the influence of magnetic substances.
- Phenomenon known as local attraction.
- Caused by the proximity of iron, steel structures, keys, knife, steel tapes, framed spectacles, iron buttons, arrows, pens, chain, steel tapes etc.

Correction for Local Attraction

When Error is Small:

- Difference between BB and FB is nearly 180^o, BB to be increased or decreased by an amount in order to obtain the corresponding FB.
- Mean is taken between this and FB

Example:

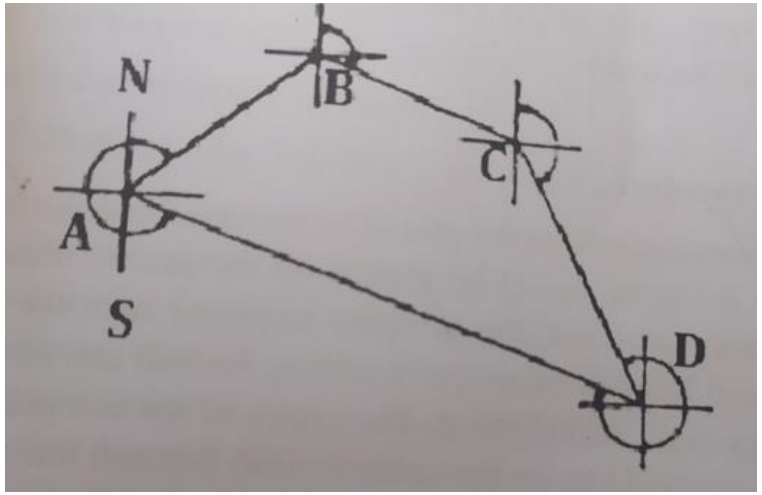
Let the observed FB and BB of a line are $82^o18'$ and $262^o30'$ respectively.

Solution:

Difference between BB and FB is $180^o12'$. Hence 12' is the error which needs to be adjusted.

Half of this added to FB and other half is subtracted from BB.

New corrected bearing are $82^o24'$ and $262^o24'$ respectively and difference is 180^o exactly.



When the Error is Considerable:

Following Procedure is Adopted:

- **Included angles of affected stations are calculated** from the observed bearings.
- Starting from the unaffected line and using the calculated angle, correct bearing of each line is then computed.

Example:

Line.	F.B.	B.B.
AB	52°15′	232°15′
BC	140°40′	320°55′
CD	170°30′	350°10′
DA	290°10′	110°15′

Solution:

From the above data it is found that Stations **A & B are free from local attraction** as the difference between FB and BB of AB is 180^{o}.

Included Angles:

FB of BC= BB of AB - <B=140º40’

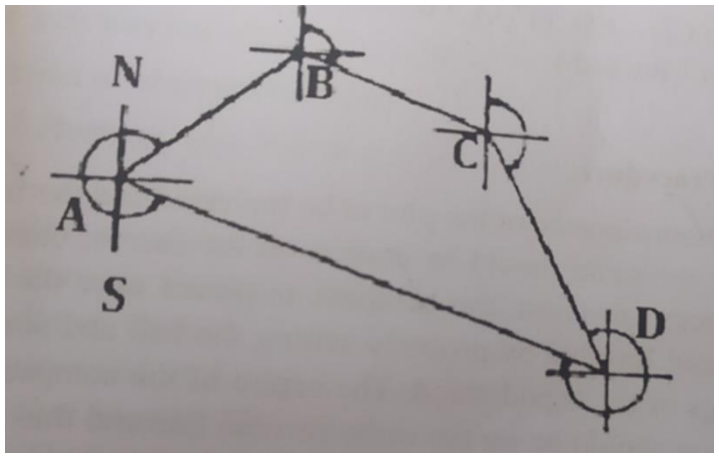
BB of BC= FB of BC + 180º=320º40

FB of CD=BB of BC - < C =170º 15’

BB of CD = FB of CD +180º =350º15’

FB of DA = BB of CD - < D =290º15’

BB of DA = FB of DA - 180º = 110º15



Included Angles:

Corrected Bearings:

< A = BB of DA – FB of AB

=110 º15’ - 52 º15’= 58º0’

<B =BB of AB – FB of BC =

=232 º15’ - 140 º40’=91º25’

< C = BB of BC – FB of CD= 150º25’

< D = BB of CD – FB of DA = $60^{o}0’$

Sum=360 (checked)

What is the Procedure to Perform Traverse Survey?

