THEODOLITE SURVEYING:

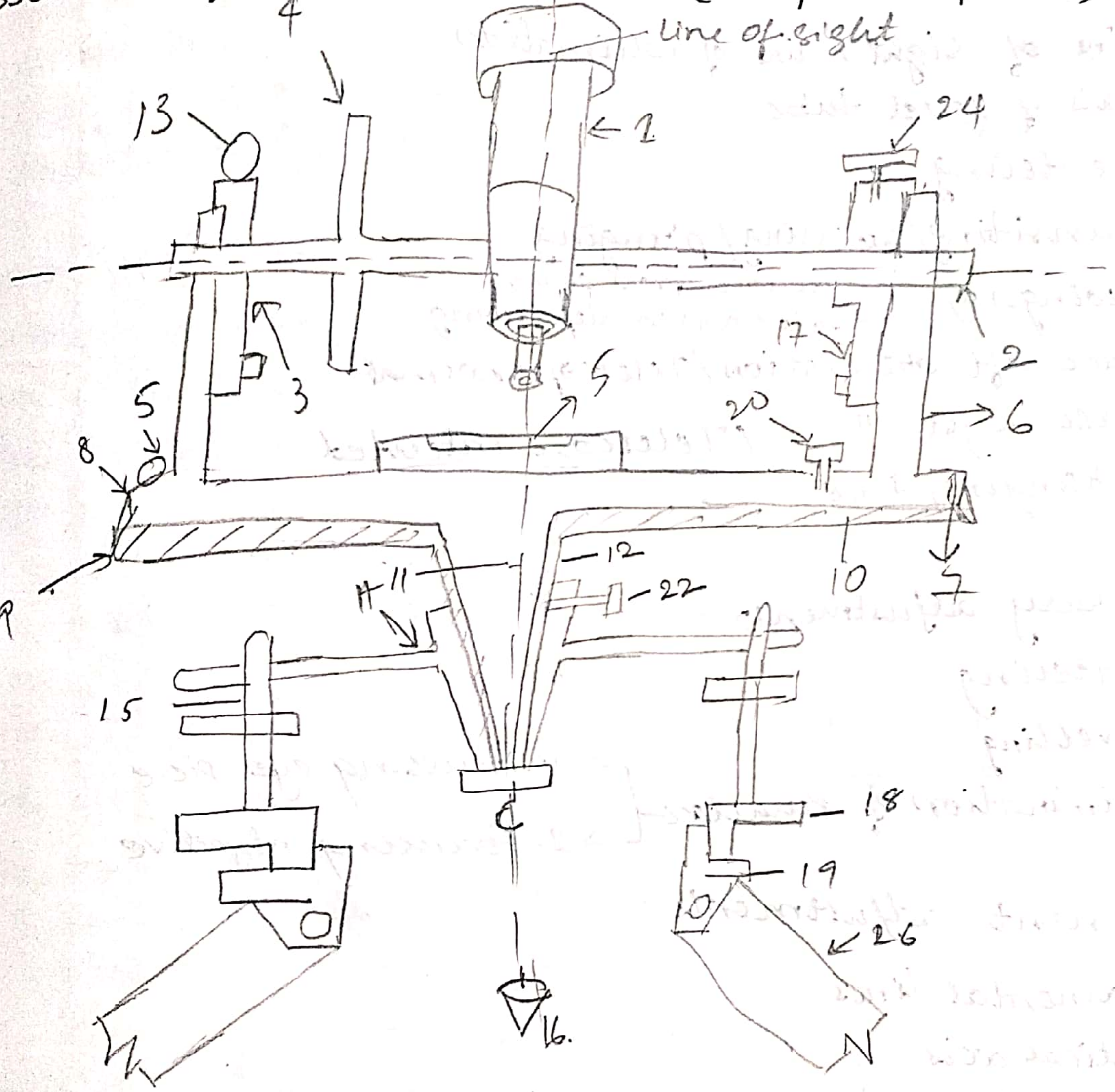
Theodolite :

Theodolite is a most precise instrument designed for measurement of horizontal angle and vertical angle, locating points on line, prolonging survey lines, establishing grades, determining difference in elevation, setting out of curves.

Types of theodolites:

1. Transit theodolite
2. Non-transit theodolite.

Essentials of transit theodolite (component parts):



1. Telescope
2. Trunnion Axis
4. Vernier circle
3. vernier frame
5. Plate level
6. standards (A frame)
7. Upper plate
8. Horizontal plate vernier
9. Horizontal circle
10. Lower plate
11. Inner axis

12. outer axis
13. Altitude level
14. levelling head
15. levelling screw
16. Plumb bob
17. Arm of vertical circle clamp
18. Foot plate
19. Tripod Head
20. upper clamp.
22. Lower clamp
24. Vertical circle clamp
26. Tripod

optical plummet : ⊕

Definitions :

1. vertical axis
2. Horizontal axis / Trunnion Axis / transit
3. Line of sight / line of collimation .
4. Axis of level tube
5. Centering
6. Transiting / reversing / plunging
7. Swinging
   - clock wise - Right swing
   - Anti clockwise - left swing
8. Face left observation / Telescope normal
9. Face right " / Telescope inverted .
10. changing face .

Temporary adjustments

1. centering
2. levelling
3. Elimination of Parallax
   1. Focussing eye piece
   2. Focussing objective .

Permanent adjustments :

(i) Fundamental lines

1. vertical axis
2. Horizontal axis
3. L. C (line of collimation)
4. Axis of plate level
5. " " Altitude level
6. " " striding " ((If provided)

optical plummet :

(ii) Desired relations:

1. Axis of plate level must lie in a plane perpendicular to vertical axis.

2. Line of collimation must be ⊥lar to the horizontal axis at the intersection with vertical axis.
3. Horizontal axis must be ⊥lar to vertical axis
4. Axis of altitude level (telescope level) must be parallel to the line of collimation.
5. Vertical circle vernier must read '0' when line of collimation is horizontal
6. Axis of striding level (if provided), must be parallel to the horizontal axis.

