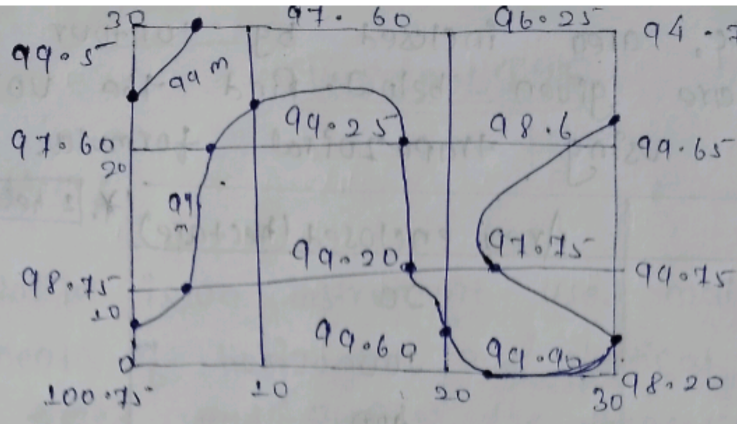


Measurment of volume of reservoir (water body) :-

Reservoirs are made for water supply and for irrigation Project. A countour map is very useful to study the possible location of dam and the volume of water to be confined. All the contours are closed line with in the reservior area.

The areas $A_1, A_2, A_3 \ldots A_n$ between successing contour lines can be determined by planimeter and if h is the contour interval, the capacity of reservoir can be esstemeted by the application of either the trapezoidal or the ~~Prismodal~~ Prismoidal formula.

→ Trapezoidal formula :

$$V = h\left\{\frac{A_1 + A_n}{2} + A_2 + A_3 + A_4 + \ldots\ldots A_{n-1}\right\}$$

→ Prismoidal formula :

$$V = \frac{h}{3}\left\{(A_1 + A_n) + 4(A_2 + A_4 + \ldots A_{n-1}) + 2(A_3 + A_5 + \ldots A_{n-2})\right\}$$

Q: From the topographic, area inclosed by contour lines for a proposed dam are given below. Find the volume impounded water using trapezoidal formula.

contour (m)	Area enclosed (hectare)
500	20
505	100
510	400
515	900
520	1100

*. $\boxed{1 \text{ hectare} = 10{,}000 \text{ m}^2}$

Soln

From trapezoidal formula,

$$V = h\left\{\frac{A_1 + A_n}{2} + A_2 + A_3 + \ldots A_{n-1}\right\}$$

last 2nd point

Last Point

$$= \cancel{5\left\{\frac{500+520}{2} + 505 + 510 + 515\right.}$$

$$= 5\left\{\frac{20+1100}{2} + 100 + 400 + 900\right\} \times 10000 \text{ m}^3$$

$$= 5\left\{\frac{1120}{2} + 1400\right\} \times 10000 \text{ m}^3$$

$$= 5\left\{\frac{1120 + 2800}{2}\right\} \times 10000 \text{ m}^3$$

$$= 5\left\{\frac{3920}{2}\right\} \times \overset{5000}{\cancel{10000}} \text{ m}^3$$

$$= 5 \times 3920 \times 5000 \text{ m}^3$$

$$= 98{,}000{,}000 \text{ m}^3$$

UNIT - 02

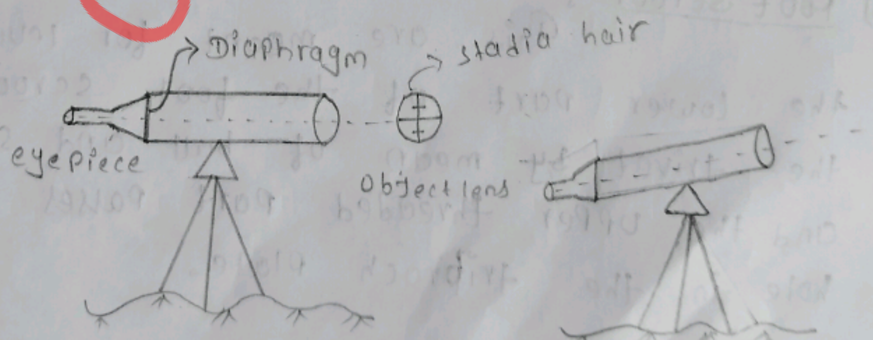
THEODOLITE

Introduction :