The steps are:

- Reconnaissance
- Selection of Traverse Stations
- Linear and Angular Measurements

Step 1: Reconnaissance: It is a preliminary field inspection of the entire area that needs to be surveyed. This involves:

1. The surveyor goes to the field and checks the entire area.
2. He decides the best plan of working.
3. He checks the intervisibility of the traverse stations
4. He decides the method of traversing to be adopted
5. Based on the method chosen, the instruments and accessories are selected accordingly.

Step 2: Selection of Traverse Stations

1. A minimum number of traverse stations should be selected.
2. Take the length of the traverse line as long as possible to reduce the time and centering effect of stations.
3. Try to select stations on a level and firm ground
4. After selecting the stations, mark them using pegs.

Step 3: Linear and Angular Measurements

1. The distances between the stations are measured using a tape or chain or the Tacheometric method or EDM instruments.
2. The angular measurements are done using a compass or theodolite.

Methods of Traversing in Surveying

The survey lines and directions are measured **using distance-measuring devices and angle-measuring devices**.

Usually, **a theodolite is used to measure the angles and a tape is used to measure the distances**. However, any combination of linear and angular measuring devices can be used.

The different **methods of traversing are mentioned below:**

1. Chain Traversing
2. Free or Loose Needle Method of Traversing- Chain and Compass Surveying
3. Fast Needle Method - Theodolite Surveying
    a. Included Angle Method
    b. Deflection Angle Method
    c. Fast Needle Method

Chain Traversing

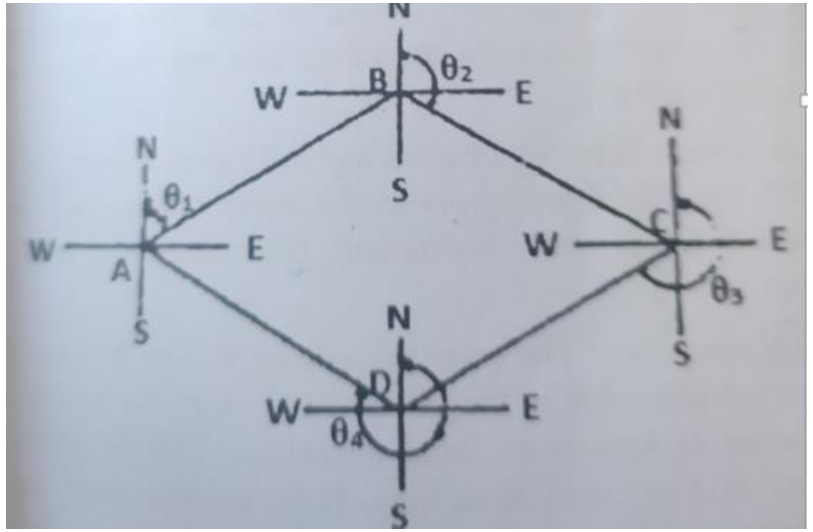
Here, the traverse lines are measured using chain and tape alone. This is a very crude method and cannot be completely relied on.

Chain and Compass Surveying - Free or Loose Needle Method

In this method, the magnetic bearings of the survey lines are measured using **compass** and the traverse lines are measured using, a **tape or chain.** The direction of the magnetic meridian of each traverse line is determined independently.

Field Procedure of Compass Traversing

- **Reconnaissance** of plot and **fixing of stations** as in chain survey.
- When **compass is fixed**, Compass is fixed over the station A and **levelled.**
- Now the **sight vanes of the compass** is **turned towards of the ranging rods at station at B, FB of line AB is taken** and length of AB is measured.