Uses of theodolite:

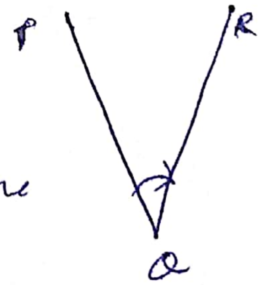
1. prolonging survey lines to 2. take horizontal angle and
3. to take vertical angle
4. Take deflection angle
5. To take magnetic bearings
6. To set curves
7. To measure direct angles.
8. To run a straight line b/w 2 points
9. To fix C/L of a road / railway track / Canal / Sewer line
10. To locate the point of intersection of two straight lines.
11. To locate points on a line
12. To Determine difference in elevation
13. To establish gradients.

Measurement of Horizontal angles:

It is of two methods:
1. Method of Repetition
2. Method of Reiteration.

1. Method of Repetition:

This method is used to measure horizontal angle to a finer degree of accuracy than that obtained with the least count of vernier.



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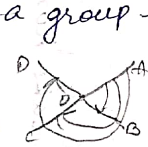
Inst at	Sighted to	Face left A ° ′ ″	Face left B ° ′ ″	Right swing mean ° ′ ″	No of Repetition	Horizontal angle (FL) ° ′ ″	Face right A ° ′ ″	Face right B ° ′ ″	Left swing Mean ° ′ ″	No. of Repetition	Horizontal angle (FR) ° ′ ″	Avg horizontal angle $\frac{FL+FR}{2}$

(ii) Reiteration method:

This method is suitable for measurement of angles of a group having a common vertex point.



Procedure: 1. Set instrument at 'O' and level it. Set one vernier to 0° and bisect A accurately.

2. Loose upper clamp and turn telescope clockwise to B. Read both verniers. The mean of vernier readings will give $\angle AOB$.

3. Similarly bisect 'C' and 'D' succesively, and take readings. Since the graduated circle remains fixed in entire process each included angle is obtained while taking difference between two consecutive readings.

4. On final sight to 'A' reading on A should match with the initial reading. If not the error is to be distributed to all ~~sta~~ angles. If error is large repeat the experiment and take fresh set of readings.

Inst at	sighted to	Face left A	Face left B	Swing mean Mean	Horizontal	Face right	Avg

5. Repeat steps 2-4 with other face.

Measurement of Vertical Angle:

Vertical angle is the angle which the inclided line of sight makes with the horizontal.

Inst. at	Sighted to	Face left A ° ' "	B ° ' "	Mean ° ' "	Horizontal angle ° ' "	Face right A ° ' "	B ° ' "	Mean ° ' "	Horizontal angle	Avg H.A
O	A									
	B									

Table for vertical angle:

Inst. at	Sighted to	Face left C ° ' "	D ° ' "	Swing mean ° ' "	Vertical angle ° ' "	Face right C ° ' "	D ° ' "	Left swing mean ° ' "	Vertical angle	Avg V.A

Principles of Electronic Theodolite:

Theodolites used for angular measurements can be classified as 3 types.
(i) Vernier theodolites (ii) Micrsotic theodolites (optical theodolites) (iii) Electronic theodolites.

Electronic theodolite:

1. In this absolute angle measurement is provided by a diamond system with opto electronic scanning.
2. These are provided with control panels with keyboards with LCD (Liquid crystal display).

3. The LCD's with points and symbols present the measured data clearly.
4. The keyboard contains multi function keys.
5. The main operations require only a single key stroke.
6. Electronic theodolites works with electronic speed and efficiency.
7. They measure electronically and open the way to electronic data acquisition and data processing.
8. They have two models manufactured by M/s ~~WILD HERBRUGG LTD~~ M/s WILD HEERBRUGG LTD

(i) WILT - T - 1000 Elect theod

(ii) WILT - T - 2000 ~~Elect the~~ & T-2000-S Elect theod

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Trignometrical levelling:

It is the process of determining the difference of elevations of stations from observed vertical angle and known distances, which are assumed to be either horizontal or geodetic lines at MSL.

It can be done by 3 cases:

Case(i) Base of object is accessible

Case(ii) Base of object is inaccessible (Instrument stations in the same vertical plane as the elevated object.

There are three cases to calculate RL of Q.

Case(a) Instrument axes at same level

Case(b) Instrument axes at at different levels.

(i) B is higher than A

(ii) A is higher than B

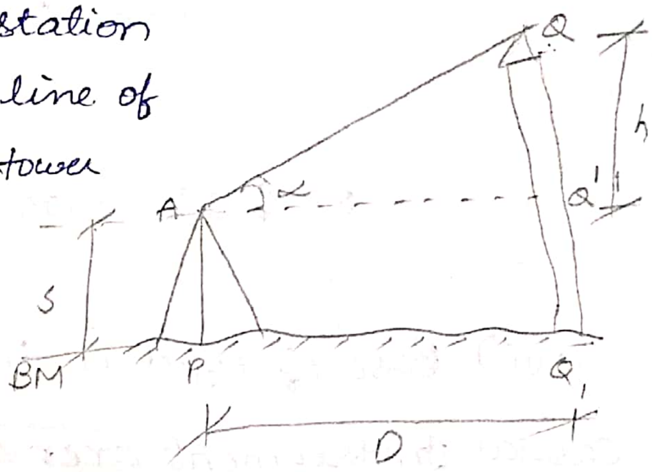
Case (c) Instrument axes at very different levels

(3rd case not in syllabus)

Case(i) Base of object is accesible:

Let P is instrument station
AQ' is line of sight or line of collimation. Q' is top of tower or vane.

h is equal to QQ' =
~~Q=~~ height of top of pole from line of sight.



D is horizontal distance from instrument station P and base of the ~~two~~ tower Q_1.

$$\tan\alpha = \frac{h}{D} \Rightarrow h = D\tan\alpha$$

$$RL \text{ of } Q = RL \text{ of } BM + S + h$$

Problem:

An instrument was set up at P and angle of elevation to a vane 4m above foot of staff held at Q was 9°30'. The horizontal distance between P and Q was 2000m. Determine RL of staff station Q, given that RL of instrument axis was 2650.38 m

Sol:-

$Q = \cancel{4m}$ $\alpha = 9°30'$

$S = 4m$

$D = 2000m$

RL of Q = ? RL of BM = ~~2650.38~~m

$C = 0.06728 D^2$ mts

$C = 0.06728(2)^2$

$C = 0.27m$

$h = D\tan\alpha = (2000) \cancel{0.27} \times \tan 9°30' = 334.68m$

$h + C = 334.68 + 0.27 = 334.95m$

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RL of top of Vane = RL of inst axis + h + c