The theodolite is an instrument used mainly for accurate measurement of horizontal and vertical angle. cause of its various ~~used~~ ~~multi purpose~~ the theodolite is some time known as universal instrument. The following are the different purposes for which theodolite can be used :-

(i) Measurement of horizontal angle.
(ii) Measurement of vertical angle.
(iii) Measurement of diffelction angle.
(iv) Measurement of bearings.
(v) Measuring the horizontal distance between two Points.
(vi) Finding the vertical height of an object.
(vii) Finding the difference of ellivation between various Points.
(viii) Ranging a line.

(i) Axis of telescope
(ii) Line of sight
(iii) Line of collimation



1.) Axis of telescope :- This axis is an imaginary line passing through the optical centre of object lens and the optical centre of eyepiece.

2.) Line of sight :- The line of sight is the an imaginary line that passes through intersection of the cross hair on the diaphargm and optical centre of object lens.

3.) Line of collimation :- It is an imaginary line passing through intersection of cross-hair at the diaphragm and the optical centre of the object glass and its contimulation. A line of sight is called line of collimation when it is horizontal.

#. Parts of theodolite :

(i.) Trivet :- It is a circular plate having a central threaded hole for fixing the theodolite on the tripod stand by a wing nut. It is also called baseplate. Three foot screw are secure to this plate by mean of a wall and soacket arragement.

(ii.) Foot scroop :- This are meant for levelling the instrument the lower part of the foot scroop are secured in the trivet by mean of ball and socket arrangement and the upper threaded part passes through the threaded hole in the tribrach plate.

(iii.) Tribrach :- It is a traingular plate carrying foots at its ends.

(iv) Levelling head :-

The trivet, footscrew and the tribrach constitued a body which is known as levelling head.

(v) Spindles :-

The theodolite consist of two spindles or one inner and other outer. The inner exis is solid and conical and outer is hollow. The two spindles are coaxial

(vi) Lower Plate :-

The lower plate is attached to the outer axis also known as scale plate. It is ~~deper~~ develled and the scale is graduated from 0° to 360° in clockwise direction. Each degree is again sub divided into two, three or four. Thus the value of one small division may be 30 minute, 20 minute or 15 mintue respectively.

- The lower provided with climp screew and a tanget screw which control its movement when climp screw tighteted this Plate is fixed in the outer axis.

(vii) Upper Plate :-

The upper plate contains the vernier scale A and B. It is attached to the inner axis. Its motion is control by upper climp screw and upper tanget screw when the climp screw is tighteted the vernier scale are fixed in inner axis and for the find adjustment of scale tanget screw is rotated.

(viii) Plate bubble :-

Two plate bubble are mounted at right angle to each other on the upper surface of the vernier plate. One bubble is kept parallel to the horizontal axis of the theodolite the bubbles are meant for levelling the instrument at the measuring the horizontal angle.

(ix.) Telescope :-

The telescope is pivoted between the standards at right angle to the horizontal axis. It can be rotated about its horizontal axis in the vertical plane. The telescope is provided with focusing screw, clapping screw, and tanget screw.

(x.) Vertical circle :-

The vertical circle is rigidally fixed with the telescope and moves it with it. It is divided into four quardent each quadernt is graduated from 0° to 90° in opposite direction with the 0 mark at the end of horizontal diameter of the vertical circle.

- The joining the 0 mark co crossponde to the line of collimation.

Temporary Adjustment of Theodolite :

Temporary adjustment are the adjustment which are required to be make at each setting of the instrument before taking observations.