- Simultaneously, **offsets are taken on both sides** of with the help of chain, tape and optical square.
- Compass is then **shifted to station B** and **levelled**.
- Now turning the **sight vane towards station A**, bearing of BA is taken. This angle is the **FB of BA** and **BB of AB**.
- In this way, FB, BB, length and offsets of each line are measured.
- To minimize the errors in readings, at least 3 reading of line from the same station should be taken and mean will be considered.
- **Field book to record** as chain survey except recording of FB and BB of each line.
- **BB of previous line** and **FB of front line** to be recorded at each station.

Plotting of a Compass Traverse

Following steps should be considered before plotting a traverse:

- Selection of suitable **scale**
- A **rough sketches** of the traverse to an approximate scale to see as to how best way the sides can be arranged, on drawing sheet.
- **Correction** of the observed bearing.

Methods of Plotting of Compass Traverse Survey:

- By **Parallel Meridians** through each station
- By **included angle** and
- By **Rectangular coordinates**.

By Parallel Meridians through each station

- Station **A is fixed first** on the drawing sheet, then a line NS (**magnetic meridian) is drawn** through it.
- **Bearing of the line AB** is drawn with a protractor and its length is taken from the chosen scale.
- **Station B is now located**. Now through B, again magnetic meridian NS is drawn
- Bearing and the length of the line BC are drawn in the same way as AB.
- Same procedure is followed for the stations C & D.

By Included Angle:

- Method consist of **drawing a magnetic meridian** NS through station A.
- **Bearing of the line AB is drawn** by a protractor and its length is measured from the chosen scale.
- **Station B is now fixed**.
- Now the **included angle is ABC at B**, which was **calculated from BB of AB and FB of BC.**
- **Length BC is taken** from the chosen scale and station C is fixed.
- At C,D and E the same procedure is followed.

Plotting of Compass Traverse by Rectangular Coordinate Method

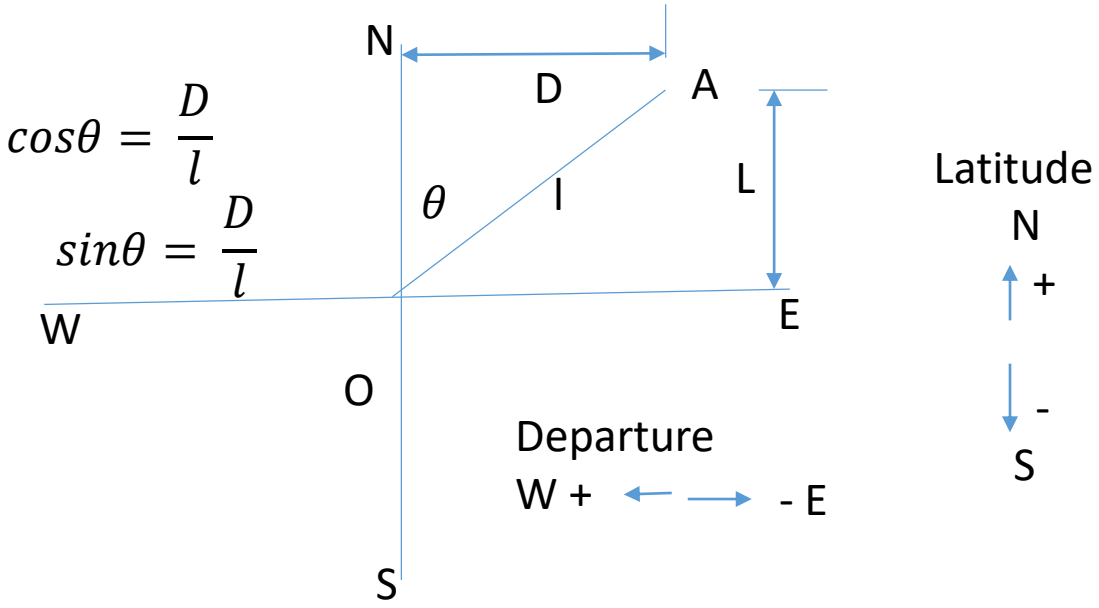
- Coordinate are the **Latitude** and **Departure**.
- To know the coordinates of a point:

$D = lsin\theta$ $\quad L = lcos\theta$

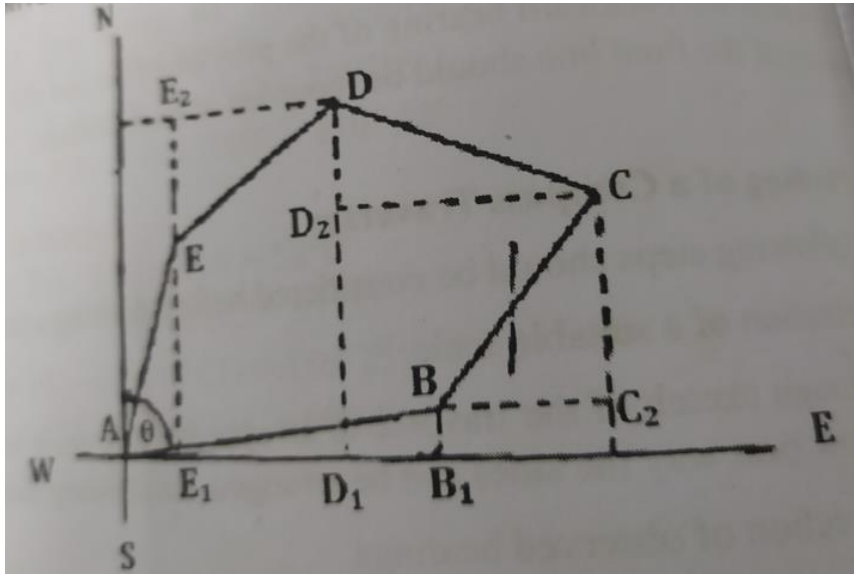
l==length

$\theta = WCB$

$l = \sqrt{(D^2 + L^2)}$



- Reference axes are NS and line EW perpendicular to it at A.
- If the bearing and length of the line AB are known, its projection on the the magnetic meridian NS and on the line perpendicular to it, EW, may be obtained.
- From the Figure, BB_1= AB Sin θ, where θ= bearing of line AB, and AB_1=AB Cos θ.
- Knowing BB_1 and AB_1, the station can be easily located.
- Similarly, stations C, D and E can be located.



Methods of Traversing in Surveying

Included Angle Method (Theodolite Surveying - Fast Needle Method)

