

LABORATORY 1

TITLE: THE STUDY OF THEODOLITE

AIM: The Study of different parts of theodolite and temporary adjustments.

APPARATUS: Theodolite

PARTS OF A THEODOLITE

1. Telescope: A telescope is used to sight and measure angles to targets.
2. Horizontal Circle: A circular scale that measures horizontal angles.
3. Vertical Circle: A circular scale that measures vertical angles.
4. Levelling screws: Used to level the instrument and ensure accurate measurements.
5. Tripods: A three-legged stand that supports the theodolite.
6. Aiming screws: Used to fine-tune the telescope's aim.
7. Micrometer: A device that measures small angles or distances.
8. Bubble levels: Used to ensure the instrument is level.
9. Some theodolites have built-in illumination for night time use.
10. Vertical axis: It is the axis about which the telescope can be rotated in a horizontal plane.
11. Horizontal axis: It is the axis about which the telescope can be rotated in vertical plane.
12. Line of collimation: It is the imaginary line joining the intersection ~~object~~ of the cross hairs of the diaphragm to the optical center of the object glass and its continuation.
13. Axis of the telescope: It is line joining the optical center of the object glass to the center of the eye-piece.
14. Axis of the level tube: It is straight line tangential to the longitudinal curve of the level at the center of the tube.
15. Centering: The process of setting the theodolite exactly over the station. marks.

Erstam

EXPERIMENT 2

TITLE: MEASUREMENT OF HORIZONTAL ANGLES

Aim: To determine the horizontal angles between two points by the use of theodolite.

APPARATUS:

1. Theodolite: It is used to determine vertical and horizontal angle between points.
2. The Ranging Rod: It is used for ranging lines and helps the sighting of a distant point.
3. Note books: For recording of field results.
4. Tripod: Used for mounting theodolite.

THEORY

Angular measurements ~~using the theodolite~~ can be done using two principal methods.

Methods of reiteration

Method of Repetition

In the method of reiteration, the angle between two points is measured severally on both faces and the mean obtained. This method has a high degree of ~~accuracy~~ accuracy and eliminates error in the final result.

In the method of repetition, an angle is measured twice in one angle. The entire process can be repeated a number of times and the average of the angles recorded as the final angle.

PROCEDURES

1. Reconnaissance: This was achieved by checking the surrounding for objects, features. Every observable feature was noted.
2. The theodolite was set-up by mounting it on a tripod stand.
3. The necessary adjustments were done by centering plumb bob at O and leveling the theodolite with the spirit level.
4. Using the ranging rods, stations A and B was marked out.
5. The theodolite was positioned at the left side of the observer.
6. The theodolite was positioned ~~at the~~ upper clamp was unlocked and the lower clamp was unlocked.
7. To set the horizontal angle at zero, the theodolite was rotated.
8. While the horizontal angle was still at zero, the telescope was focused at station A. The lower clamp ~~was~~ locked and that of the upper clamp being unlocked.
9. Then the lower clamp was ~~locked~~, upper clamp ~~unlocked~~. The telescope was swung from station A to focus on station B while taking the reading at B.
10. The experiment was repeated 2 more times and then the average was determined.
11. The upper clamp was locked while the lower clamp was unlocked.
12. The telescope was transitted into a vertical plane and then rotated through 180° in the horizontal plane.
13. With the face changed to right, the focus on B. The lower clamp was locked while the upper clamp was unlocked swung left from station B to focus on station A. The reading was then taken at A.
14. The procedure was repeated 2 more times and the average was determined.
15. The results were recorded and obtained appropriately in the notebook.