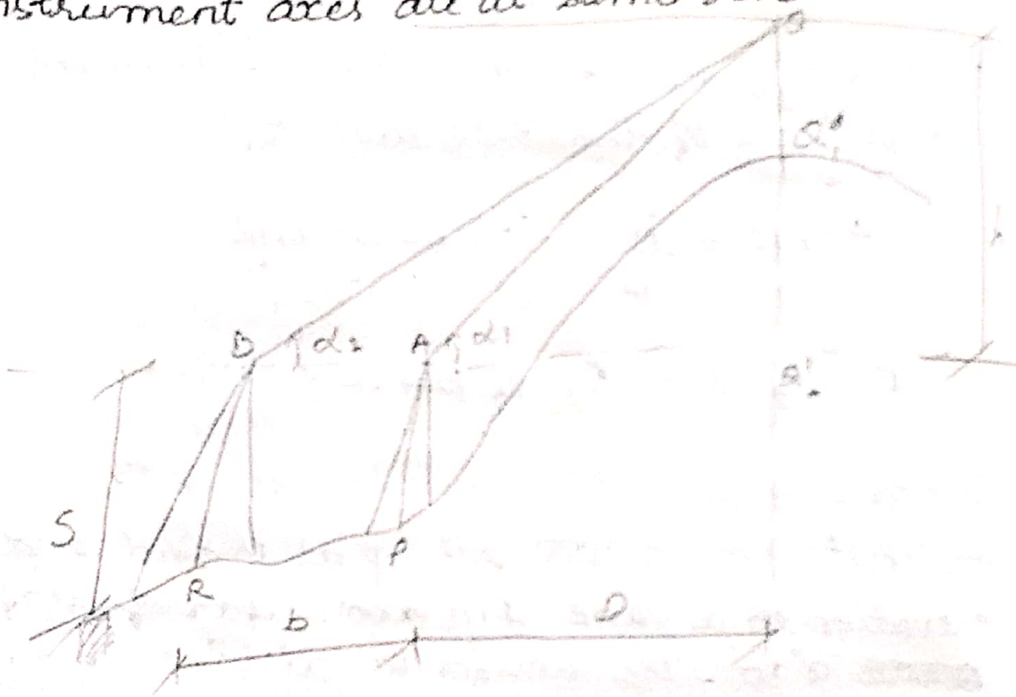
$= 2650.38 + 334.95$

$= 2985.33\,m$

RL of 'Q' $= 2985.33 - 4 = 2981.33\,m$.

Case (ii) Base of object is inaccessible:

Case (a) Instrument axes are at same level



Consider $\Delta AQQ'$ $\tan\alpha_1 = \frac{h}{D}$

$h = D\tan\alpha_1 \rightarrow (1)$

$\Delta BQQ'$ $\tan\alpha_2 = \frac{h}{b+D}$

$h = (b+D)\tan\alpha_2 \rightarrow (2)$

$(1) = (2)$

$D\tan\alpha_1 = (b+D)\tan\alpha_2$

$D\tan\alpha_1 = b\tan\alpha_2 + D\tan\alpha_2$

$D\tan\alpha_1 - D\tan\alpha_2 = b\tan\alpha_2$

$D(\tan\alpha_1 - \tan\alpha_2) = b\tan\alpha_2$

$$\boxed{D = \frac{b \tan\alpha_2}{(\tan\alpha_1 - \tan\alpha_2)}}$$

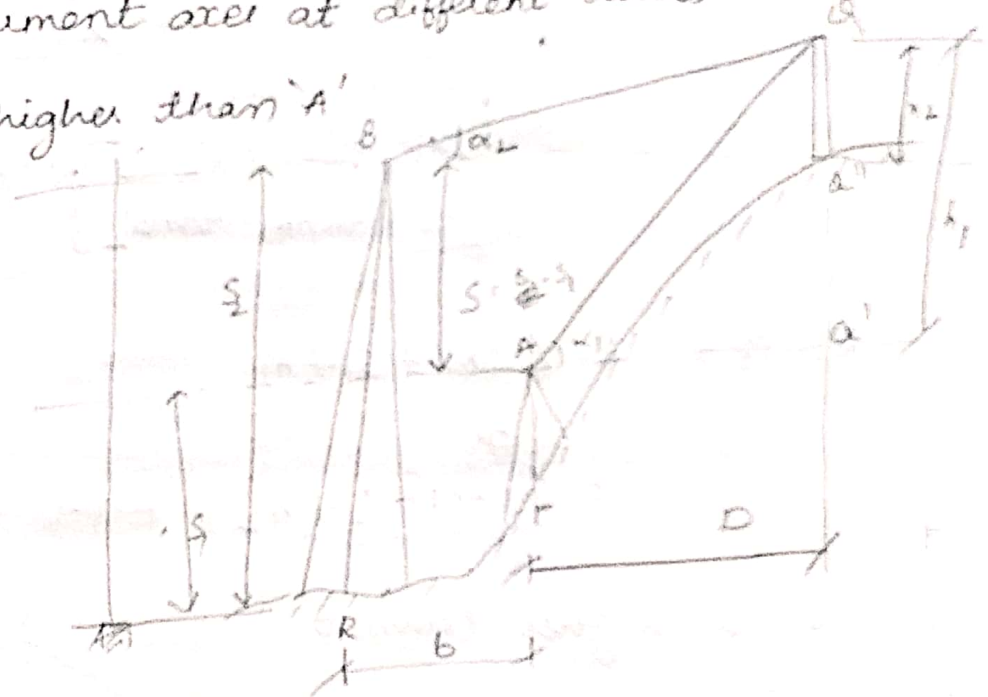
$$h = D \tan\alpha_1$$

$$\boxed{h = \frac{b \tan\alpha_2 \tan\alpha_1}{(\tan\alpha_1 - \tan\alpha_2)}}$$

RL of 'Q' = RL of BM + S + h.