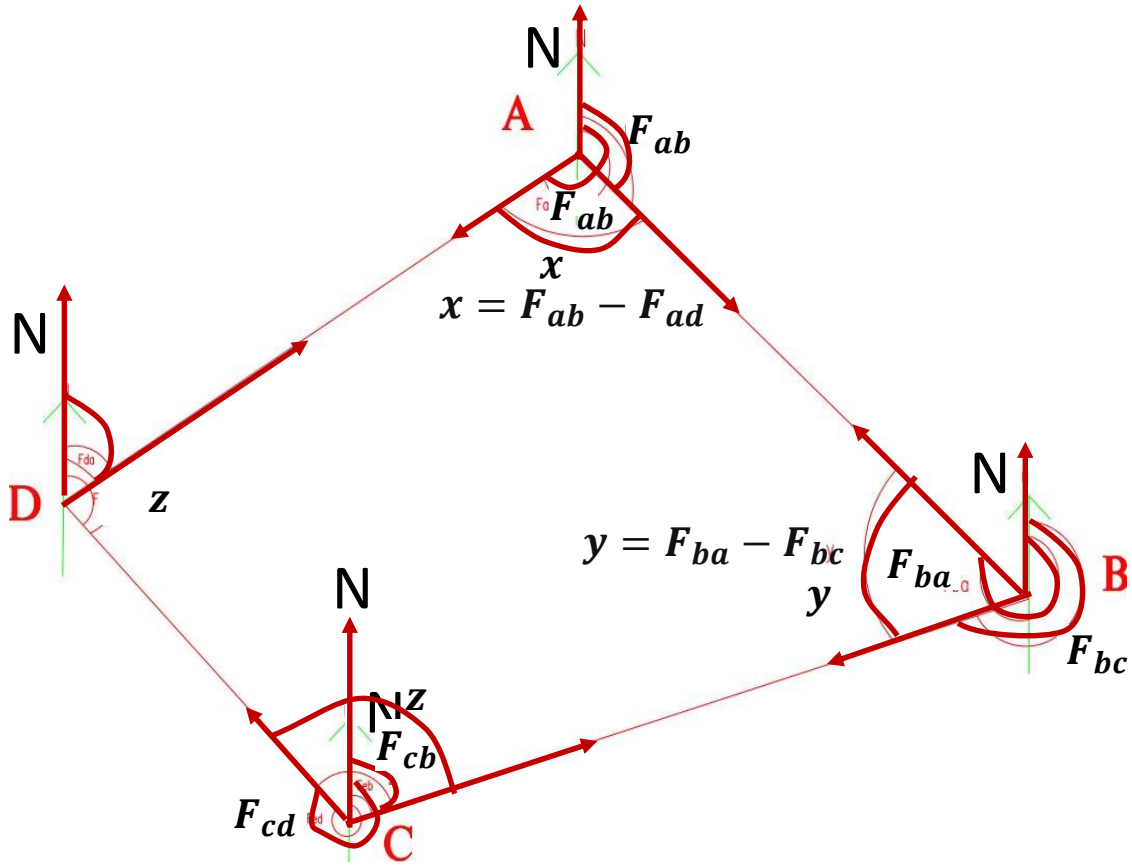
Theodolite is used to determine the included angles and hence suitable only for closed traversing.

Considering a closed traverse ABCD. Included angles to be determined (say x, y, z, w).

Set-up the instrument at point A and orient the telescope with the North direction
Get the fore-bearing (FB) to line AB (F_{ab}) and AD (F_{ad}). Then the included angle, $x = F_{ab} - F_{ad}$

Set the instrument at B, and orient with the North. Get the FB of line BC (F_{bc}) and back-bearing (BB) of line BA (F_{ba}). Then the included angle, $y = F_{ba} - F_{bc}$.

Similarly, set the instrument at C, and find (F_{cb}) and (F_{cd}). And the included angle, $z = 360 - F_{cd} - F_{cb}$.
Finally, set the instrument at D, take (F_{da}) and AD (F_{dc}. And the included angle, $w = F_{dc} - F_{da}$.



The linear measurement AB,BC,CD, and DA are measured either using a tape or a chain.

Methods of Traversing in Surveying

Included Angle Method (Theodolite Surveying - Fast Needle Method)

To check whether we get a closed traverse, the following formula is used:
Sum of the interior angles $= 180(n-2)$;
Here, 'n' is the number of traverse lines involved in the traverse.

In the above examples, n = 4; Therefore, $180(n-2) = 180(4-2) = 360$ = 360 degrees.

The sum of the included angles measured using theodolite must be equal to the 360 degrees as calculated above. If there is variation, the correction is provided. It is mainly performed using Bowditch Rule.

Methods of Traversing in Surveying

Deflection Angle Method (Theodolite Surveying - Fast Needle Method)

Used for location survey of railways, pipelines, highways, etc. Mostly employed for open traversing