↳ The following five temporary adjustment are required.

- setting up
- centering
- Levelling
- Focusing the eyepiece
- Focusing the objective

*. Setting up :-

- To set up the instrument, the tripod, should be placed over the required station.
- The legs of the tripod should be spread such that they make an angle of about 60° with the horizontal.
- The shoes of the legs should be facing the same direction. The shoes of legs should be pushed into the ground by applying a force parallel to the legs.
- Instrument is then taken out of the box. The instrument from the base (and not from the telescope) is then lifted and tightly screwed on the tripod head after removing the cap provided on the tripod head.
- The height of the tripod is adjusted so that the telescope is at the eye level up the surveyor. For centering purposes, a plumb bob is suspended from the hook beneth the inner spindle.

*. Centering :-

- Centering is done to place the vertical axis exactly over the station mark.
- Approximate centering is done with the help of the tripod legs.
- The tripod legs are moved radialy or circumferentially for centering.
- As the legs are moved radialy, the plumb bob shifts in the direction of the movement of the leg without seriously affecting the levelling of the instrument.
- When the legs are moved sideways or circumferentially, the plumb does not shift much, but the levelling is affected.
- Approximate levelling is checked with reference to a small circular provided on the tribach.

*. Levelling :-

- Accurate levelling of theodolite is done using levelling screw of foot screw with reference to the plate level.
- The levelling is done to make the vertical or to make the horizontal plate truly horizontal.
- The basic approach is to make the axis of the plate bubble horizontal. This happens when the plate level is horizontal.

*. Focusing the eyepiece :-

- The eyepiece is focused on making the crosshairs distinct and clear.
- The following procedure is followed for this purpose
- Point the telescope towards the sky or hold a sheet of white paper in front of the objective.
- Move the eyepiece in or out by rotating it gradually untill the crosshairs appear quite sharp and distinct.
- Focusing on the eyepiece depends upon the eyesight (vision) of the surveyor.
- The eyepiece, one focused, need not to be disturbed if the same surveyor is using it.
- In some telescope, graduations are marked on the eyepiece. The surveyor can note down the graduations corresponding to his vision and adjust the eyepiece to the same graduation whenever focusing is required.

*. Focusing the objective :-

- The objective is focused to bring the image of the object in the plane of the crosshairs.
- The following procedure is adopted.
- Direct the telescope towards the object.
- Turn the focusing screw ~~untill~~ untill the image of the object appear

clear and sharp.

- When focusing has been done, there is no parallax, i.e. there will be no apparent movement of image of the object relative to the crosshairs when the observer moves his eye from one side to the from top to bottom.
- Focusing on the objective depends upon the distance of the object.
- When the distance of the object is changed, focusing has to be done again.

#. Permanent Adjustment of Theodolite :

Permanent adjustment deal with the fundamental lines and their relationships and should be done once in a while to ensure that the instrument is properly adjusted. Permanent adjustment of theodolite is done four steps :

- Adjustment of plate level.
- Adjustment of line of sight.
- Adjustment of the horizontal axis
- Adjustment of altitude level.

*. Adjustment of plate level :-

The first pernanent adjustment plate level adjustment is done for making the axis of plate bubble prependicular to the vertical axis when the bubble is central.

*. Adjustment of line of sight :-

Line of sight is imaginary line passing through the intersection of the crosshair on the diaphram and optical centre of the objective lens. When a line of sight comes in a horizontal plane, it is called a line of collimation. The line of sight generates a vertical plane when the horizontal axis is perpendicular to the vertical axis. The line of sight should coincide with the optical axis of the telescope.

*. **Adjustment of the horizontal axis :-**
The adjustment of the horizontal axis is done by the spire test. In this test horizontal axis should be perpendicular to the vertical axis.

*. **Adjustment of altitude level :-**
Adjustment of altitude level or vertical axis of the frame. The adjustment can be done with the help of tanget screws and clips screws.

