Traverse/Compass surveying

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Introduction

- The Traversing consists of using a variety of instrument combinations to create polar vector inspace, **that is 'lines' with a magnitude(distance)** and **direction (bearing).**
- These vectors are generally contiguous and create a polygon which conforms to various mathematical and geometrical rules.
- The equipment used generally consists of something to determine direction like a compass or theodolite, and something to determine distance like a tape or Electromagnetic Distance Meter (EDM).

Function of Traverse

- Traverses are normally performed around a parcel of land so that features on the surface or the boundary dimensions can be determined.
- A traverse provides a simple network of 'known' points that can be used to derive other information.

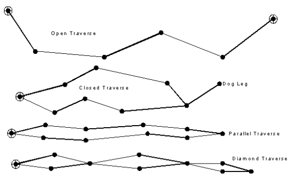
Types of Traverse

There are two types of traverse used in survey.These are

- Open traverse, and
- Closed traverse.

Types of Traverse

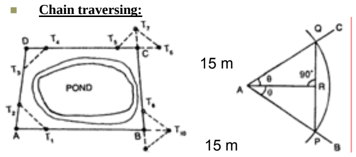
Close Traverse: When a series of connected lines forms a close circuit, it is called a close traverse. Close traverse is suitable for the survey of boundaries of ponds, forests estates. or starts at a known points and ends at a second known point.



Open Traverse: When a sequence of connected lines extends along a general direction and doesn't return to the starting point, it is known as open traverse or unclosed traverse. Open traverse is suitable for the survey of roads, rivers and coastlines.

Methods of traversing

- **Chain traversing:**



$$c^2 = a^2 + b^2 - 2ab\cos(C)$$

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

Then $\angle BAC = 2\theta$

Here $AP = AQ = 15$ m

In triangle PAR,

$$\sin\theta = \frac{PR}{AP} = \frac{2PR}{2AP} = \frac{PQ}{30}$$

$$\therefore \quad \theta = \sin^{-1}\frac{PQ}{30}$$

- **Compass traversing:** Fore bearings and back bearings between the traverse leg are measured
- **Theodolite traversing:** Horizontal angles between the traverse legs are measured. The length of the traverse legs are measured by chain/tape or by stadia method
- **Plane table traversing:** Plane table is set at every traverse station in clockwise and anticlockwise direction and the circuit is finally closed. During traversing the sides of the traverse are plotted according to any suitable scale.

Prismatic compass

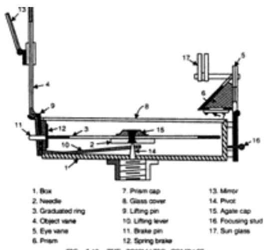
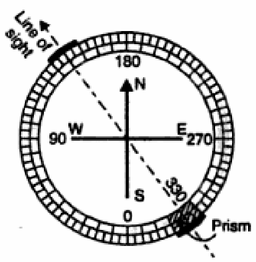
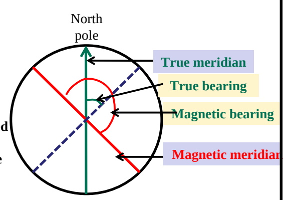


FIG. 5.12. THE PRISMATIC COMPASS.



Compass traversing: Important Definition

- **True meridian: Line or plane passing through geographical north pole and geographical south pole**
- **Magnetic meridian: When the magnetic needle is suspended freely and balanced properly, unaffected by magnetic substances, it indicates a direction. This direction is known as magnetic meridian. The angle between the magnetic meridian and a line is known as magnetic bearing or simple bearing of the line.**



Terms

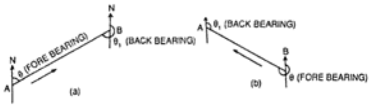
- **Arbitrary meridian: Convenient direction is assumed as a meridian.**

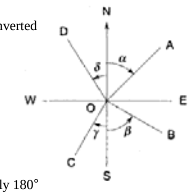
- **Grid meridian: Sometimes for preparing a map some authoritative agencies assume several lines parallel to the true meridian for a particular zone these lines are termed as grid meridian.**

- **Designation of magnetic bearing**
  - Whole circle bearing (WCB)
  - Quadrantal bearing (QB)

- WCB: The magnetic bearing of a line measured **clockwise from the North Pole** towards the line is known as WCB. Varies 0-360°

- **Quadrantal Bearing:** The magnetic bearing of a line measured clockwise or anticlockwise from NP or SP (whichever is nearer to the line) towards the east or west is known as QB. This system consists of 4-quadrants NE, SE, NW, SW. The values lie between 0-90°
  - QB of OA = N a E
- **Reduced Bearing:** When the whole circle bearing of a line is converted to quadrantal bearing it is termed as reduced bearing.
- **Fore and Back Bearing:**





  - In WCB the difference between FB and BB should be exactly 180°
  - BB=FB+/-180°
  - Use the +ve sign when FB<180°
  - Use the –ve sign when FB> 180°

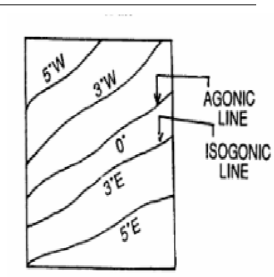
- **Magnetic declination:** The horizontal angle between the magnetic meridian and true meridian is known as magnetic declination.

- **Dip of the magnetic needle:** If the needle is perfectly balanced before magnetisation, it does not remain in the balanced position after it is magnetised. This is due to the magnetic influence of the earth. The needle is found to be inclined towards the pole. This **inclination of the needle with the horizontal** is known as dip of the magnetic needle.

- **Local Attraction**
- **Method of correction for traverse:**
  - **First method:** Sum of the interior angle should be equal to (2n-4) x 90. if not than distribute the total error equally to all interior angles of the traverse. Then starting from unaffected line the bearings of all the lines are corrected using corrected interior angles.

  - **Second method:** Unaffected line is first detected. Then, commencing from the unaffected line, the bearing of other affected lines are corrected by finding the amount of correction at each station.

- Isogonic Line: Lines pass through the equal declination known as isogonic lines.
- Agonic Line: Lines pass through the zero declination known as agonic line.



Vaiation of Magnetic Declination

1.Secular Variation: After every 100 years or so magnetic meridian swings from one direction to the opposite direction and hence declination varies.

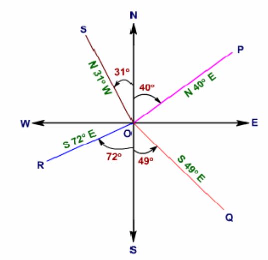
2.Annual Variation: Magnetic declination varies due to the rotation of the earth. The amount of variation is about 1to 2 minutes

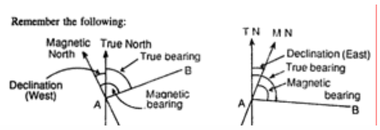
3.Diurnal Variation: Magnetic declination varies due to rotation of its earth on its own axis. The amount of variation 3 to 12 minutes.

4.Irregular Variation: Variation due to some natural causes such as earth quake, volcanic erruptions and so on. The variation is known as "Irregular Variation"

Reduced Bearing

Reduced Bearing:The reduced bearing (R.B) also known as quadrantal bearing(Q.B) of a line is defined by **the acute angle** which the line makes with the meridian. Thus, it depends on the quadrant in which the line presents. It is measured in **clockwise or anti-clockwise** direction either from the North or from the South limb of the meridian whichever is nearer and thus provides minimum angle. reduced bearing of a line is designated by the direction from which it is measured (i.e., either N for North or S for South) followed by the value of the angle at the end, the direction to which it is measured (i.e., either E for East or W for West).





Determination of true bearing and magnetic bearing:

(a) True bearing = magnetic bearing ± declination

Note [use the positive sign when declination east, and the negative sign when declination west.]

(b) Magnetic bearing = true bearing ± declination

Note [Use the positive sign when declination west, and the negative sign when declination east.]

Problems:

- Convert the following WCBs to QBs
  - (a) WCB of AB = 45°30'

    (Ans 45°30')
  - (b) WCB of BC = 125°45'

    (Ans 180- 125°45' = 54° 15')
- Fore bearing of the following lines are given. Find back bearing
  - AB=S 30°30' E
  - BC=N 40°30' W
- The magnetic bearing of a line AB is 135°30' what will be the true bearing, if the declination is 5°15' W.

Problem

The interior angle of close traverse are given below ∟A=120°, ∟B=95°, ∟C=60°, ∟D=85° . The measured bearing of line AB is 50°. Find bearings of other lines.

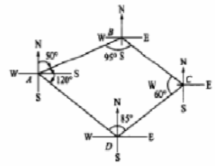
Solution: Figure 4.10 shows the traverse of the example 4.6.

$$\text{Bearing of } AD = 50° + 120° = 170°$$
$$\text{Bearing of } DC = \text{Bearing } AD + 85°$$
$$= 170° + 85°$$
$$= 170° + 85° - 180° = 75°$$
$$\text{Bearing } CB = \text{Bearing of } DC + 60° + 180°$$
$$= 75° + 60° + 180°$$
$$= 315°$$
$$\text{Bearing } BC = 315° - 180° = 135°$$

Check

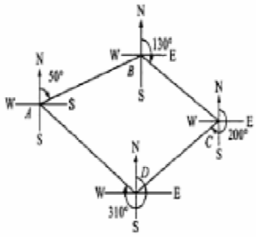
$$\text{Bearing of } AB = \text{Bearing of } CB + 95° - 180°$$
$$= 315° + 95° - 180° = 230°$$

Bearing $AB = 230° - 180° = 50°$ which is the given bearing of AB.



Problems

- The WCB of the following Lines are obtained by a prismatic compass calculate the interior angles



Solution: Now from Figure 4.8, we get

$$\angle A = \text{WCB of } AD - \text{WCB of } AB$$
$$= (310° - 180°) - 50°$$

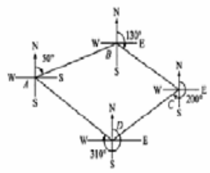


Figure 4.8 Plotted traverse of Example 4.4.