case(b) Instrument axes at different levels

(i) 'B' is higher than 'A'



consider $\Delta AQQ'$

$$\tan\alpha_1 = \frac{h_1}{D}$$

$$h_1 = D \tan\alpha_1 \rightarrow ①$$

$\Delta BQQ''$

$$\tan\alpha_2 = \frac{h_2}{b+D}$$

$$h_2 = (b+D)\tan\alpha_2 \rightarrow ②$$

$$h_1 - h_2 = S$$

$$D\tan\alpha_1 - (b+D)\tan\alpha_2 = S$$

$$D \tan\alpha_1 - b\tan\alpha_2 - D\tan\alpha_2 = s$$

$$D(\tan\alpha_1 - \tan\alpha_2) - b\tan\alpha_2 = s$$

$$D(\tan\alpha_1 - \tan\alpha_2) = s + b\tan\alpha_2$$

$$\boxed{D = \frac{s + b\tan\alpha_2}{\tan\alpha_1 - \tan\alpha_2}}$$

$$\boxed{h_1 = \frac{s + b\tan\alpha_2}{(\tan\alpha_1 - \tan\alpha_2)} \times \tan\alpha_1}$$

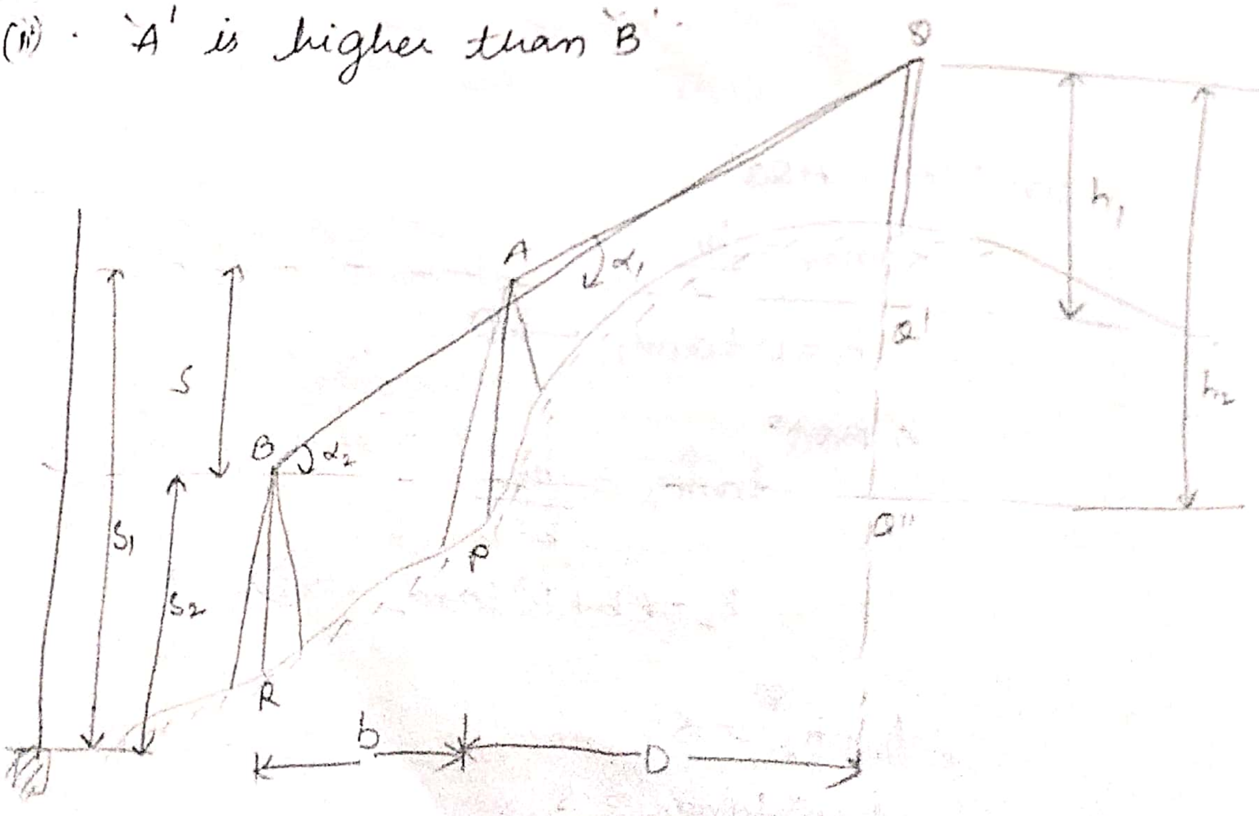
$$\boxed{h_2 = \left[b + \frac{s + b\tan\alpha_2}{(\tan\alpha_1 - \tan\alpha_2)}\right] \times \tan\alpha_2}$$

RL of Q = RL of BM + S_1 + h_1

or

RL of BM + S_2 + h_2

(ii) 'A' is higher than 'B'



$\Delta AQQ'$

$h_1 = D\tan\alpha_1 \longrightarrow (1)$

$\Delta BQQ''$

$h_2 = (b+D)\tan\alpha_2 \longrightarrow (2)$

$h_2 - h_1 = S$

$S = (b+D)\tan\alpha_2 - D\tan\alpha_1$

$S = b\tan\alpha_2 + D\tan\alpha_2 - D\tan\alpha_1$

$S = D(\tan\alpha_2 - \tan\alpha_1) + b\tan\alpha_2$

~~D = S~~ $S - b\tan\alpha_2 = D(\tan\alpha_2 - \tan\alpha_1)$

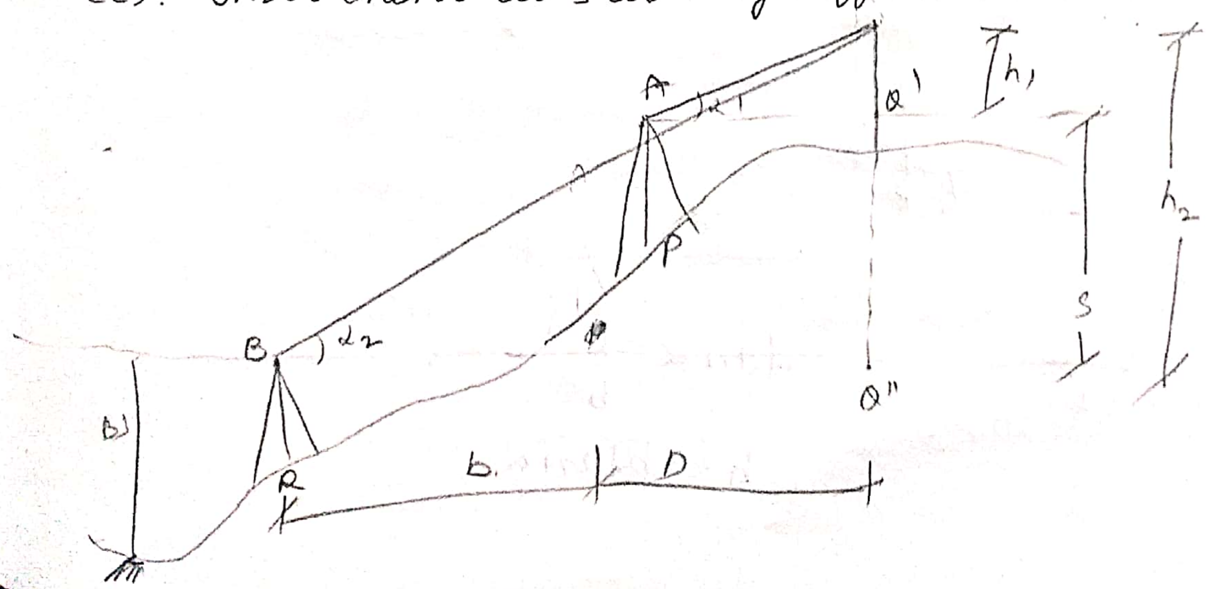
$$\boxed{D = \frac{S - b\tan\alpha_2}{(\tan\alpha_2 - \tan\alpha_1)}}$$