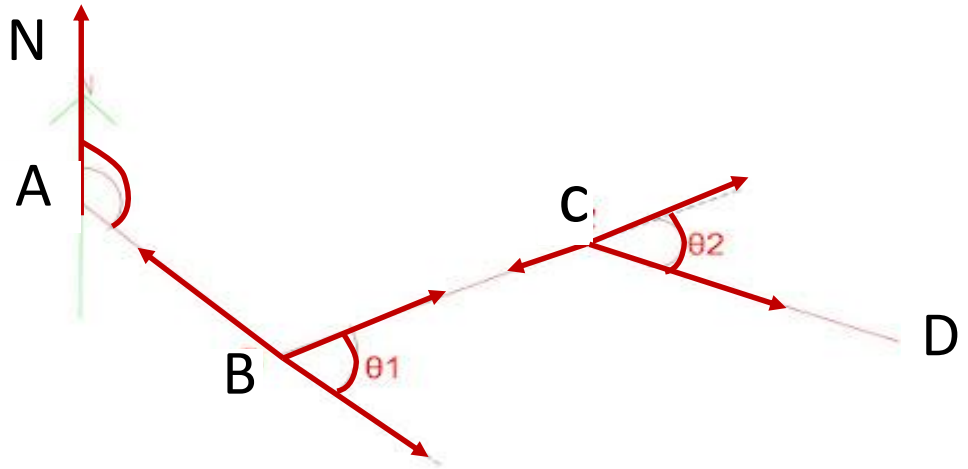
Place instrument at A and find magnetic bearing of AB.

Now set instrument at B, sight A and set the instrument reading to zero.

Transit the telescope, (now the instrument is set along the direction of line AB). Now measure the deflection angle by sighting to C.

Now place the instrument at C, sight B and set the instrument to zero reading. Now transit the telescope and sight D. This gives the deflection angle at C.

Based on whether the angle is measured clockwise or anti-clockwise, positive and negative signs are given.



Methods of Traversing in Surveying

Fast Needle Method (Theodolite Surveying - Fast Needle Method)

- Fast needle method in traversing gives the direct measurement of included angle.
- The work can be checked during its progress and the errors can be detected and rectified immediately. Hence, the field work become less cumbersome and the computations are simple compared to other method of measuring angles.
- This method is used to measure the magnetic bearings and length of traverse lines. the magnetic meridian is established only at the starting station.
- Set the instrument at A, and determine the magnetic meridian of line AB (Fab). We will lock this angle in the theodolite (by tightening the upper clamp of the theodolite).
- Then, shift the instrument and place set at B, loosen the upper clamp and sight C, tighten the upper clamp.
- Now, place the instrument at D, loose the upper clamp, sight A.
- If the whole procedure is done correctly, the final angle shown on the scale will be 360 degrees.

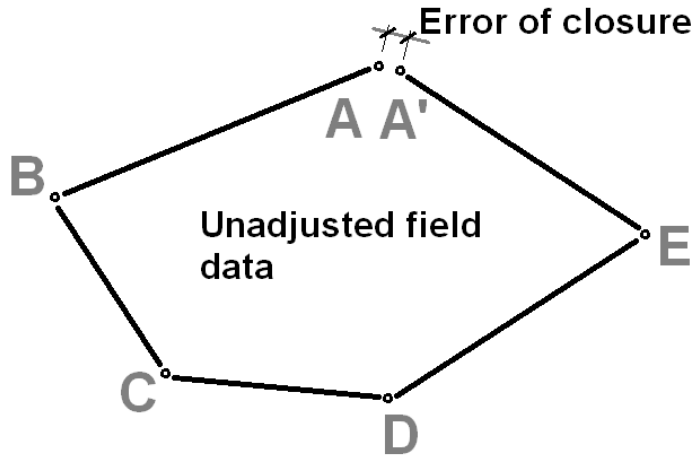
Methods of Traversing in Surveying

Plane Table surveying

- In this case, the traverse s measured and plotted on paper fixed on a plane table at the same time.
- The plane table equipment is installed one by one at each traverse station, clockwise or anti clockwise.
- On paper, the sides of each traverse station are drawn to some suitable scale.
- If there is a closing error, graphical approaches are employed for its adjustment.

Closing Error of Closed Traverse

In a closed traverse, the **end of last line** should meet the Starting point. But while plotting, it will be observed that the **last line does not generally end** at starting point. This **discrepancy is termed as closing error**.



Why this error?

This error is **due to incorrect measurements** of angles and sides in the field.