Since $(310° - 180°) = 130°$ is FB of AD

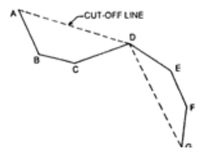
$$= 130° - 50° = 80°$$
$$\angle B = \text{bearing of } BA - \text{Bearing of } BC$$
$$= (180° + 50°) - 130° = 100°$$
$$\angle C = \text{Bearing } CB - \text{Bearing } CD$$
$$= (180° + 130°) - 200°$$

Checks on traverse: Closed traverse

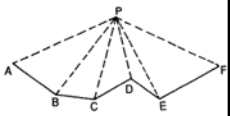
- Check on closed traverse:
  - Sum of the measured interior angles (2n-4) x 90°
  - Sum of the measured exterior angles (2n+4) x 90 °
  - The algebric sum of the deflection angles should be equal to 360°. Right hand deflection is considered +ve, left hand deflection –ve
- Check on linear measurement
  - The lines should be measured once each on two different days (along opposite directions). Both measurement should tally.
  - Linear measurement should also be taken by the stadia method. The measurement by chaining and stadia method should tally.

Checks on traverse: Open traverse

- Taking cut-off lines: measured the bearings and lengths of cut off lines after plotting and tally with actual values.



- Taking an auxiliary point: Take P permanent point as auxiliary point measured bearings and lengths of P from each traverse point. If survey is accurate, while plotting all the measured bearing of P should meet at P.



3.3 PRINCIPLE OF COMPASS SURVEYING

The principle of compass surveying is traversing, which involves a series of connected lines. The magnetic bearings of the lines are measured by prismatic compass and the distances of the lines are measured by chain. Such survey does not require the formation of a network of triangles.

Interior details are located by taking offsets from the main survey lines. Sometimes subsidiary lines may be taken for locating these details.

Compass surveying is recommended when:

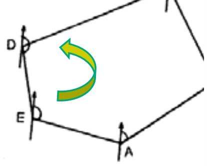
1. A large area to be surveyed
2. The course of a river or coast line is to be surveyed and
3. The area is crowded with many details and triangulation is not possible

Compass surveying is not recommended for areas where local attraction is suspected due to the presence of magnetic substances like steel structures, iron ore deposits, electric cables conveying current, and so on.

Problems

Problem 5 **A closed traverse is conducted with five stations A, B, C, D and E taken in anticlockwise order, in the form of a regular pentagon. If the FB of AB is 30°0′, find the FBs of the other sides.**

$$\text{Interior angle of pentagon} = \frac{(2N-4)\times 90^\circ}{5} = \frac{540^\circ}{5} = 108^\circ$$



FB of AB = 30°0′

FB of BC = BB of AB + ∠B
= (30°0′ + 180°0′) + 108°0′
= 210°0′ + 108°0′ = 318°0′

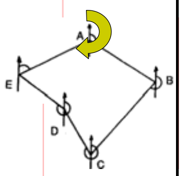
FB of CD = BB of BC + ∠C
= (318°0′ – 180°0′) + 108°0′
= 138°0′ + 108°0′ = 246°0′

FB of DE = BB of CD + ∠D
= (246°0′ – 180°0′) + 108°0′
= 66°0′ + 108°0′ = 174°0′

FB of EA = BB of DE – exterior ∠E
= (174°0′ + 180°0′) – (360°0′ – 108°0′)
= 354°0′ – 252° = 102°0′

Problem 8 The following are the bearings observed in traversing, with a compass, an area where local attraction was suspected. Calculate the interior angles of the traverse and correct them if necessary.

Line	FB	BB
AB	150°0′	330°0′
BC	230°30′	48°0′
CD	306°15′	127°45′
DE	298°00′	120°00′
EA	49°30′	229°30′



(a) Interior ∠A = BB of EA – FB of AB
= 229°30′ – 150°0′ = 79°30′

(b) Interior ∠B = BB of AB – FB of BC
= 330°0′ – 230°30′ = 99°30′

Exterior ∠C = FB of CD – BB of BC
= 306°15′ – 48°0′ = 258°15′

(c) Interior ∠C = 360°0′ – 258°15′ = 101°45′

Exterior ∠D = FB of DE – BB of CD
= 298°00′ – 127°45′ = 170°15′

(d) Interior ∠D = 360°0′ – 170°15′ = 189°45′

(e) Interior ∠E = BB of DE – FB of EA
= 120°0′ – 49°30′ = 70°30′

Check Sum of interior angles = ∠A + ∠B + ∠C + ∠D + ∠E
= 541°0′

But, the sum of angles should be $(2N - 4) - 90° = 540°0'$

Contd…

Here, Error = 541° – 540° = + 1°

Correction per angle $= -\frac{60'}{5} = -12'$

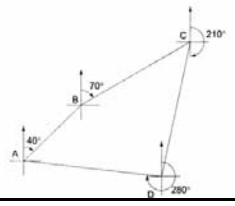
The error should equally distributed among all the angles.

Angle	Calculated value	Correction	Corrected value
∠A	79°30′	– 12′	79°18′
∠B	99°30′	– 12′	99°18′
∠C	101°45′	– 12′	101°33′
∠D	189°45′	– 12′	189°33′
∠E	70°30′	– 12′	70°18′
	Total = 541°0′		540°00′

Problems

Example 3.2 Determine the value of included angles in a closed compass traverse ABCD (Fig. 3.11) conducted in clockwise direction, given the following fore bearings of the respective lines.

Line	F.B.
AB	40°
BC	70°
CD	210°
DA	280°



Included angle at A= 280-180-40=60

=FB of DA-180-FB of AB

Included angle at B= 40+180-70= 150

=FB of AB+180-FB of BC

Included angle at C= 70+180-210

=FB of BC+180-FB of CD

Formula: FB of previous line+/-180-FB of next line

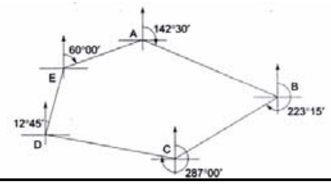
Example 3.3 Following are the bearings taken in a closed compass traverse.

Line	F.B.	B.B.
AB	S37°30′E	N37°30′W
BC	S43°15′W	N44°15′E
CD	N73°00′W	S72°15′E
DE	N12°45′E	S13°15′W
EA	N60°00′E	S59°00′W

Compute the interior angles and correct them for observational errors.

Solution Refer to Fig. 3.12. Convert the quadrantal bearings to whole circle bearings.

Lines	F.B.	B.B.
AB	142°30′	322°30′
BC	223°15′	44°15′
CD	287°00′	107°45′
DE	12°45′	193°15′
EA	60°00′	239°00′



Traverse Survey

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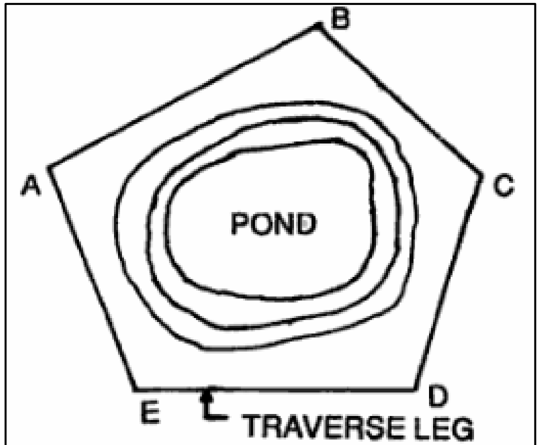


Fig. 3.7 Closed Traverse

Open Traverse: When a sequence of connected lines extends along a general direction and doesn't return to the starting point, it is known as open traverse or unclosed traverse. Open traverse is suitable for the survey of roads, rivers and coastlines.

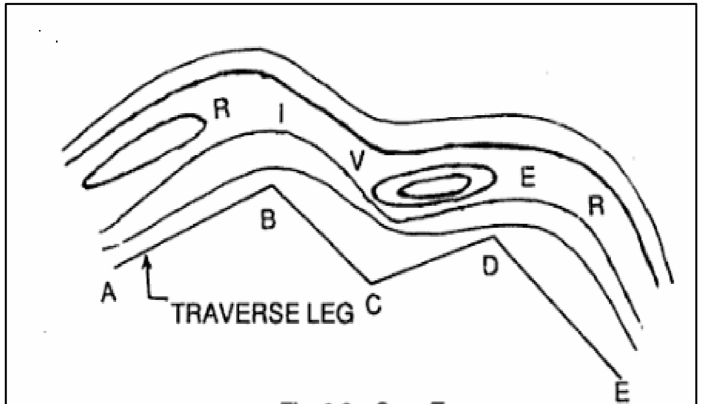


Fig. 3.8 Open Traverse

Methods of Traversing

Traverse Survey may be Conducted by the following methods:

1. Chain Traversing (by chain angle)
2. Compass Traversing (by free neddle)
3. Theodolite Traversing (by fast needle)
4. Plane Table Traversing (by plane table)

Chain Traversing

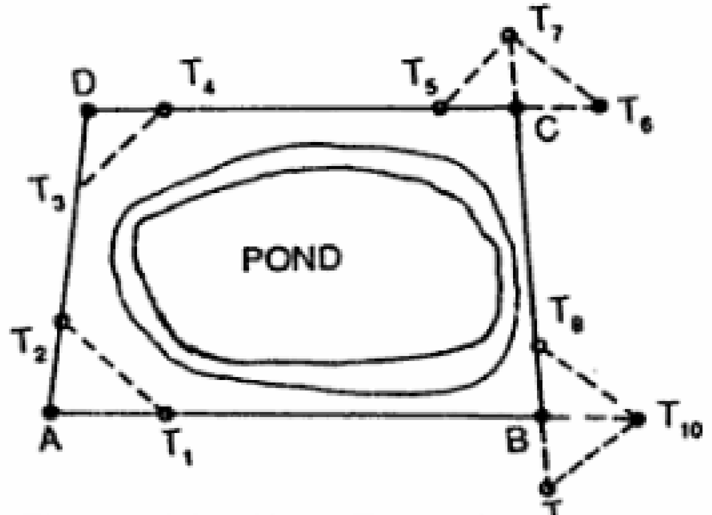


Fig. 3.9 (a) Chain Traversing

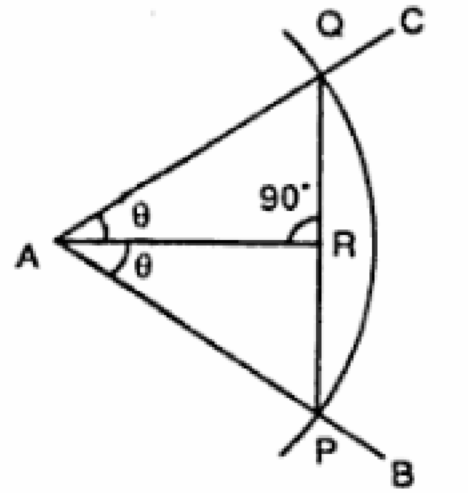


Fig. 3.9(b)

$$c^2 = a^2 + b^2 - 2ab\cos(C)$$

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

Compass Traversing

- In this method, the fore and back bearings of the traverse legs are measured by prismatic compass and the sides of the traverse by chain or tape. Then the observed bearings are verified and necessray corrections for local attraction are applied. In this method closing errors may occured when traverse is plotted.