$$\boxed{h_1 = \left(\frac{S - b\tan\alpha_2}{(\tan\alpha_2 - \tan\alpha_1)}\right)\tan\alpha_1}$$

$$\boxed{h_2 = \left(b + \frac{S - b\tan\alpha_2}{\tan\alpha_2 - \tan\alpha_1}\right)\tan\alpha_2}$$

RL of Q = RL of BM + S_1 + h_1

Case (C): Instrument axes at very different levels.



If $S_2 - S_1$ or S is too great then we will adopt this method.

S = diff in level between two axes A and B

$$h_1 = D \tan\alpha_1$$

$$h_2 = (b+D)\tan\alpha_2$$

② − ①

$$S = (b+D)\tan\alpha_2 - D\tan\alpha_1$$

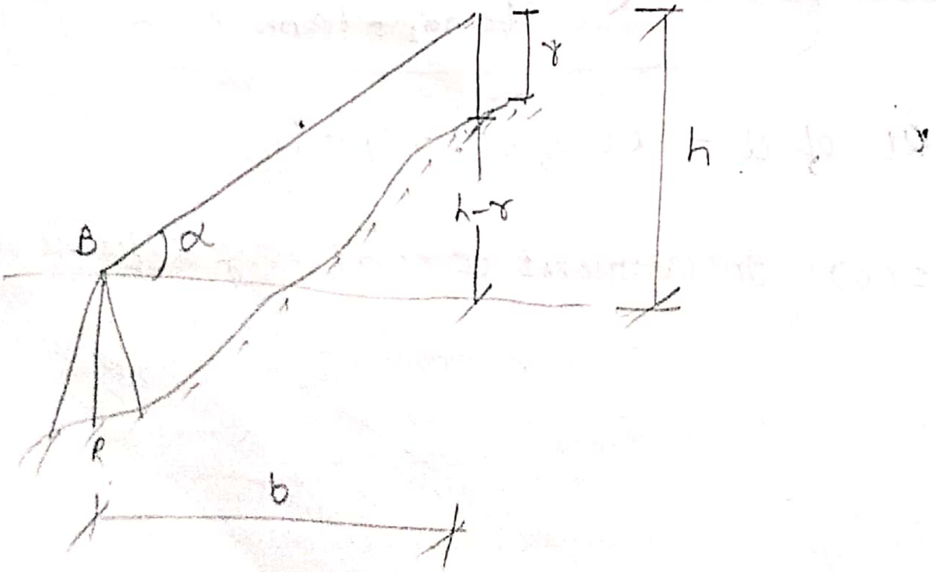
$$S = D(\tan\alpha_2 - \tan\alpha_1) + b.\tan\alpha_2$$

$$S - b\tan\alpha_2 = D(\tan\alpha_2 - \tan\alpha_1)$$

$$b\tan\alpha_2 - S = D(\tan\alpha_1 - \tan\alpha_2)$$

$$\boxed{D = \frac{b\tan\alpha_2 - S}{\tan\alpha_1 - \tan\alpha_2}}$$

$$h_1 = \frac{b\tan\alpha_2 - S}{\tan\alpha_1 - \tan\alpha_2} \times \tan\alpha_1 .$$



$$\tan\alpha = \frac{h}{b}$$

$$h = b\tan\alpha$$

From above fig we have height of station P' above axis at B. = $h - \gamma$

$$\boxed{h - \gamma = b\tan\alpha - \gamma}$$

Height of axis at A above axis at B is

$$S = h - \gamma + h'$$

$$S = b\tan\alpha - \gamma + h'$$

where h' = height of instrument at B.

Substituting the value of 'S' in eqn D and h_1, we will get D and h_1.

RL of 'Q' = RL of Inst axis at A + h_1

(or) RL of Inst axis at B + h_2.

RL of Q = RL of BM + B.S at B + S + h_1

where

$$\boxed{S = b\tan\alpha - \gamma + h'}$$

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MODULE - IV

TRAVERSING

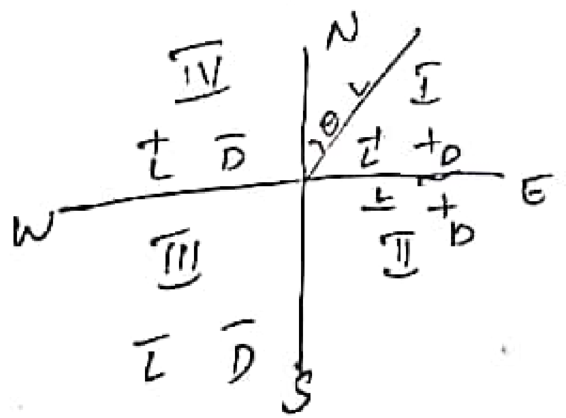
Methods of Traversing:

1) Chain traversing - linear -
2) Chain & compass traversing (loose needle method) - chain & compass
3) Transit tape traversing
   a) By fast needle method - Theodolite with compass.
   b) By measurement of angles b/w lines. - Theodolite - accurate than all above methods.
4) Plane table traversing.

Checks for closed traverse:

1) Sum of Interior angles = $(2n-4)90°$.
2) Sum of exterior angles is $(2n+4)90°$
3) Traverse by deflection angles
   algebraic sum of deflection angle = 360°.
   By taking right deflection as +ve and left deflection as negative.
4) Traverse by direct observation of bearings.
   F.B of last line = its B.B ± 180° measured at initial station.