PROCEDURES
CALCULATIONS

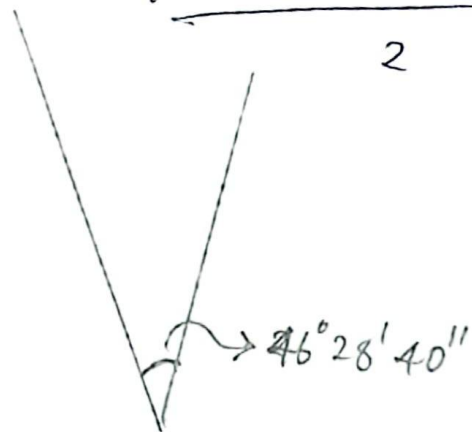
Experimental Result

STATION O	FROM A	TO B	ANGLE AOB
Face left	0°	46°10'	46°10'
Face left	0°	46°7'	46°10'
Face left	0°	46°15'	46°15'
Average			46°10'40"

STATION O	FROM B	MISSING TO A	ANGLE BOA
Face Right	226°15'	179°39'	46°38'
Face Right	226°45'	179°43'	49°2'
Face Right	226°10'	179°30'	46°40'
Average			46°46'40"

Average reading, $\theta = \frac{\text{Average face left} + \text{Average Face Right}}{2}$

$$= \frac{46^{\circ}10'40'' + 46^{\circ}46'40''}{2} = 46^{\circ}28'40''$$



OBSERVATIONS

- 1) I observed that the initial angle for face left was $0^{\circ} 0' 0''$ while that of face right was $226^{\circ} 15' 0''$ indicating the difference in using both faces.
- 2) I observed that the angle were taken in the face left and face right positions to minimize errors.
- 3) I observed that the average $\hat{B}OA$ angle was greater than \hat{AOB} angle.

PRECAUTIONS

- 1) We ensured that the theodolite was accurately levelled before taking our readings.
- 2) We ensured that we avoided error due to parallax while taking our readings.
- 3) We ensured that the theodolite was aimed at the same point on our target to avoid discrepancies in the recorded angles.

CONCLUSIONS

By taking readings in the face left and face right directions and averaging them, it helps to reduce or recover instrumental errors. Also if the face left and face right readings are similar, it suggests that the experiment is reliable and the instrument is functioning well like the experiment concluded above.

40''

OBSERVATIONS

1. I observed that the initial angle for face left was $0^{\circ} 0' 0''$ while that of face right was $226^{\circ} 15' 0''$ indicating the closures in ring both faces.

EXPERIMENT 3

TAKE: VERTICAL ANGLE MEASUREMENT

Aim: To determine the elevation of an inaccessible point whose base is accessible or inaccessible

APPARATUS: theodolite: Used in measurement of vertical and horizontal angles.

Tripod stand: Used in holding the theodolite in place.

Measuring tape: For measuring distances.

Stadia rod: Used in measuring vertical distances.

THEORY

The vertical angle is measured using a theodolite. The angle is the smaller angle between the spanning axes of the instrument and the line of sight determined by the telescope and it is called the zenith angle (z). A vertical angle is made by an inclined upwards or downwards from the horizontal.

PROCEDURES

We used A as the inaccessible point whose whole elevation is required and B as its projection on the ground which is accessible.

1. The theodolite was set up at C, at a distance of 14.95m from B and levelled accurately to the alidade level.
2. Sighting to point A, the vertical angle α subtended at the line of collimation was observed both on face left and face right.
3. The values measured were recorded and average taken.
4. Using the line of sight, a staff reading h on the bench mark established nearby the instrument was taken.
5. Then the horizontal distance BC was accurately measured using tape.

FOR ACCESSIBLE BASE

1. Reconnaissance was observed.
2. The instrument was set-up at station P.
3. All temporary adjustments were performed.
4. The line of collimation was set horizontally with the vertical angle reading at zero.

OBSERVATIONS

1. Observed that the initial angle for face left was $0^\circ 0' 0''$...
5. The bottom of the object at A was sighted and the vertical angle reading was taken
6. The bottom of the object at B was sighted and the vertical angle reading was taken
7. The horizontal distance between the instrument station and the object D was taken
8. The height of the object was then calculated.