Theodolite Traversing

- In such traversing the horizontal angles between the traverse legs are measured by theodolite. The lengths of the legs are measured by chain or by employing the stadia method. The magnetic bearings of the other sides are calculated. The independent coordinates of all the traverse stations then found out. This method is very accurate.

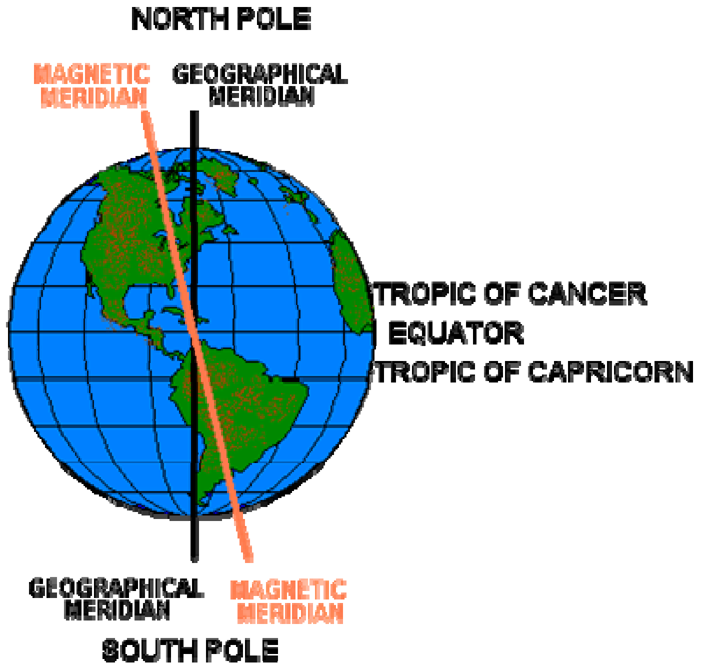
Plane Table Traversing

In this method a plane table is set at every traverse station in the clockwise or anticlockwise direction, and circuit is finally closed. During traversing, the sides of the traverse are plotted according to any suitable scale. At the end of the work, any closing error which may occur is adjusted graphically.

Terms

Bearing

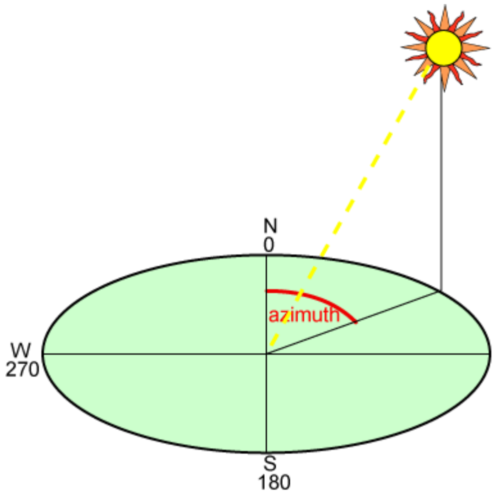
Bearing of line is its direction relative to meridians like magnetic, true or arbitary meridians and are expressed in angles.



True Meridian and True Bearing/Azimuth

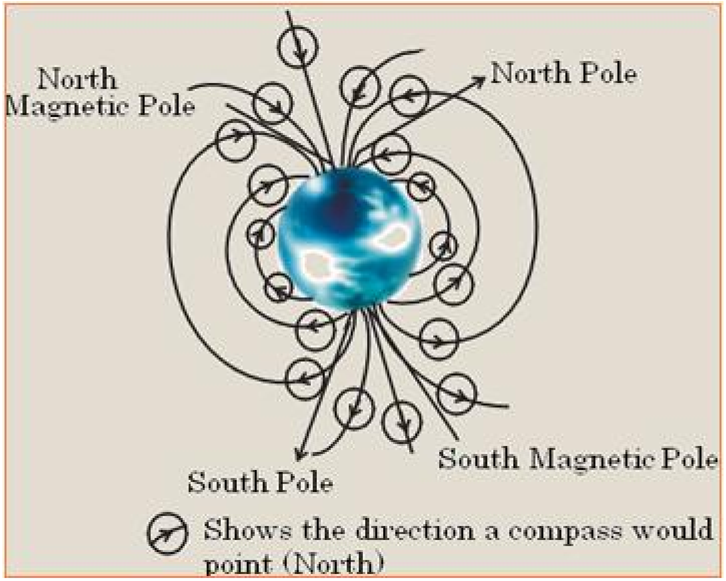
The line or plane passing through the geographical north pole, geographical south pole and any point on surface of the earth is known as the true meridian or geographical meridian. The true meridian at a station is Constant. The true meridians passing through different points on the earths surface are not parallel, but coverage towards the pole. But for surveys in small areas, the true meridians passing through the different points are assumed parallel.

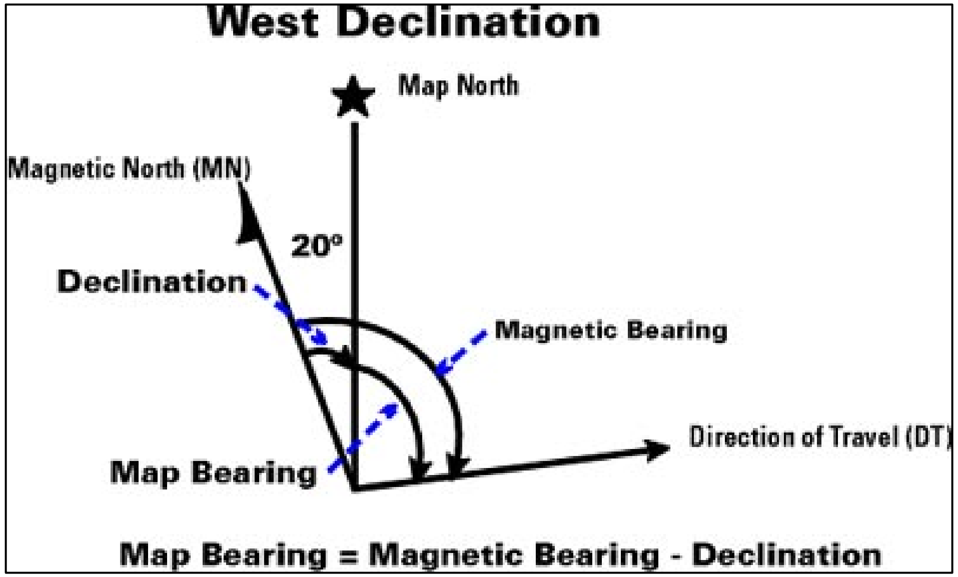
True Bearing: Angle between true meridian and a line is known as “True Bearing” of the line. It is also known as the “Azimuth”



Magnetic Meridian and Magnetic Bearing:

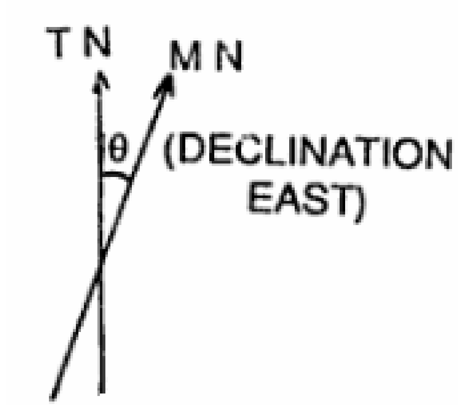
When a magnetic needle is suspended freely and balanced properly, unaffected by magnetic substances, it indicates a direction. This direction is known as the magnetic meridian.



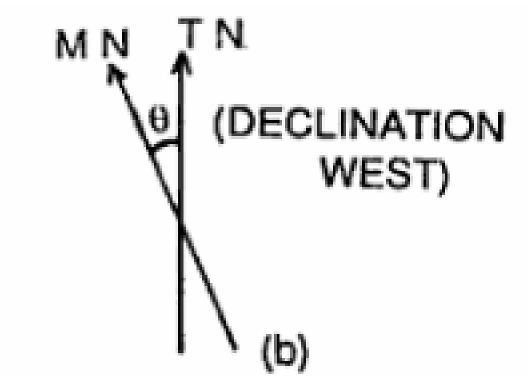


Magnetic Declination

The horizontal angle between the magnetic meridian and the true meridian is known as magnetic declination.

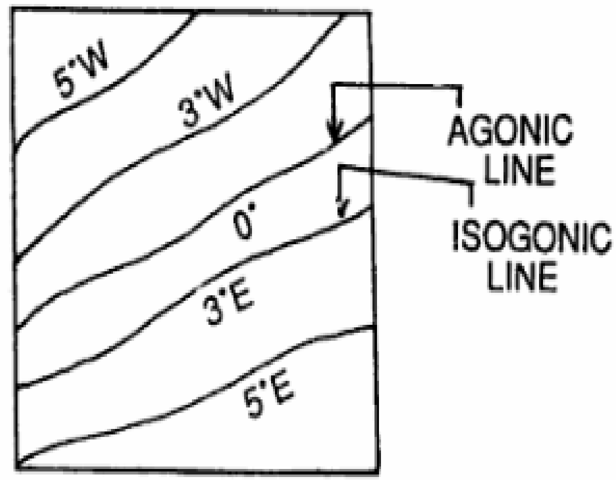


When a north end of the magnetic needle is pointed towards the west side of the true meridian the position is termed "Declination West"



When the north end of the magnetic needle is pointed toeards the east side of the true meridian the position is termed as "Declination East"

- Isogonic Line: Lines pass through the equal declination known as isogonic lines.
- Agonic Line: Lines pass through the zero declination known as agonic line.