Traverse Computations:



latitude is always ∥ to N-S meridian

$L = L\cos\theta$

$D = L\sin\theta$

Latitude: It is defined as its co-ordinated length measured parallel to true north or magnetic north or any other reference direction.

Departure:

It is defined as its co-ordinated length measured ⊥lar to the meridian direction.

Northing: Latitude of line is +ve when measured north ward or upward is termed as northing.

Easting: Departure of line is +ve when measured eastward is termed as easting.

Consecutive co-ordinates or Dependent co-ordinates:

Latitude and departure co-ordinates of any point with reference to the preceeding point are equal to latitude and departure of line joining the preceeding point to the point under consideration. Such coordinates are known as consecutive co-ordinates.

Independent co-ordinates:

The co-ordinates of traverse stations can be calculated wrt a common origin.

The total latitude and departure of any point wrt a common origin are called independent co-ordinates or total co-ordinates of that point.

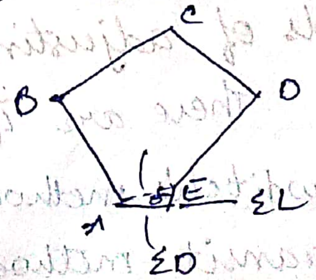
Closing error:

$$\text{closing error } 'e' = \sqrt{(\Sigma L)^2 + (\Sigma D)^2}$$

Direction of closing error =

$$\tan\theta = \frac{\Sigma D}{\Sigma L}$$

$$\theta = \tan^{-1}\left(\frac{\Sigma D}{\Sigma L}\right)$$



The sign of (+ or -) ΣD & ΣL will thus define the quadrant in which the closing error lies.

Adjustment of angular error:

In a closed traverse if angles are measured with same degree of precesion error in sum of angles may be distributed equally to each angle of the traverse.

Adjustment of bearings:

e = error

N = sides we get

Correction for 1^{st} line $= \frac{e}{N}$

Correction for 2^{nd} line $= \frac{2e}{N}$

Correction for 3^{rd} line $= \frac{3e}{N}$

Correction for N^{th} line $= \frac{\cancel{N}e}{\cancel{N}} = e$.

Balancing of Traverse:

The term balancing is generally applied to the operation of applying corrections to the latitude and departure, so that $\Sigma L = 0$ & $\Sigma D = 0$.

This applies only when survey forms a closed polygon.

Methods of adjusting traverse:

There are 4 methods.

1. Bowditch's method
2. Transit method
3. Axis method
4. Graphical method.

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Bowditch's method:

→ The errors in linear measurements are directly proportional to $\sqrt{l}$ · and errors in angular measurements are inversely proportional to $\sqrt{l}$. where l is length of a line.

→ Bowditch's rule also termed as compass rule is mostly used to balance a traverse where linear and angular measurements are of equal precision.

→ Total error in latitude and in departure is distributed in proportion to the lengths of sides.

Bowditch's Rule:

Correction to latitude or departure of any line

$$(C_L \text{ or } C_D) = \frac{\text{length of that side } (l)}{\text{Perimeter of traverse}} \times \text{total error in latitude or departure.}$$

$$C_L = \Sigma L \times \frac{l}{\Sigma l}$$

$$C_D = \Sigma D \times \frac{l}{\Sigma l}.$$

Gales traverse table:

Traverse computations are usually done in a tabular form, a more common form is called Gale's traverse table.

Procedure:

1. Adjust interior angles to satisfy geometrical conditions i.e sum of interior angles $(2n-4)90°$ and sum of adjust exterior angles $(2n+4)90°$.

   In case of compass traverse, bearings are adjusted for local attraction if any.
2. Starting with observed bearings of one line, calculate bearings of all other lines. Reduce all bearings to quadrantal system.

3. Calculate consecutive co-ordinates (i.e L&D)
4. Calculate ΣL and ΣD.
5. Apply necessary corrections to latitude and departures so that $\Sigma L=0$ and $\Sigma D=0$. The corrections may be applied either by transit rule or by compass rule depending up on type of traverse
6. Using corrected consecutive co-ordinates, calculate independent co-ordinates to the points so that they are all +ve, the whole of the traverse thus lying in North-East quadrant.

Omitted Measurements:

Omitted measurements are Missing quantites can be calculated by latitudes and departures provided the quantities required are not more than 2.

In such cases there can be no ~~ch~~ check on the field work nor the survey can be balanced.

Since for a closed traverse $\Sigma L=0$, $\Sigma D=0$ we have $\Sigma L = l_1 \cos\theta_1 + l_2 \cos\theta_2 + l_3 \cos\theta_3 + \cdots = 0$

$\Sigma D = l_1 \sin\theta_1 + l_2 \sin\theta_2 + l_3 \sin\theta_3 + \cdots = 0$

where l_1, l_2, l_3 etc. are lengths of the lines. $\theta_1, \theta_2, \theta_3$ etc are their reduced bearings

There are 4 cases in omitted measurements;

Case (i) : ~~(a)~~ Bearing or length ~~are~~ or bearing and length of one side omitted.

Case (ii) : Length of one side and bearing of another side

Case (iii) : Lengths of two sides omitted.

Case (iv) : Bearings of two sides omitted.

Line of Length (1)	Point (2)	Angle (3)	Correction (4)	Corrected angle (5)	(6) WCB	(7) R.B	(8) Consecutive Co-ordinates N	S	E	W	(9) Corrections N	S	E	W	(10) Corrected consecutive Co-ordinates N	S	E	W	(11) Independent coordinates N	E
	A	95°24'	-6'	95°18'			107.97		3.77		+0.2		-0.01		108.23		3.76		200*	100*
AB 250					86.42	N86°42'E														
	B	88°42'	-6'	86°36'			14.39		244.57		+0.03	-	-0.71		14.42		246.8		214.42	346.85
BC 123					178.06'	S1°54'E														
	C	88°12'	-6'	88°06'				122.94	4.12			+0.29	+0.01			122.6	4.11		91.77	352.96
CD 256					270°00'	N 90°N														
	D	88°06'	-6'	88°00'			0			256.00	+0			0.33	0			256.73	91.77	96.23
DA 108					2°00'	N2°E														
SUM		360°24'	-24'	360°00'			122.36	122.94	257.66	256.00	+0.29	-0.29	-0.73	+0.73	122.65	122.65	258.3	256.32		
							-0.58		+1.46		+0.58		-1.46		0		0			

GALES TRAVERSE TABLE

case(4)

Problem:

The table below gives the lengths and bearings of lines of a traverse ABCDE. The length and bearing of EA having been omitted. Calculate length and bearing of line EA.