Permissible error:

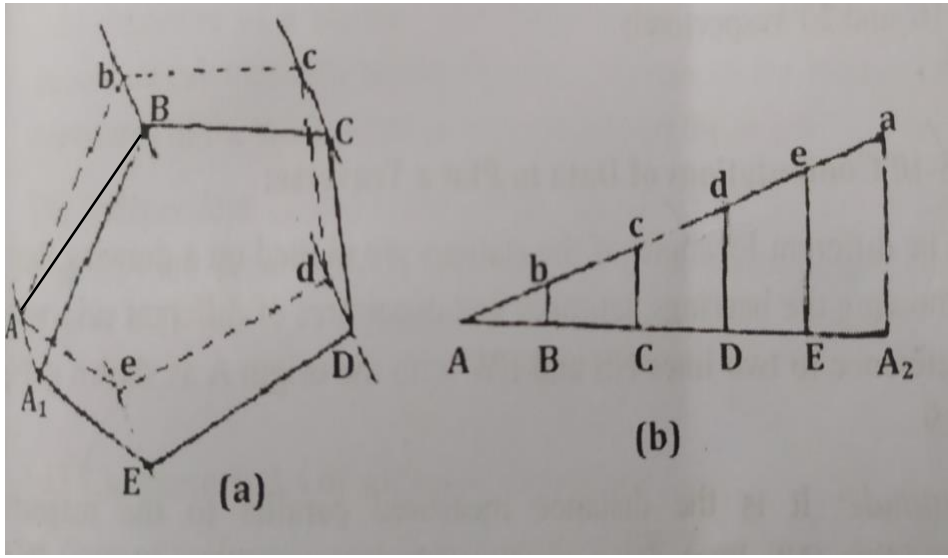
- In compass survey, the permissible error per bearing **should not be more than 15 minutes** because the **least value that can be read in the graduated scale is 15 minutes.**
- **Total angular error of closure** should **not exceed** $\mathbf{15\sqrt{N}}$**,** where N is the number of sides of a traverse.
- In case **of lengths of sides**, the error of closure should not exceed 1 in 600.

How to adjust such Error

- If the closing error is very small, it may be neglected. If it is considerable, adjustment can be done by the following method:
- Let, **ABCDE is a polygon**, which has been plotted from the measured field data.
- According to definition of a closed polygon, **point A_1 and A should coincide.**
- **Distance AA_1 is the closing error** which needs to be adjusted.

Adjustment of Sides Error: (Graphical Method)

- **Draw line AA_2 to a suitable scale so that** AA_2= sum of all sides of traverse.
- A perpendicular **A_2a = closing error AA_1 is drawn at A_2.**
- Aa is joined and perpendiculars Bb, Cc, Dd and Ee are drawn.
- These perpendiculars are the respective corrections or distances through which the stations B, C, D and E should be **moved upwards in this case**.



- At stations B, C, D and E of the traverse, lines parallel to AA_1 are drawn.
- Now the stations B, C, D and E are shifted upwards by the amounts Bb, Cc, Dd and Ee repectively.
- Abcde is adjusted or corrected traverse.

Adjustment of Angular Error

- In a closed traverse, the sum of **included angles must be equal to (2N-4)x 90°,** where N is the number of sides.
- But in practical cases, there is always angular error.
- If the total **angular error in a traverse of 5 sides is 20 minutes** then the correction at the starting station will be $\frac{20}{5}$ =4 minutes.
- The corrections in angles at 2^{nd}, 3^{rd}, 4^{th}, and 5^{th} stations are 8', 12', 16' and 20' respectively.

Characteristics of a Closed Traverse

- Sum of the included angle=(2N-4)x90^o, where N=number of sides.
- Sum of excluded angle= (2N+4) x90^o
- Forward bearing and back bearing of a line must differ by 180 ^{o}
- Sum of the Northings=sum of the Southings.
- Sum of the Eastings=sum of the Westings.
- Difference between the bearings of two lines at a stations is the included or excluded angle.