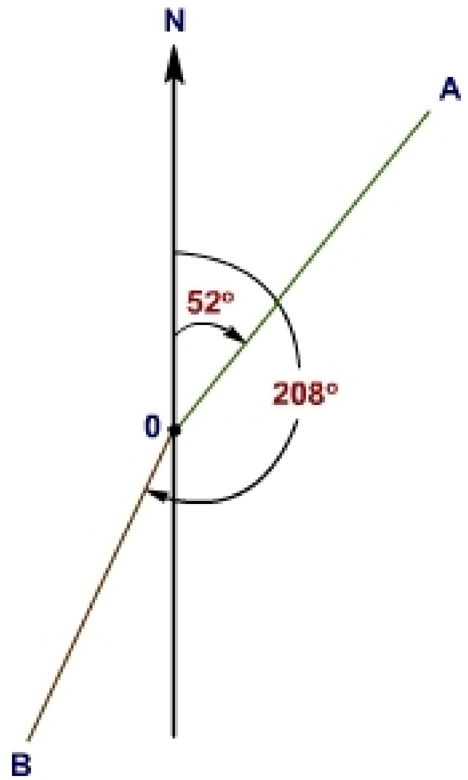
Variation of Magnetic Declination

1. Secular Variation: After every 100 years or so magnetic meridian swings from one direction to the opposite direction and hence declination varies.
2. Annual Variation: Magnetic declination varies due to the rotation of the earth. The amount of variation is about 1 to 2 minutes
3. Diurnal Variation: Magnetic declination varies due to rotation of its earth on its own axis. The amount of variation 3 to 12 minutes.
4. Irregular Variation: Variation due to some natural causes such as earth quake, volcanic erruptions and so on. The variation is known as “Irregular Variation”

- Arbitary Meridian: Sometimes for the survey of a small area, a convenient direction is assumed as a meridian, known as arbitary meridian.

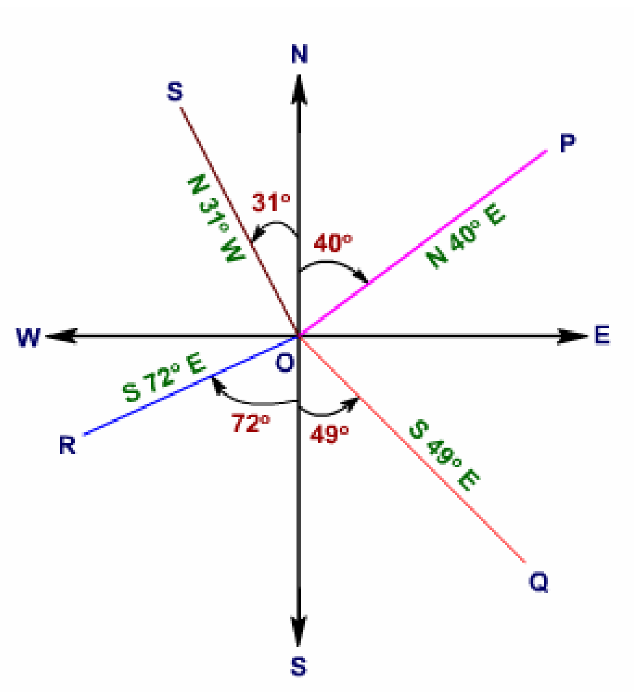
The angle between arbitary meridian and a line is known as arbitary bearing of the line.

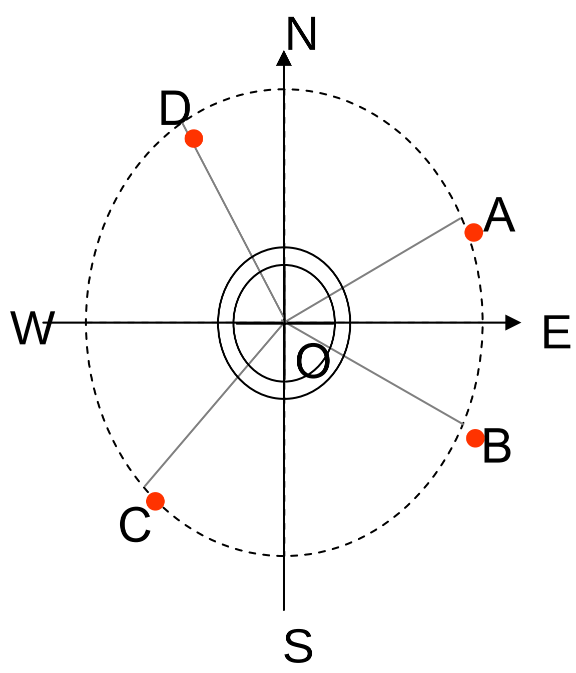
Whole Circle Bearing: The whole circle bearing (W.C.B) of a line is the horizontal angle measured clockwise from the North limb of the meridian. It varies from 0° to 360°



Reduced Bearing:The reduced bearing (R.B) also known as quadrantal bearing(Q.B) of a line is defined by **the acute angle** which the line makes with the meridian. Thus, it depends on the quadrant in which the line presents. It is measured in **clockwise or anti-clockwise** direction either from the North or from the South limb of the meridian whichever is nearer and thus provides minimum angle.

reduced bearing of a line is designated by the direction from which it is measured (i.e., either N for North or S for South) followed by the value of the angle at the end, the direction to which it is measured (i.e., either E for East or W for West).





From O, the reduced bearing

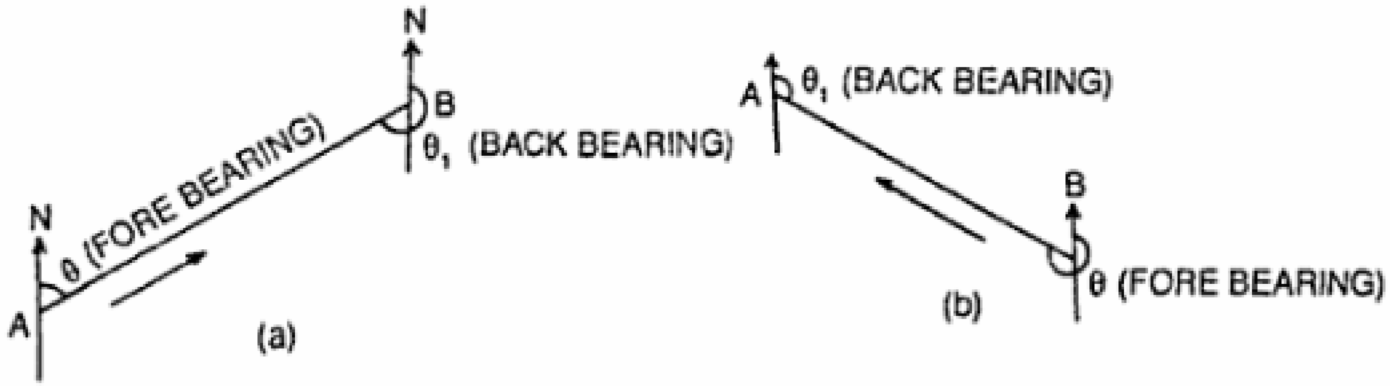
A:	N70°E
B:	S75°E
C:	S42°W
D:	N37°W

Fore bearing or Forward Bearing: The bearing of a line measured in the forwrard direction (i.e., along the progress of survey) is known as fore bearing.

Fore bearing = Back bearing ± 180°

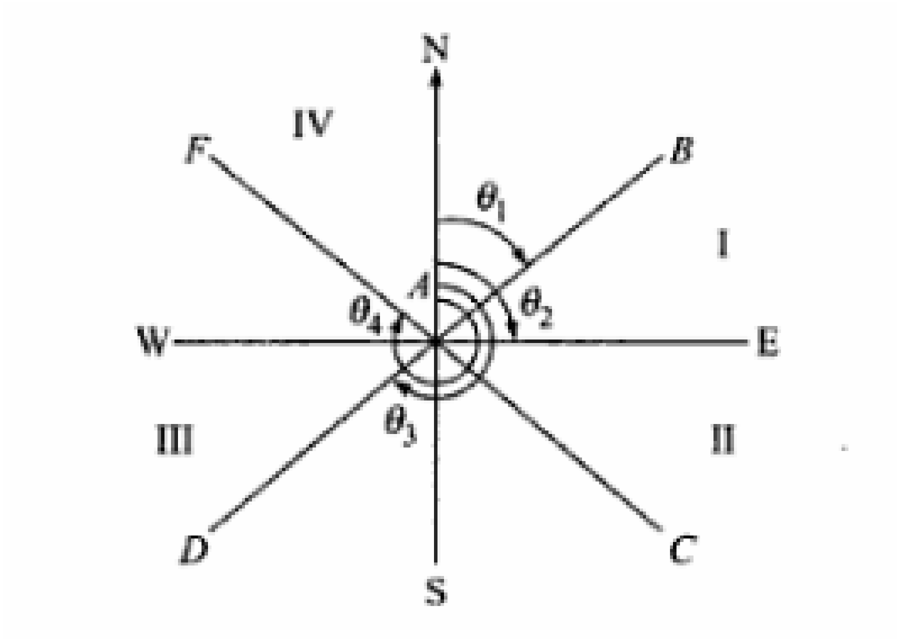
Back Bearing: The bearing of a line measured in the backward direction (i.e., opposite to the direction of progress of survey) is known as back bearing.