Line	Length (m)	Bearing
AB	204	87°30'
BC	226	20°20'
CD	187	280°
DE	192	210° 30'
EA	?	?

sol:-

Line	Latitude +	Latitude −	Departure +	Departure −
AB	8.90		203.80	
BC	211.91		78.53	
CD	32.47			184.16,
DE		−165.43		−97.44.
EA				

$\Sigma L' = 87.84$ $\Sigma D' = \cancel{195.60}\ 0.73$

Latitude of EA + $\Sigma L'$ = 0.

Latitude of EA = −87.86,

Dep of EA = −0.72.

$$\tan\theta = \frac{\Sigma D}{\Sigma L} = \frac{0.72}{87.86}$$

$\theta = 0^\circ 28'$

$\theta = S\ 0^\circ 28' W$.

$\theta = 180^\circ 28'$.

$$\text{length of } EA = l = \frac{L}{\cos\theta} = \frac{87.86}{\cos 0^\circ 28'} = 87.86\,m$$

case (ii).

Length of one side & Bearing of another side omitted:

problem:

In a closed traverse ABCDE, the line AB and bearing of line EA couldn't be measured in the field. From the measurements, the following information is available.

Sol:-

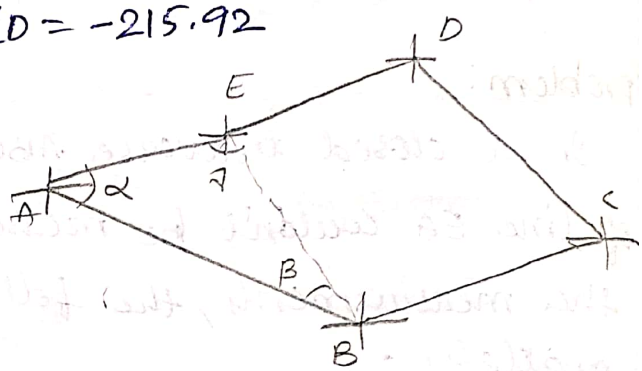
Line	length in mts	WCB Bearings	RB/QB
AB	?	95°	S 85° E
BC	140m	27°28'	N 27° 28' E
CD	163m	317°30'	N 42° 30' W
DE	173m	260°00'	S 80° W
EA	201 m	?	

Latitude ($l\cos\theta$)		Departure ($l\sin\theta$)	
+	−	+	−
124.22		64.57	
120.18			110.12
	30.04		170.37

$\Sigma L = 214.36$ $\Sigma D = -215.92$

length of closing line

EB =



latitude of EB + 214.36 = 0

Dep of EB − 215.92 = 0.

$\therefore$ Dep of EB = − ~~214.36~~ 215.92

lat of EB = − 214.36

length of closing line = EB = $\sqrt{(215.92)^2 + (-214.36)^2}$

$= 304.26\,m$

$\tan\theta = \frac{\Sigma D}{\Sigma L} = \frac{215.92}{214.36} = S\,45°\,12'\,27.82''\,E$

$\boxed{\theta = 134°\,47'\,32.18''}$

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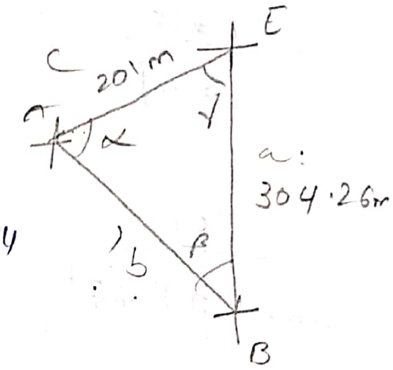
consider ΔABE



β = Bearing of BE − Bearing of BA

$= 314°47'32.14'' - 275°0'00''$

$= 39°47'32.14''$.

$\cancel{\cos\alpha = \frac{a^2+b^2-c^2}{2ab}}$

$\cancel{= \frac{(304.26)^2+b^2-(201)^2}{2(304.26)(b)}}$

Apply sine rule

$$\frac{AE}{\sin\beta} = \frac{304.26}{\sin\alpha}$$

$$\frac{201}{\sin(39°47'32.14'')} = \frac{304.26}{\sin\alpha}$$

$$314.05 = \frac{304.26}{\sin\alpha}$$

$$\sin\alpha = \frac{304.26}{314.05}$$

$$\alpha = \sin^{-1}\left(\frac{304.26}{314.05}\right)$$

$$\alpha = 75°39'22.31''$$

$\gamma = 180 - (\alpha+\beta)$

$= 64°33'5.55''$

$$\frac{AE}{\sin\beta} = \frac{AB}{\sin\gamma}$$

$$\frac{201}{\sin 39°47'} = \frac{AB}{\sin 64°33'}$$

$$AB = 283.64\,m.$$

γ = Bearing of EB + Bearing of EA

$64°33'55'' = 134°47'32.18'' +$ Bearing of EA.

Bearing of EA $= 199°20'37.73''$

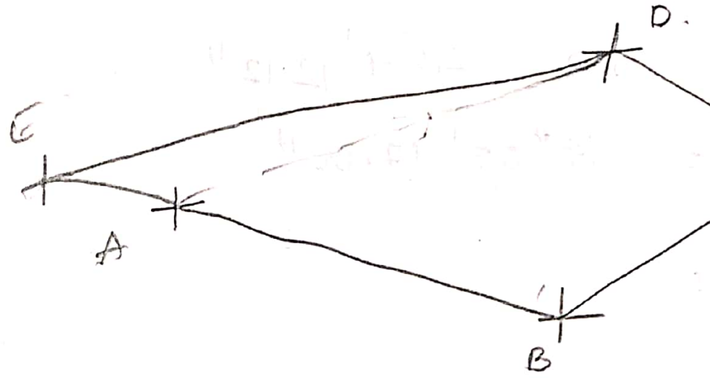
Case (iii) lengths of two sides omitted

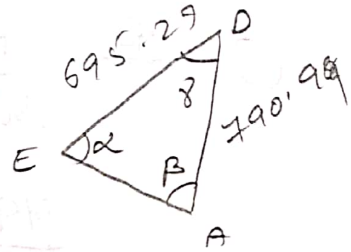
Problem:

A closed traverse was conducted around an obstacle and following observations were made workout missing quantities.