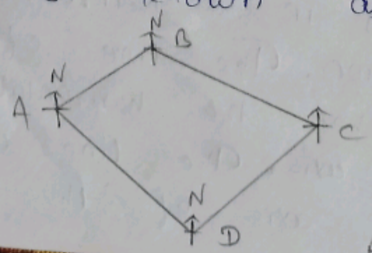
UNIT - 03

THEODOLITE TRAVERSING

(i) Closed traverse
(ii) Open traverse

Traversing is that type of survey in which a number of connected survey line form the framework and the direction and length of the survey lines are measured with the help of angle measuring instrument and tape or Chain respectively.

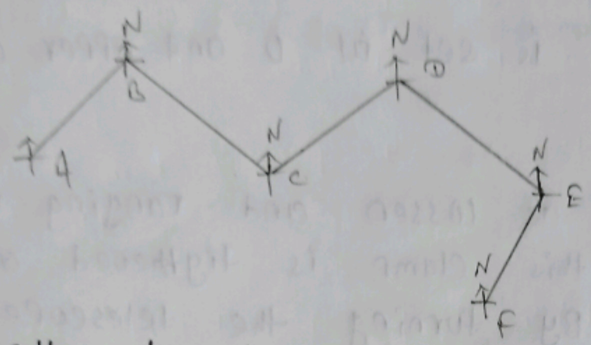
*. **Closed traverse:-**
When the form a circuit ends at the starting point, it is known as closed traverse.



ABCDA

*. Open traverse :-

When ~~lime~~ line from a circuit ends alse where starting Point, it is said to be open traverse.



Traverse ABCDEF

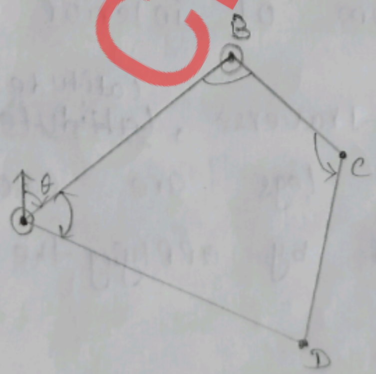
#. Methods of traversing :

a.) Included angle method

b.) Deflection angle method

a.) Included angle method :-

This method is knows most suiatable for closed traverse. The traverse may be taken clockwise or anticlockwise order but generally closed traverse taken in the anticlock wise order. In this method the bearing of the initial line is taken after this included angle is determined.



↳ Procedure :

Step 1 :- The theodolite is setup and centred over A. The plate bubble is levelled. vernier A is ~~ste~~ set at 0° and B at 180°. The upper clamp is fixed.

Step 2 :- The telescope is oriented along the north line with the help of compass. The magnetic bearing of AB is ~~majored~~ measured.

Step 3 :- Again vernior A is set at 0 and upper clamp is kept fixed.

Step 4 :- The lower clamp is lossen and ranging rod at B is bisected. Now this clamp is tigthened and upper clamp is lossen. By turning the telescope clockwise direction, the ranging rod at D is bisected. The readings ~~count~~ on vernicars are ~~rotate~~ noted $\angle A$ is obtain in this fashion.

The face of instrument is changed and $\angle A$ is measured once more. The mean of two observation it will give the value of $\angle A$.

Step 5 :- Similarly other angles are measured by centering the theodolite ~~and at~~ station B, C & D etc.

The arthmetical check is applied as follow

$(2N-4) \times 90^\circ$ = sum of interior angle.

Step 6 :- For plotting the traverse, ~~lattidute~~ latitude and departure of the traverse legs are calculated. The interior details are marked by applying the plane table method.