Back Bearing = Fore Bearing ± 180°



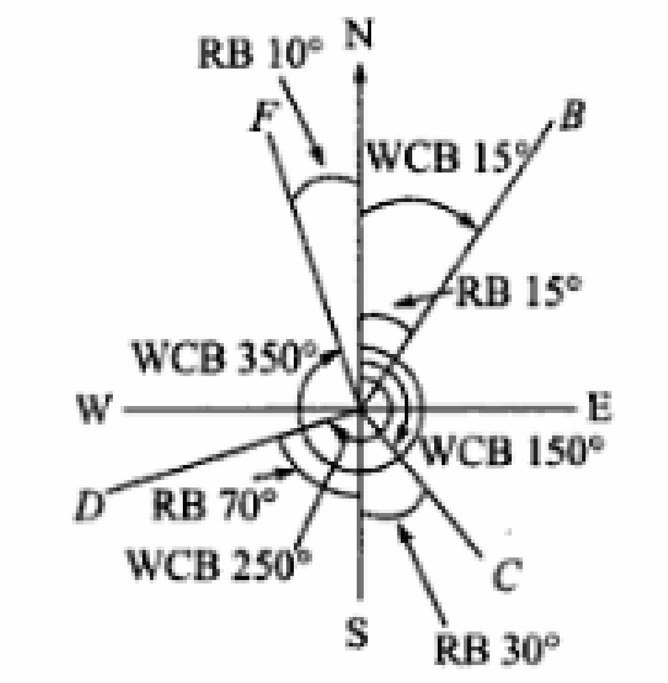
Problem1 (WCB,RB)

The whole circle bearing of line AB=30°, AC=140°,AD=210° and AF=300° Convert them to RB



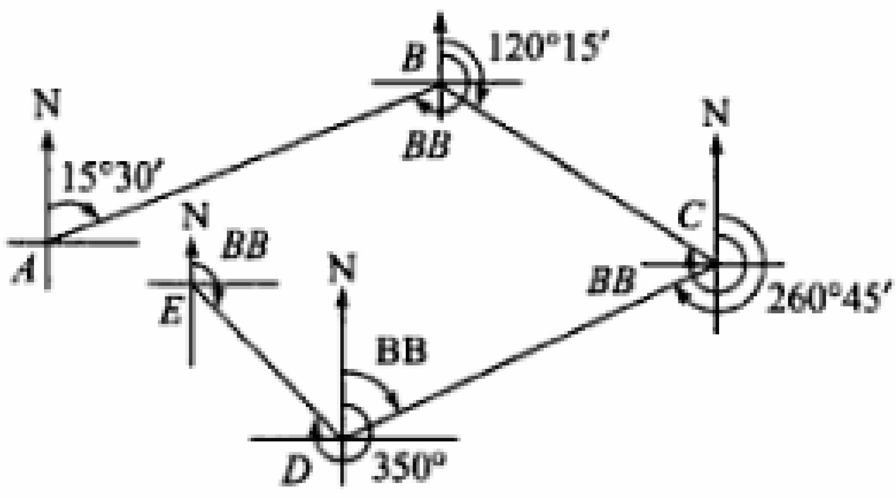
Problem 2 (WCB,RB)

- Convert the Following RB to WCB:
- i) N 15° E ii) S 30° E iii) S 70° W iv) N 10° W



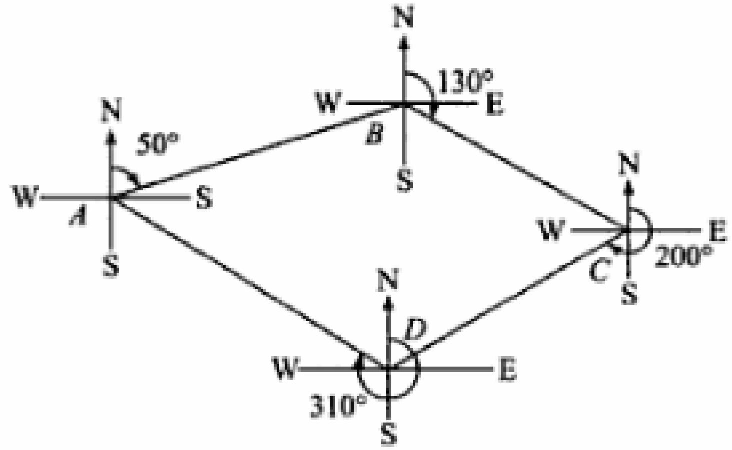
Problem 3 (FB,BB)

- The follwoing are the observed FB of the lines:
- AB=15°30’, BC=120°15’,CD=260°45’, DE=350° Find their Back bearing.



Problem 4

- The WCB of the following Lines are obtained by a prismatic compass calculate the interior angles



Line	WCB
AB	50°
BC	130°
CD	200°
DA	310°

Solution: Now from Figure 4.8, we get

$$\angle A = \text{WCB of } AD - \text{WCB of } AB$$
$$= (310° - 180°) - 50°$$

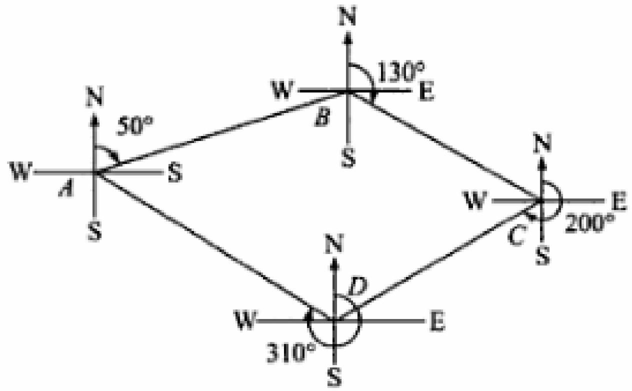


Figure 4.8 Plotted traverse of Example 4.4.

Since $(310° - 180°) = 130°$ is FB of AD

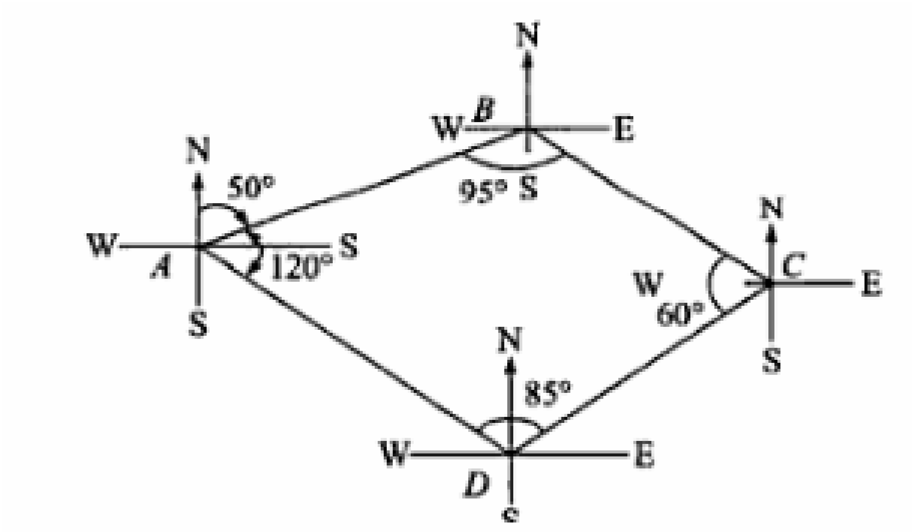
$$= 130° - 50° = 80°$$
$$\angle B = \text{bearing of } BA - \text{Bearing of } BC$$
$$= (180° + 50°) - 130° = 100°$$
$$\angle C = \text{Bearing } CB - \text{Bearing } CD$$
$$= (180° + 130°) - 200°$$

$$= 310° - 200° = 110°$$
$$\angle D = \text{Bearing } DC - \text{Bearing } DA$$
$$= (200° - 180°) - 310° + 360° = 70°$$

$$\text{Sum} = \angle A + \angle B + \angle C + \angle D = 80° + 100° + 110° + 70°$$
$$= 360°$$

Problem 5

- The interior angle of close traverse are given below ∟A=120°, ∟B=95°, ∟C=60°, ∟D=85° . The measured bearing of line AB is 50°. Find bearings of other lines.



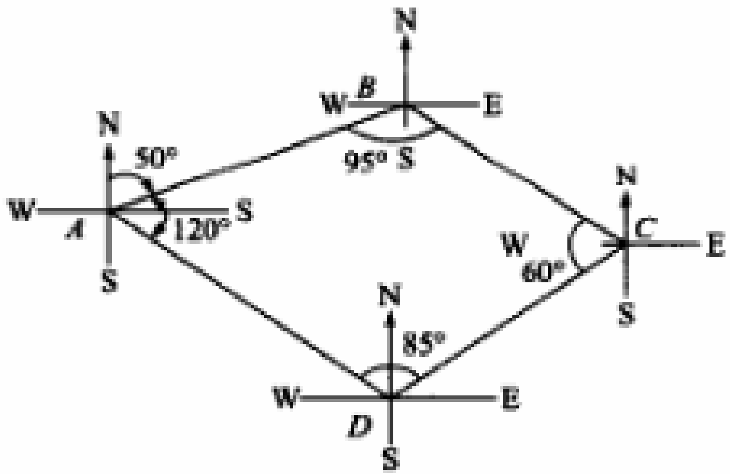
Solution: Figure 4.10 shows the traverse of the example 4.6.

$$\begin{aligned}
\text{Bearing of } AD &= 50° + 120° = 170° \\
\text{Bearing of } DC &= \text{Bearing } AD + 85° \\
&= 170° + 85° \\
&= 170° + 85° - 180° = 75° \\
\text{Bearing } CB &= \text{Bearing of } DC + 60° + 180° \\
&= 75° + 60° + 180° \\
&= 315° \\
\text{Bearing } BC &= 315° - 180° = 135°
\end{aligned}$$

Check

$$\begin{aligned}
\text{Bearing of } AB &= \text{Bearing of } CB + 95° - 180° \\
&= 315° + 95° - 180° = 230°
\end{aligned}$$

Bearing AB = 230° – 180° = 50° which is the given bearing of AB.