Sides	Length (m)	Azimuth (WCB)	R.B	Latitude ($l\cos\theta$) +	Latitude ($l\cos\theta$) −	Departure ($l\sin\theta$) +	Departure ($l\sin\theta$) −
AB	500	98°30'	S 81°30'E		73.90	494.51	
BC	620	30°20'	N 30°20'E	535.12		313.12	
CD	468	298°30'	N 61°30'W	223.31	~~223.31~~		411.29
DE	?	230°	S 50°W				
EA	?	150°10'	S 29°50'E				

$\Sigma L = 684.53$ $\quad \Sigma D = 396.33$





~~A~~ Latitude of ~~ED~~ DA $+684.53=0$

Latitude of DA $= -684.53$

Departure of ~~EB~~ DA $+396.33=0$

Departure of DA $= -396.33$.

Length of closing line DA $= \sqrt{(684.53)^2 + (396.33)^2}$

$= 790.99$ m

$\tan\theta = \dfrac{\Sigma D}{\Sigma L} = \dfrac{396.33}{684.53}$

$\therefore \theta = S\,30^\circ\,4'\,12.12''\,W$

$\theta = 210^\circ\,4'\,12.12''$

$\alpha =$ Bearing of ~~EA~~ EA $-$ Bearing of ED

$\alpha = (\cancel{180}\,150^\circ 10') - (\cancel{180}\,230^\circ - 180)$

$\alpha = \cancel{130^\circ 30' 10''}\;100^\circ 10'$

$\beta =$ Bearing of AD $-$ Bearing of AE

$\beta = (210^\circ 4' 12.12'' - 180^\circ) - (180^\circ + 150^\circ 10')$

$= 59^\circ 54' 12.12''$

γ = Bearing of DE - Bearing of DA

$\gamma = 230 - 210^\circ 4' 12.12''$

$= 19^\circ 55' 47.88''$

Apply sine rule:

① ~~~~ $\frac{DA}{\sin\alpha} = \frac{DE}{\sin\beta}$

$\frac{790.99}{\sin(100^\circ 10')} = \frac{DE}{\sin(59^\circ 54' 12.12'')}$

DE = 695.27 m.

②

$\frac{DE}{\sin\beta} = \frac{EA}{\sin\gamma}$

$\frac{695.27}{\sin(59^\circ 54' 12.12'')} = \frac{EA}{\sin(19^\circ 55' 47.88'')}$

EA = 274.04 m

Case (iv) Bearings of two sides omitted.

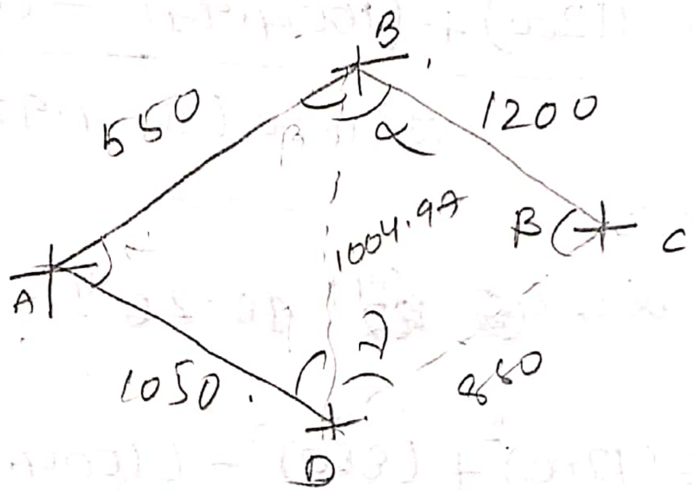
Problem:

~~When bearings of two sides are~~

While traversing, a closed traverse lining Naini, allahabad, a closed traverse ABCD was made. Due to obstructions it was not possible to observe the bearings of lines BC and CD. Calculate the missing bearings.

Line	length (m)	WCB	R.B	Latitude +	Latitude −	Departure +	Departure −
AB	5500	60°	N 60° E	275		476.31	
BC	1200	294° 57' 6.82"					
CD	880	239° 43' 18.4"					
DA	1050	310°	N 50° W	674.93			804.35

$\Sigma L = 949.93$ $\quad\quad$ $\Sigma D = -328.04$



Latitude of BD $+ 949.93 = 0$

Latitude of BD $= -949.93$

Departure of BD $- 328.04 = 0$

Departure of BD $= 328.04$

$$\text{length of BD} = \sqrt{(-949.93)^2 + (328.04)^2}$$

$$= 1004.97\,m.$$

$$\tan\theta = \frac{\Sigma D}{\Sigma L} = \frac{328.04}{949.93} \Rightarrow \theta = 19^\circ 3' 4.92''.$$

$$\theta = S\,19^\circ 3' 4.92'' E$$

$$\theta = 160^\circ 56' 55.08''$$

Apply cosine rule:

$$\cos\alpha = \frac{(1200)^2 + (1004.97)^2 - (880)^2}{2(1200)(1004.97)}$$

~~$\cos\alpha =$~~

$$\alpha = 45^\circ\, 59'\, 48.26''$$

$$\cos\beta = \frac{(1200)^2 + (880)^2 - (1004.97)^2}{2(1200)(880)}$$

$$\beta = 55^\circ\, 13'\, 48.42''$$

$$\gamma = 100 - (\alpha + \beta)$$

$$= 180 - (45^\circ\, 59'\, 48.26'' + 55^\circ\, 13'\, 48.42'')$$

$$= 78^\circ\, 46'\, 23.32''$$

Δ BCD

$\therefore \alpha =$ Bearing of BD − Bearing of BC

$-45^\circ 59' 48.26'' + 160^\circ 56' 55.08''$ = Bearing of BC

Bearing of BC $= 114^\circ\, 57'\, 6.82''$

Scanned with CamScanner

α = Bearing of DC − Bearing of DB

$78^\circ 46' 23.32'' =$ Bearing of DC − $(180^\circ + 160^\circ 56' 55.08'')$

Bearing of DC = $59^\circ 43' 18.4''$