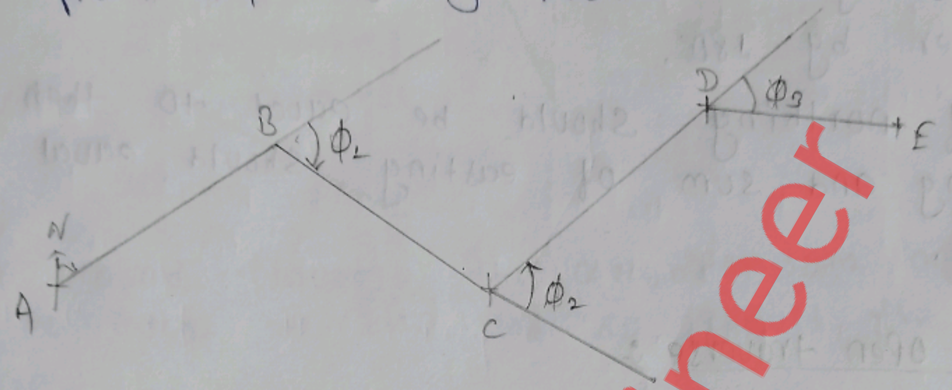
1.

2.

*.

(b.) Deflection angle method :-

This method is suitable for open tranverse and mostly required imployed in the survey of river, coastline, Roads, railway etc. suppose an open traverse start from ~~a~~ A following procedure are adopted.



- The theodolite is setup at A, and then settin centred and levelled. After this bearing of the line AB is measured in the usual manner.
- The theodolite is now shifted and centred over B. The Plate bubble is levelled and vernior A set at 0°. Then backsight is taken on A. The telescope is <u>transited</u> and by turning it clockwise the ranging rod at C is ~~bisected~~ bisected. The vernior reading are taken. Then ~~de~~flection angle ϕ_1 is determine it is the average value of the angle obtained from vernior A and B.
- Similarly the other deflection angle ϕ_2 & ϕ_3 are measured.
- A filled book is prepared in which deflection angle and ~~ob~~ offset are clearly noted.

*. Checks in closed traverse :-

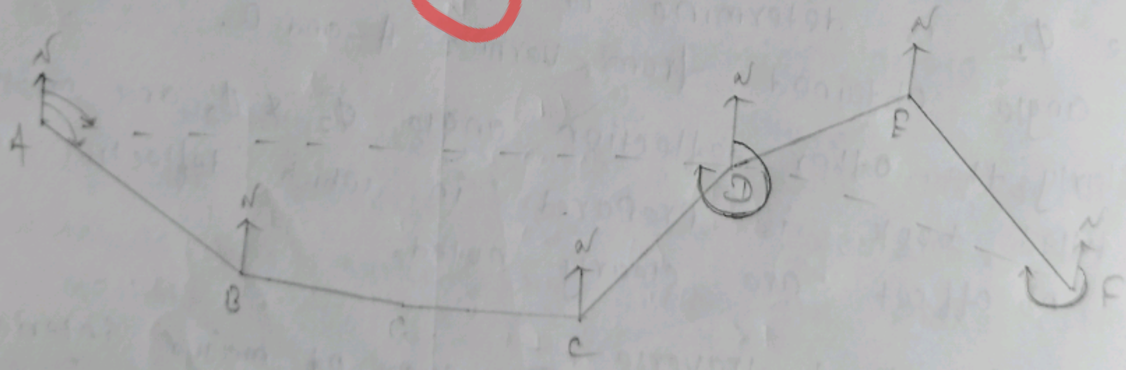
The sum of major interior angle should be equal to $(2N-4)\times 90°$ and sum of measured exterior angle ~~to~~ equal to $(2N+4)\times 90°$.

- The algebric sum of the deflection angle should be equal to 360°, consodring right hand deflection be positive and left hand deflection negative.
- The fore bearing and back bearing ~~and~~ of finshing line should defer by 180°.
- The sum of northing should be equal to than that of the southing and sum of easting should equal to that of westing.