TRAVERSE CALCULATIONS

PROCEDURE FOR TRAVERSE CALCULATIONS (BOWDITCH ANALYTICAL METHOD)

- Adjust angles or directions
- Determine bearings or azimuths
- Calculate and adjust latitudes and departures
- Calculate rectangular coordinates

- Adjustment of Angles

$$\sum \text{Interior Angles} = (n-2) \times 180^\circ$$

n = the number of interior angles

DETERMINING BEARINGS OR AZIMUTHS

- Requires the direction of at least one line within the traverse to be known or assumed
- For many purposes, an assumed direction is sufficient
- A magnetic bearing of one of the lines may be measured and used as the reference for determining the other directions
- For boundary surveys, true directions are needed

The general formula that is used to compute the azimuths is:

forward azimuth of line = back azimuth of previous line + clockwise (internal) angle

The back azimuth of a line is computed from

$$\textit{back azimuth} = \textit{forward azimuth} \pm 180^\circ$$

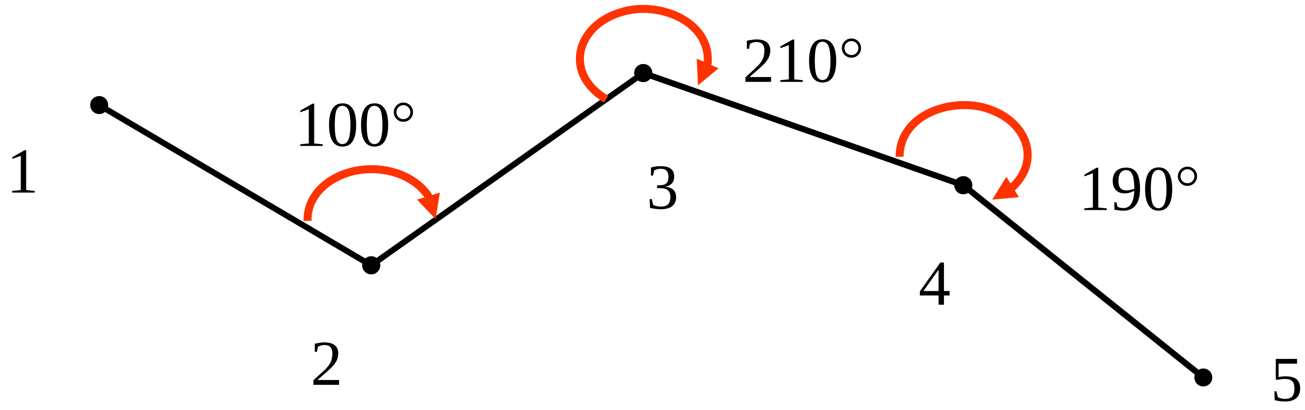
DETERMINING BEARINGS OR AZIMUTHS

Therefore for a traverse from points 1 to 2 to 3 to 4 to 5, if the angles measured at 2, 3 and 4 are 100°, 210°, and 190° respectively, and the azimuth of the line from 1 to 2 is given as 160°, then

$$Az23 = Az21 + \text{angle at } 2 = (160° + 180°) + 100° = 440° \equiv 80°$$

$$Az34 = Az32 + \text{angle at } 3 = (80° + 180°) + 210° = 470° \equiv 110°$$

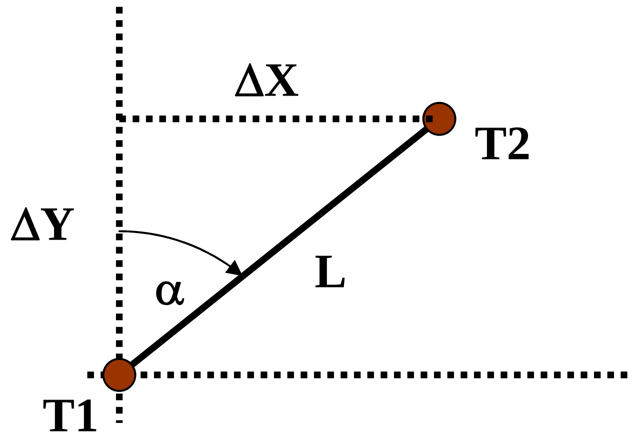
$$Az45 = Az43 + \text{angle at } 4 = (110° + 180°) + 190° = 480° \equiv 120°$$



Calculation of Latitudes (ΔY) and Departures (ΔX)

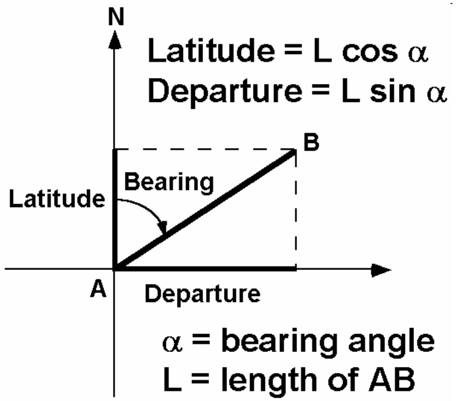
Latitude = L Cos α = ΔY

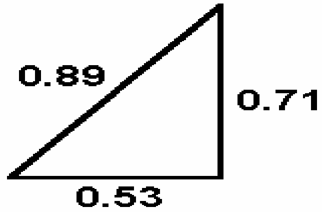
Departure = L Sin α = ΔX



Latitudes and Departures computed for each leg of a traverse

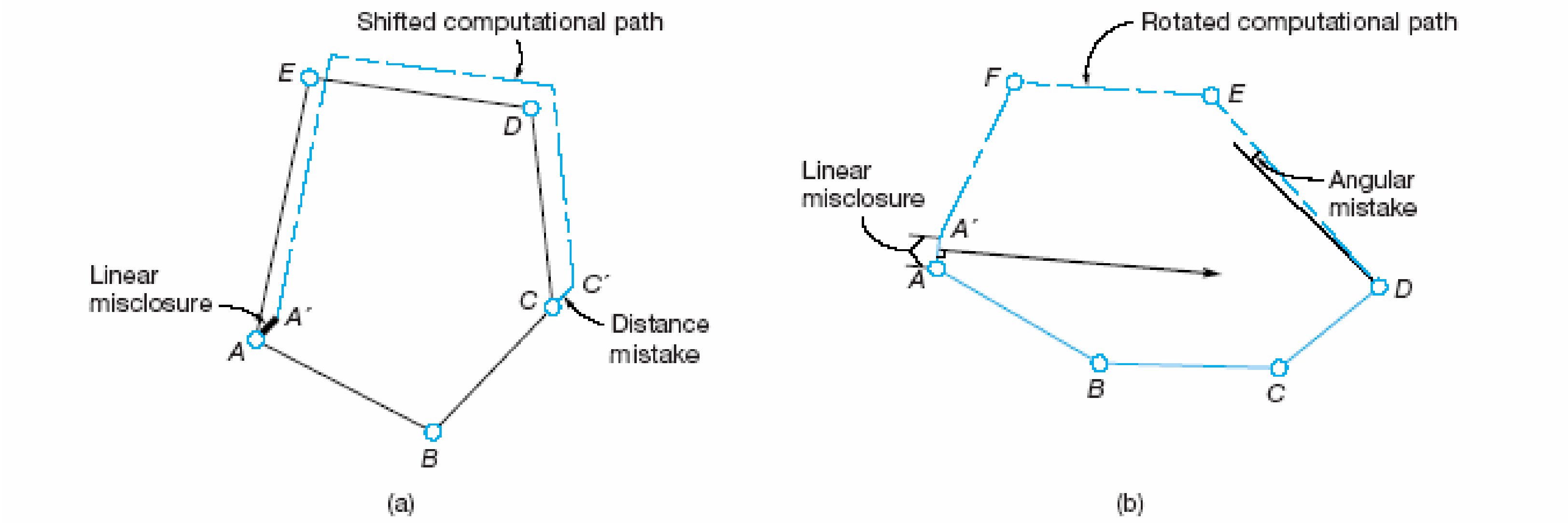
Linear Misclosure/Closing Error



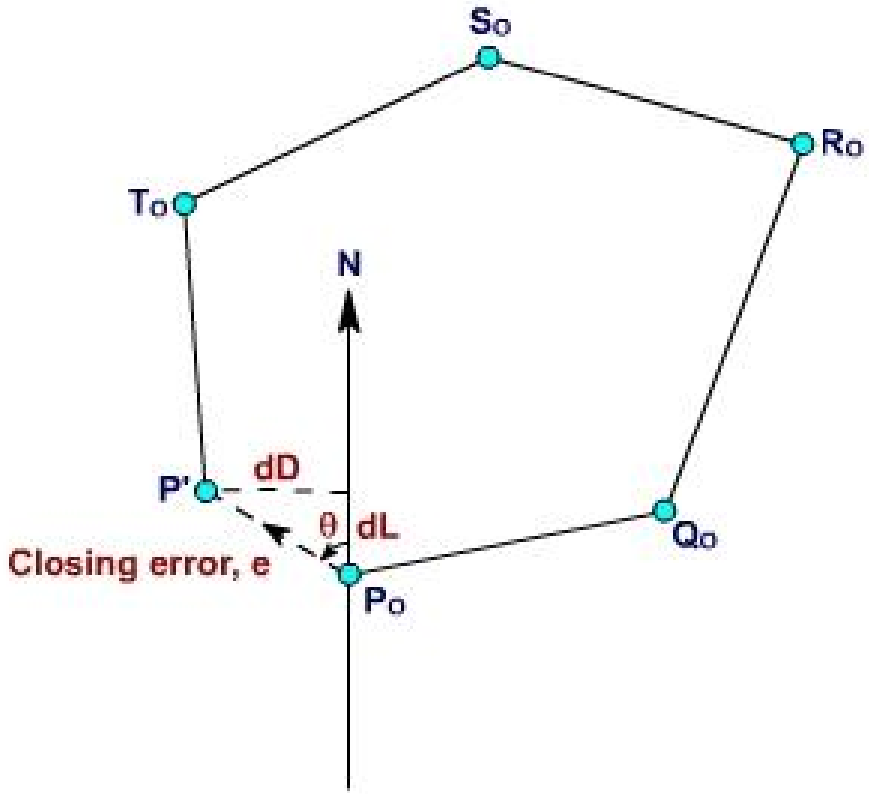


$$\sqrt{(0.53)^2 * (0.71)^2} = 0.89$$

Linear misclosure = [(departure misclosure)^2 + (latitude misclosure)^2]$^{1/2}$



Linear Misclosure/ Closing Error



Closing error of a closed loop traverse

TRAVERSE PRECISION

- The precision of a traverse is expressed as the ratio of linear misclosure divided by the traverse perimeter length.
- expressed in reciprocal form

relative precision = linear misclosure / traverse length

expressed as a number 1 / ?

read as 1' foot error per ? feet measured

Example:

linear misclosure = 0.08 ft.

traverse length = 2466.00 ft.