CALCULATIONS

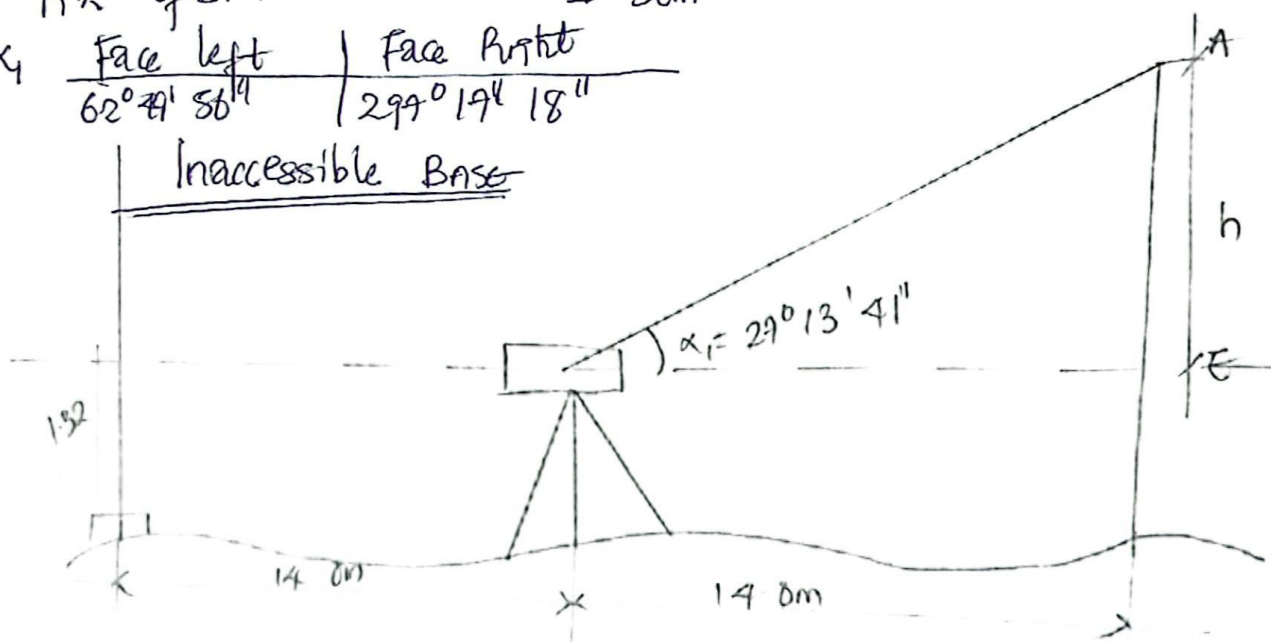
Horizontal distance (d) to object = 14.93m
 distance from station = 5.2m
 $x \rightarrow$ height of collimation = 1.48m line of sight

α_1	Face left $28^\circ 10' 04''$	Face Right <u>MISS B</u> $28^\circ 50' 16''$
α_2	Face left	Face Right

HEIGHT BASE IS INACCESSIBLE

Horizontal distance to the object = 14.8m
 Distance from instrument to staff = 14.8m
 $x \rightarrow$ line of sight = 1.32m
 R/L of BM = 50m

α_1	Face left $62^\circ 41' 56''$	Face Right $29^\circ 13' 18''$
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of collimation was ...