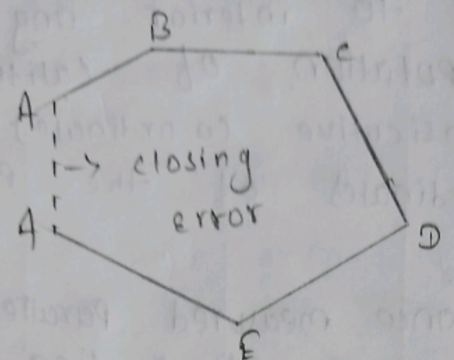
*. Check for open traverse :-

a) Tie line or cuttoff line :-

Suppose ABCDEF is an open traverse. The cuttoff line AD & DF are suitably taken. The fore bearing and back bearing of lines AD and DF are measured and so are distances AD & DF. If after plotting the traverse the distances, fore bearing and back bearing of cutoff line tally with filled measurements then traverse is said to be correct.



* Closing Error and It's Limitation :



$\Sigma L = 0$

$\Sigma D = 0$

In a closed traverse the algebric sum of latitude must be equal to zero and so should the algebric sum departure.

But due to error in field measurements of angles and length sometime finishing may not coincide with the starting point of closed traverse.

The distance by which traverse fails to closed is known as closing error.

In the figure the traverse ABCDEA' fail closed by a distance AA' which is the closing error of this traverse.

$$\boxed{\text{Closing Error } AA' = \sqrt{(\Sigma L)^2 + (\Sigma D)^2}}$$

where, L = latitude

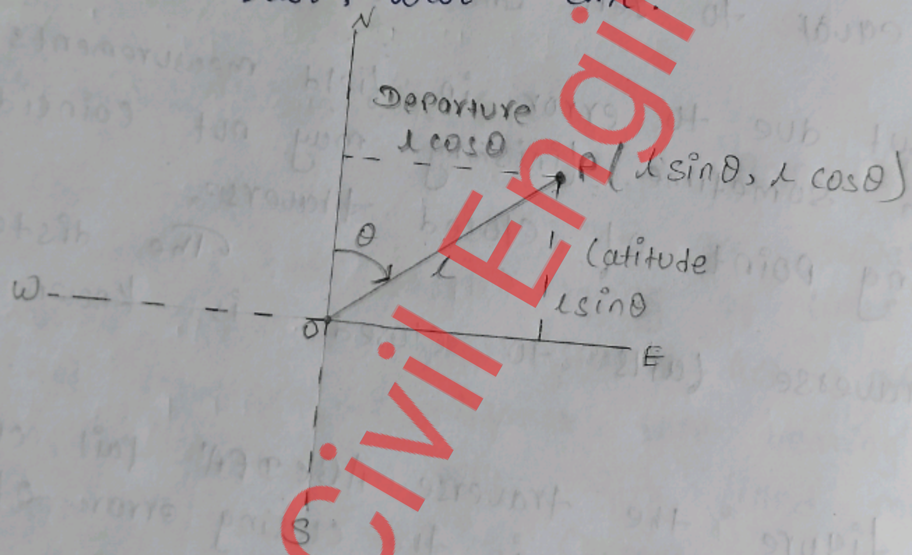
D = Departure

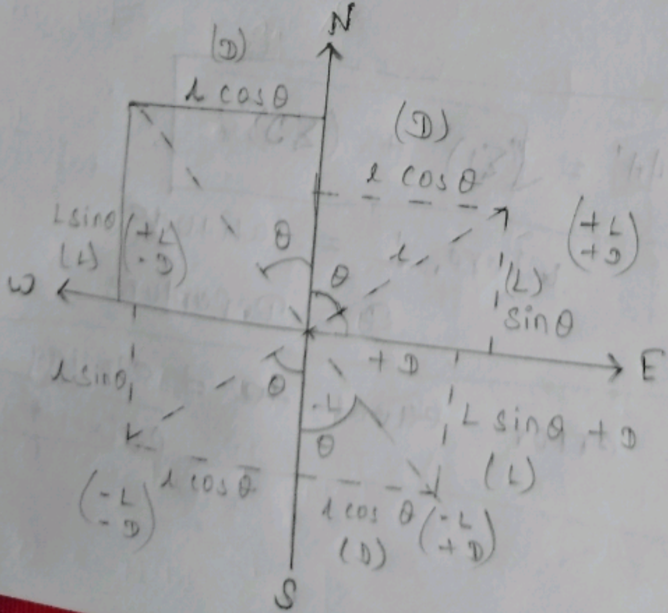
$$\boxed{\text{Relating closing error } \sim\!\sim\text{equal}\sim\!\sim \text{ to } = \frac{\text{Closing error}}{\text{Perimeter of traverse}}}$$