relative precision = 0.08/2466.00 = 1/30,000

Surveyor would expect 1-foot error for every 30,000 feet surveyed

Calculation of Traverse – Step 1

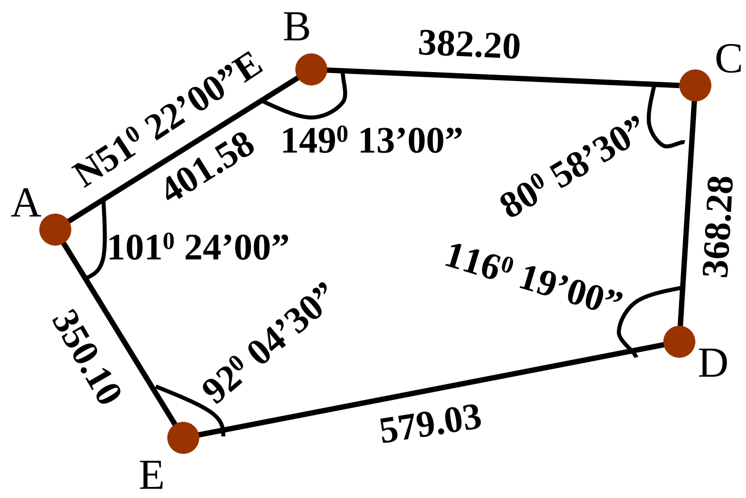
Check Interior Angle Closure

Observed	Adjusted
A = 101^0 24’ 00”	101^0 24’ 12”
B = 149^0 13’ 00”	149^0 13’ 12”
C = 80^0 58’ 30”	80^0 58’ 42”
D = 116^0 19’ 00”	116^0 19’ 12”
E = 92^0 04’ 30”	92^0 04’ 42”
Total = 539^0 59’ 00”	= 540^0 00’ 00”

Should = 540^0 00’ 00” = (n-2)*180

Misclosure = 01’ 00” = 60”

Adjustment = 60/5 = +12” per angle



observations

Compute Azimuths – Step 2

α_{AB} = 51^0 22’ 00” (given)

α_{BA} = 231^0 22’ 00”

B = 149^0 13’ 12”

α_{BC} = **82^0 08’ 48”**

α_{CB} = 262^0 08’ 48”

C = 80^0 58’ 42”

α_{CD} = **181^0 10’ 06”**

α_{DC} = 1^0 10’ 06”

D = 116^0 19’ 12”

α_{DE} = **244^0 50’ 54”**

α_{ED} = 64^0 50’ 54”

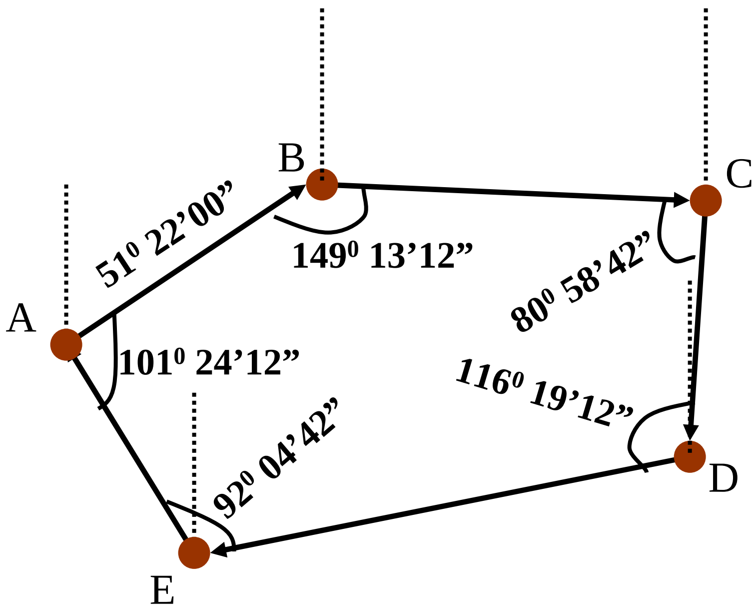
E = 92^0 04’ 42”

α_{EA} = **332^0 46’ 12”**

α_{AE} = 152^0 46’ 12”

A = 101^0 24’ 12”

α_{AB} = **51^0 22’ 00”** Check



Compute Lats and Deps - Step 3

Leg	Azimuth	Distance	Lat (LCosα)	Dep (LSinα)
AB	51^0 22’ 00”	401.58	**250.720**	**313.697**
BC	82^0 08’ 48”	382.20	**52.222**	**378.615**
CD	181^0 10’ 06”	368.28	**-368.203**	**-7.509**
DE	244^0 50’ 54”	579.03	**-246.097**	**-524.130**
EA	332^0 46’ 12”	350.10	**311.301**	**-160.193**
		Total	**-0.057**	**0.480**

Total Traverse Distance = **2081.19**

Linear Misclosure = $\sqrt{(0.057)^2 + (0.480)^2}$ = **0.483**

Precision = 0.483/2081.19 = 1/4305 …… **1/4300**

Compass Rule/Bowditch Adjustment – Step 4

Correction to Lats = $- \frac{\text{Traverse leg distance}}{\text{Total traverse distance}} * \text{Lat Misclosure}$

Correction to Deps = $- \frac{\text{Traverse leg distance}}{\text{Total traverse distance}} * \text{Dep Misclosure}$

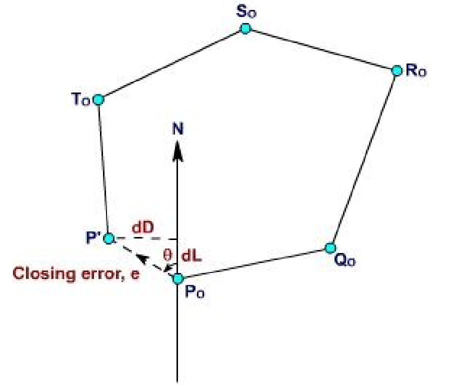
Leg	Lats	Deps		Corrn Lat	Corrn Dep	Adj Lats	Adj Deps
AB	250.720	313.697		**0.011**	**-0.093**	**250.731**	**313.604**
BC	52.222	378.615		**0.010**	**-0.088**	**52.233**	**378.527**
CD	-368.203	-7.509		**0.010**	**-0.085**	**-368.193**	**-7.594**
DE	-246.097	-524.130		**0.016**	**-0.134**	**-246.081**	**-524.264**
EA	311.301	-160.193		**0.010**	**-0.081**	**311.311**	**-160.274**
			Total	**0.057**	**-0.480**	**0.000**	**0.001**

Final Lats and Deps should be rounded to 2 decimal places

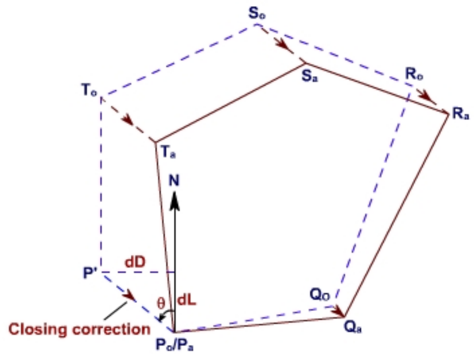
Bowditch Graphical Method

For rough surveys or traverse of small area, adjustment can also be carried out graphically. In this method of balancing, the locations and thus the coordinates of the stations are adjusted directly. Thus, the amount of correction at any station is proportional to its distance from the initial station .

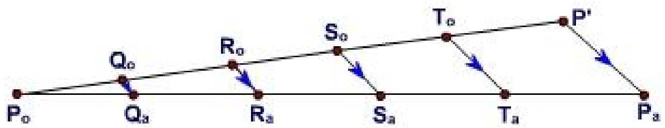
Let Po Qo Ro So To P' is the graphical plot of a closed-loop traverse PQRSTP. The observed length and direction of traverse sides are such that it fails to get balanced and is depicted in its graphical presentation by an amount Po P'. Thus, the closing error of the traverse is Po P' (Figure 1). The error Po P' is to be distributed to all the sides of the traverse in such a way that the traverse gets closed i.e., P' gets coincides with Po in its plot. This is carried out by shifting the positions of the station graphically. In order to obtain the length and direction of shifting of the plotted position of stations, first a straight line is required to be drawn, at some scale, representing the perimeter of the plotted traverse. In this case, a horizontal line Po P' is drawn [Figure 3]. Mark the traverse stations on this line such as Qo, Ro, So and To in such a way that distance between them represent the length of the traverse sides at the chosen scale. At the terminating end of the line i.e., at P', a line P' P a is drawn parallel to the correction for closure and length equal to the amount of error as depicted in the plot of traverse. Now, join Po to Pa and draw lines parallel to P' Pa at points Qo, Ro, So and To. The length and direction of Qo Qa, Ro Ra, So Sa and To Ta represent the length and direction of errors at Qo, Ro, So and To respectively. So, shifting equal to Qo Qa , Ro Ra, So Sa and To Ta and in the same direction are applied as correction to the positions of stations Qo, Ro, So and To respectively. These shifting provide the corrected positions of the stations as to Qa, Ra, Sa,Ta and Pa. Joining these corrected positions of the stations provide the adjusted traverse Pa Qa Ra, Sa Ta [Figure 2].



Closing error of a closed loop traverse



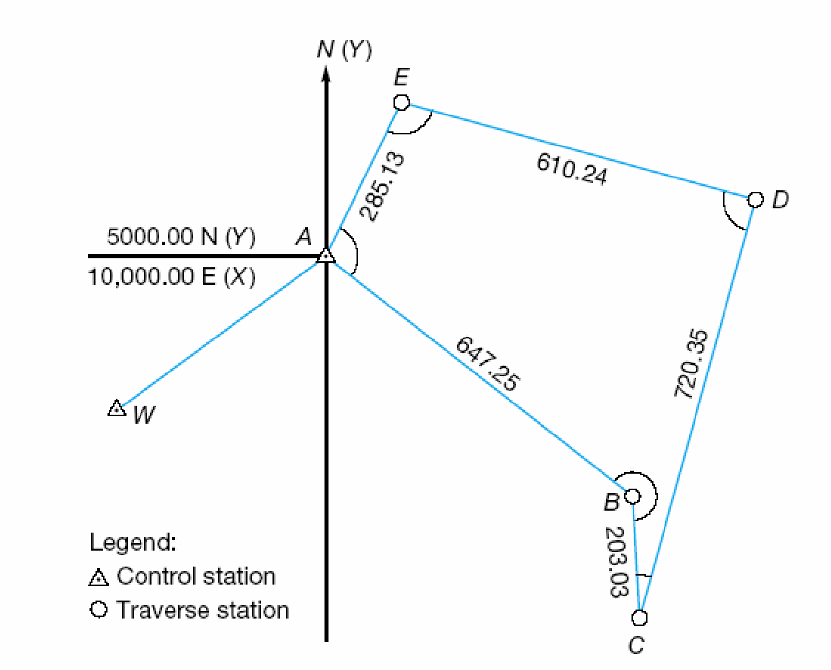
(i)