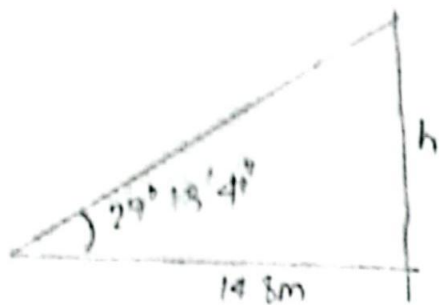
Face left angle = $62^{\circ} 49' 56''$

Face Right angle = $299^{\circ} 19' 18''$

$\alpha_1 = 90 - 62^{\circ} 49' 56'' = 27^{\circ} 10' 4''$

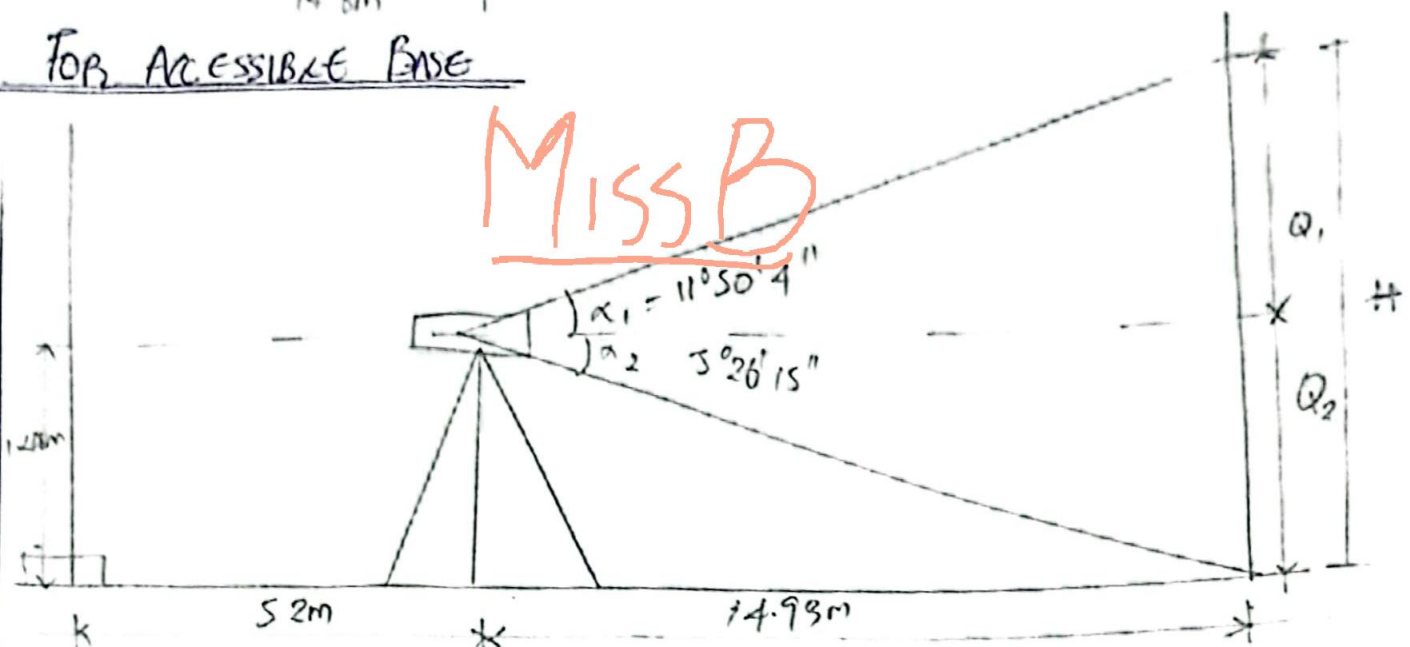
$\alpha_2 = 299^{\circ} 19' 18'' - 270 = 29^{\circ} 19' 18''$

average of $\alpha_1 = \frac{27^{\circ} 10' 4'' + 29^{\circ} 19' 18''}{2} = 29^{\circ} 13' 41''$



$\therefore h = 14.8 \tan 29^{\circ} 13' 41''$
 $= 7.615m$

TOP ACCESSIBLE BASE



Face left angle = $78^{\circ} 10' 04''$

$\alpha_1 = 90 - 78^{\circ} 10' 04'' = 11^{\circ} 49' 56''$

Face Right angle = $281^{\circ} 50' 12''$

$\alpha_2 = 281^{\circ} 50' 12'' - 270 = 11^{\circ} 50' 12''$

\therefore Average of $\alpha_1 = \frac{11^{\circ} 49' 56'' + 11^{\circ} 50' 12''}{2} = 11^{\circ} 50' 04''$

For α_2

Face left angle:

$\alpha_2 = 95^{\circ} 39' 40'' - 90 = 5^{\circ} 39' 40''$

Face Right angle:

$\alpha_2 = 270 - 264^{\circ} 49' 10'' = 5^{\circ} 12' 50''$

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OBSERVATION

∴ Avg. of $\theta = \frac{5^{\circ}29'40'' + 5^{\circ}12'20''}{2}$

$Q_1 = 14.9 \text{ km}, 11^{\circ}50'4'' = 5127$

$Q_2 = 14.9 \text{ km}, 5^{\circ}06'15'' = 1401$

∴ $H = 4.549 \text{ m}$

OBSERVATION

- 1. I observed that the instrument was properly levelled using its levelling screws or bubble level to avoid skewed readings.
- 2. I observed that the horizontal plane (line of sight) was clear and unobstructed to get vertical angles.
- 3. I observed that the instrument was on a stable platform, and was wound free to avoid slight shifts.