Computation of latitude & Departure :

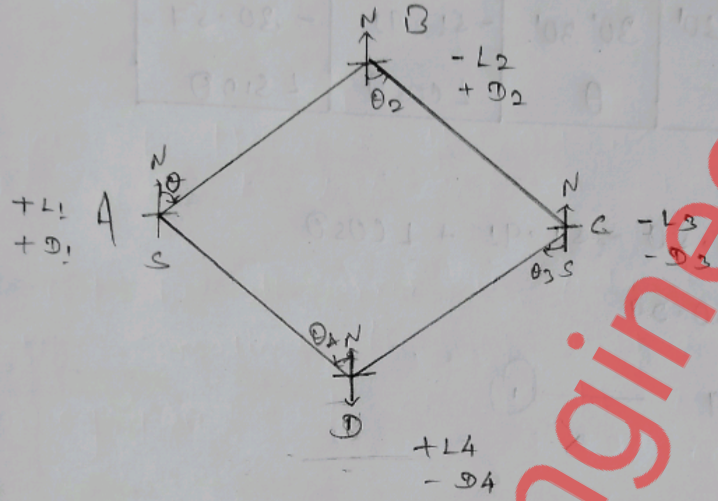
The theodolite traverse is north plotted according to interior angles or bearings. It is plotted by computation of latitude and departure of points (consicutive co-ordinate) and then finding independent coordinates of the points.

The latitude of a line is the distance measured parallel to the North, south line and departure of a line is measured parallel to the East, west line.





- Northing = Latitude of Line toward north = +L
- southing = Latitude of line toward south = -L
- Easting = Departure of line toward East = +D
- westing = Departure of line toward west = -D



$$\Sigma L = 0 \quad \left\{ \begin{array}{l} L_1 - L_2 - L_3 + L_4 = 0 \\ D_1 + D_2 - D_3 + D_4 = 0 \end{array} \right\}$$
$$\Sigma D = 0$$

Q: The following records are obtained in a traverse survey where length and bearing of last time where not recorded.

Line	length (m)	Bearing
AB	75.5	30°24'
BC	180.5	110°36'
CD	60.25	210°30'
DA	?	?

compute the length and bearing of line DA.

Solution :

Line	Length	WCB	RB	Latitude ($l\cos\theta$)	Departure ($l\sin\theta$)
AB	75.5	30°24'	30°24'	+65.12	+38.20
BC	180.5	110°26'	69°24'	-63.50	+168.95
CD	60.25	210°30'	30°30'	-51.91	-30.57
DA	L		θ	L cosθ	L sinθ

- $\Sigma L = 65.12 - 63.50 - 51.91 + L\cos\theta$

$0 = L\cos\theta - 50.29$

$L\cos\theta = 50.29$ —— (i)

- $\Sigma D = 38.20 + 168.95 - 30.57 + L\sin\theta$

$0 = L\sin\theta + 176.58$

$L\sin\theta = -176.58$ —— (ii)

Eq^n (ii) divided by eq^n (i).