(ii)

CALCULATING X AND Y COORDINATES

Given the X and Y coordinates of any starting point A, the X and Y coordinates of the next point B are determined by:



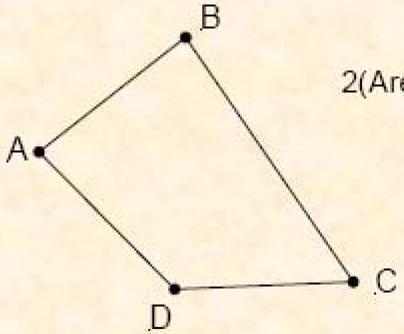
$$Y_B = Y_A + \text{latitude } AB$$

$$X_B = X_A + \text{departure } AB$$

Area Computation

I. Area Computation

By coordinates

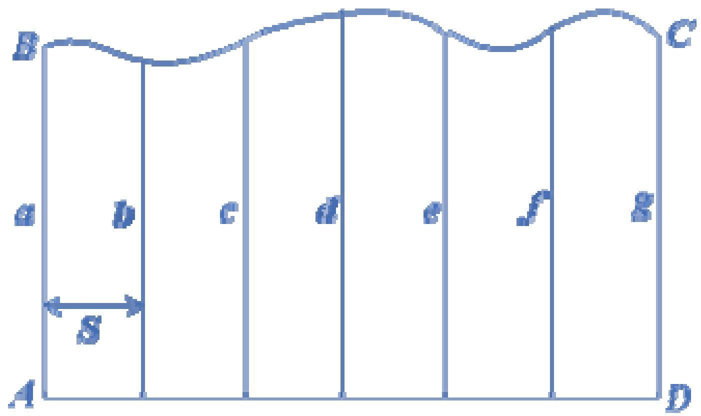


$$2(\text{Area}) = X_B Y_A + X_C Y_B + X_D Y_C + X_A Y_D - X_A Y_B - X_B Y_C - X_C Y_D - X_D Y_A$$

Coordinates		Cross multiplication ($\nearrow$)	Cross multiplication ($\searrow$)
X_A	Y_A	$X_B Y_A$	
X_B	Y_B	$X_C Y_B$	$X_A Y_B$
X_C	Y_C	$X_D Y_C$	$X_B Y_C$
X_D	Y_D	$X_A Y_D$	$X_C Y_D$
X_A	Y_A		$X_D Y_A$
	Sums:	$\Sigma(\nearrow)$	$\Sigma(\searrow)$

$$\text{Area} = \left| \frac{\Sigma(\nearrow) - \Sigma(\searrow)}{2} \right|$$

Simpson's Rule



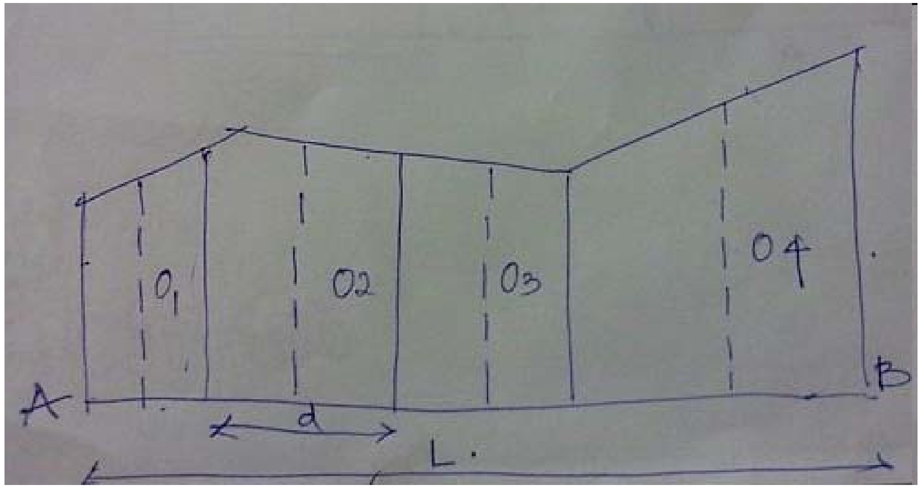
By Simpson's Rule, the area is

determined as: Area $= \frac{S}{3}[A + 2D + 4E]$

Where, A=Sum of the first and the last ordinate
D=Sum of odd ordinates
E=Sum of even ordinates
S=Width of each strip

The area is equal to the sum of the two end ordinates plus four times the sum of the even intermediate plus twice the sum of the odd intermediate ordinates, the whole multiplied by one-third the common interval between them.

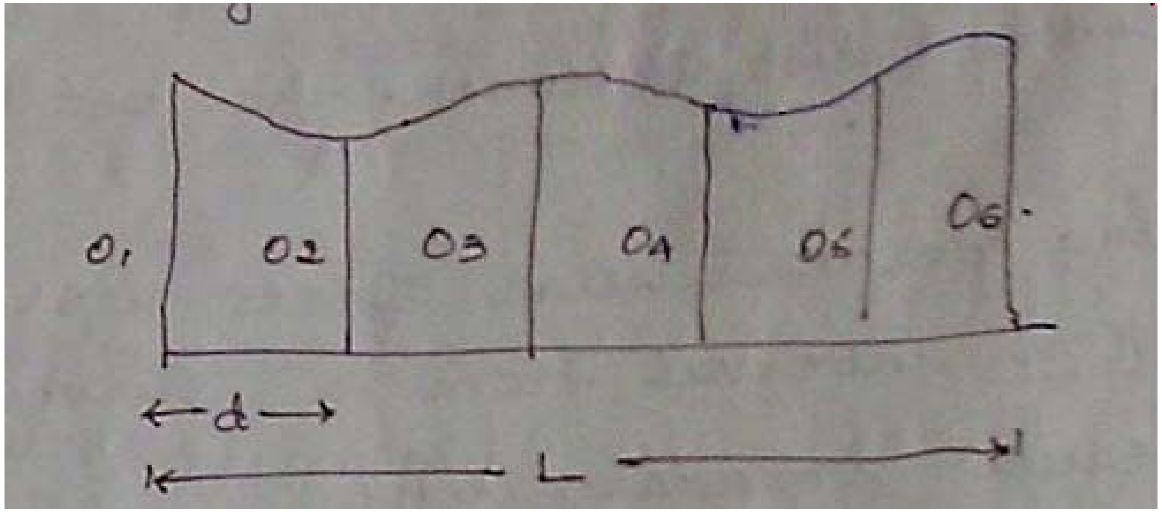
Mid-Ordinate Rule



Area = ([O1+O2+O3+ .....+ On]*L)/n
(O1 +O2 + O3 + ...+ On)*d

Where:
L = length of baseline
n = number of equal parts, the baseline is divided
d = common distance between the ordinates

Average Ordinate Rule

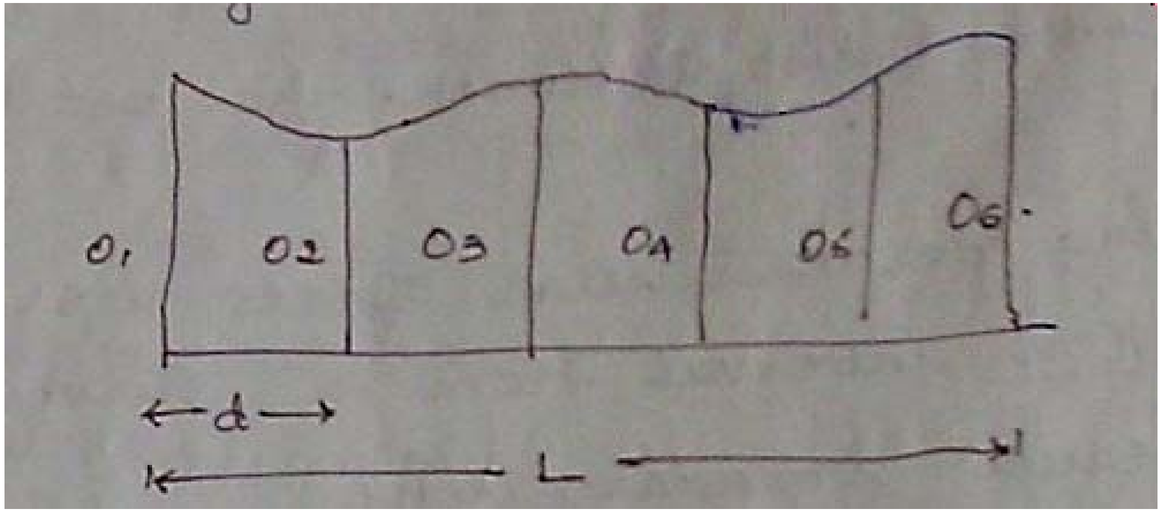


Area = [(O1+ O2+ O3+ .... + On)*L]/(n+1)

- L = length of baseline
- n = number of equal parts (the baseline divided)
- d = common distance

Trapezoidal Rule

- ***Area = [(O1+ On)/2+ O2+ …. + On-1]*d***



Problem

The following perpendicular offsets were taken at 10 meters intervals from a survey line to an irregular boundary line:

3.25,5.60,4.20,6.65,8.75,6.20,3.25,4.20,5.65

Area from Departure and Latitudes

- The Area= $\frac{1}{2}\sum$ (Total latitude × Algebraic Sum of Adjoining Departures)

LEG	LATS	DEP	CORR LAT	CORR DEP	ADJ LAT	ADJ DEP	STATION	TOTAL LAT	Algebric Sum of Adj.Dep	Double Area
AB	250.720	313.697	**0.011**	**-0.093**	**250.731**	**313.604**	B	250.731	692.131	173538.6977
BC	52.222	378.615	**0.010**	**-0.088**	**52.233**	**378.527**	C	302.964	370.933	3112379.3454
CD	-368.203	-7.509	**0.010**	**-0.085**	**-368.193**	**-7.594**	D	-65.236	-531.854	34696.027544
DE	-246.097	-524.130	**0.016**	**-0.134**	**-246.081**	**-524.264**	E	-311.317	-684.538	213108.3165
EA	311.301	-160.193	**0.010**	**-0.081**	**311.311**	**-160.274**	A	0	153.504	0
									Total	3533722,387144
									Area	Total/2