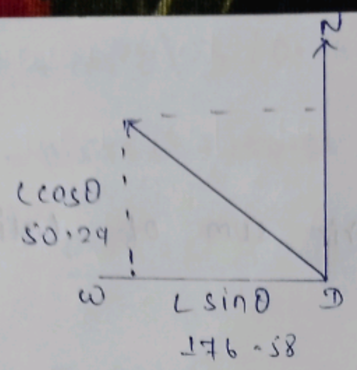
$$\frac{L\sin\theta}{L\cos\theta} = \frac{-176.58}{50.29}$$

$\tan\theta = 3.51$

$\theta = \tan^{-1} 3.51$

$\boxed{\theta = 74°5'}$ NW

$\boxed{\theta = N74°5'W}$



$L = \sqrt{(50.29)^2 + (176.58)^2}$

$\boxed{DA, L = 183.6m}$

Q. An incomplete traverse table is obtained as follow.

Line	Length	Bearing
AB	100	?
BC	80.5	140° 30'
CD	60	220° 30'
DA	?	310° 15'

Calculate the length of DA and bearing of AB

solution :

Line	Length	Bearing (WCB)	RB	Latitude	Departure
AB	100			100 cos θ	100 sin θ
BC	80.5	140° 30'	S 39° 30' E	− 80.5 cos 39° 30'	80.5 sin 39° 30'
C.D	60	220° 30'	S 40° 30' W	− 60 cos 40° 30'	60 sin 40° 30'
DA		310° 15'	N 49° 45' W	L cos 49° 45'	L sin 49° 45'

Let, l = length of DA

θ = Bearing of AB

In closed traverse the algebric sum of latitude and departure be = 0

$$\Sigma L = 0$$

$$\Sigma D = 0$$

$$100 \cos\theta - 80.5 \cos 39°30' - 60 \cos 40°30' + l \cos 49°45' = 0$$

$$100 \cos\theta - 62.11 - 45.62 + 0.64 l = 0$$

$$100 \cos\theta - 107.73 + 0.64 l = 0$$

$$100 \cos\theta = 107.73 - 0.64 l \text{ — (i)}$$

$$100 \sin\theta + 80.5 \sin 39°30' - 60 \sin 40°30' - l \sin 49°45' = 0$$

$$100 \sin\theta + 51.20 - 38.96 - 0.76 l = 0$$

$$100 \sin\theta = 0.76 l - 12.24 \text{ — (2)}$$

$$\cancel{100 \cos\theta - 62.73 - 45.62 + 0.64 l = 0}$$

$$\cancel{100 \cos\theta - 107.73 + 0.64 l = 0}$$

$$\cancel{100 \cos\theta = 107.73 - 0.64 l \text{ — (i)}}$$

From eqn (i) & (ii)

$$(100 \sin\theta)^2 = (0.76 l - 12.24)^2 \text{ — (i)}$$

$$(100 \cos\theta)^2 = (107.73 - 0.64 l)^2 \text{ — (ii)}$$

$$100^2(\sin^2\theta + \cos^2\theta) = (0.76l - 12.24)^2 + (107.73 - 0.64l)^2$$

$$10000 = 0.577l^2 + 149.81 - 2\times 0.76l \times 12.24 + 11605.75 + 0.0409l^2 - 137.9l$$

$$10000 = \underline{0.577l^2} + 149.81 - 18.60l + 11605.75 + \underline{0.409l^2} - \underline{137.9l}$$

$$10000 = \underline{0.986l^2} + 11755.56 - \cancel{165.50}l \quad 156.5l$$

$$\frac{0.986l^2}{0.986} - \frac{155.96l}{0.986} + \frac{1755.56}{0.986} = 0$$

$$l^2 = 158.72l + 1780.48 = 0$$

$$\cancel{l = 146.57\ m}$$

$$\cancel{= 12.147\ m}$$

$$l^2 - 158.72l + 1780.48 = 0$$

$$l^2 - 146.57l - 12.147l + 1780.48 = 0$$

$$l(l - 146.57) - 12.147(l - 146.57) = 0$$

$$(l - 146.57)(l - 12.147) = 0$$

$$l - 146.57 = 0, \quad l = 12.147 = 0$$

$$l = 146.57\ m, \quad l = 12.147\ m \quad \text{Ans.}$$