PRECAUTIONS

- 1. I ensured to verify the calibration of the instrument before use.
- 2. I ensured that the theodolite was set upon a firm, stable surface before taking readings.
- 3. I ensured that my line of sight was direct, as possible by avoiding measurements where the target was partially observed or at an extreme distance where atmospheric refraction affected reading.

CONCLUSION

From the experiment, the elevation of an inaccessible point whose base is either accessible or inaccessible was determined. The experiment proves that calculation of inaccessible points whose base is accessible or inaccessible could be calculated using a theodolite.

MISSING

The line of collimation was 20 times.

OBSERVATIONS

EXPERIMENT 4

TITLE: TACHEOMETRY (Determination of tacheometric constants)

AIM: To determine tacheometric constants of a theodolite

APPARATUS: Theodolite, leveling staff, level top, steel cross

THEORY

The term tacheometry was derived from 'Tachos', meaning swift or fast, and 'Metro' meaning measurement.

Therefore, Tacheometry is the speedy determination of horizontal distances between points by the use of the theodolite and leveling staff. This is achieved by means of stadia lens engraved upon the telescope diaphragm or by sighting a bar of known length.

The mathematical expression $D = Cs + k$ Applies to Tacheometry, where $D = \text{Distance}$
 $C = \text{Instrument constant (100)}$
 $S = \text{Stadia reading}$
 $k = \text{Additive constant (0)}$

It can be shown that $H = S \cos \theta$ where $\theta = \text{Angle of elevation of telescope}$

$$V = 0.5 S \sin 2\theta$$

H and V are horizontal and vertical components of distance respectively.

PROCEDURE

1. We set up the theodolite and levelled at the instrument position O .
2. We made the necessary adjustment on the instrument.
3. We marked out stations A, B , and C with the ranging rods such that the distances OA, AB, OC are equal to $15m, 30m$ & $45m$ respectively.
4. We obtained the top, middle and bottom stadia readings at station A, B & C by placing the leveling staff at those positions and sighting with the theodolite.
5. We measured the horizontal distance between the instrument and the theodolite.
6. We calculated the constant using, $D = Cs + k$.

$$D = kS + C$$

CALCULATIONS & FIELD REPORTS

Instrument station	Staff position	Distance	Staff Readings (m)			Stadia Reading
			Top	Middle	Bottom	
	A	5m	1.60	1.58	1.55	0.05
	B	10m	1.59	1.44	1.49	0.10
	C	15m	1.58	1.51	1.43	0.15

$$D_1 = 5m$$

$$s_1 = 0.05$$

$$D_2 = 10m$$

$$s_2 = 0.10$$

$$D_3 = 15m$$

$$s_3 = 0.15$$

MISS B

$$D = kS + C$$

$$D_1 = kS_1 + C \Rightarrow 5 = 0.05k + C \quad \text{--- (1)}$$

$$D_2 = kS_2 + C \Rightarrow 10 = 0.10k + C \quad \text{--- (2)}$$

$$D_3 = kS_3 + C \Rightarrow 15 = 0.15k + C \quad \text{--- (3)}$$

Solving Eqs (2) and (3) simultaneously

$$\begin{array}{r} 0.10k_1 + C_1 = 10 \\ - 0.15k_1 + C_1 = 15 \\ \hline -0.05k_1 = -5 \end{array}$$

OBSERVATION

→ $k_1 = \frac{+5}{-0.05} = 100$

... measurements changed as I adjusted the
... names and height.
... has a

Putting $k_1 = 100$ in eqn (2)

$$0.10(100) + C_1 = 10$$

$$10 + C_1 = 10$$

$$\Rightarrow C_1 = 10 - 10$$

$$\therefore C_1 = 0$$

Solving eqn (1) and (2) simultaneously

$$0.05k_2 + C_2 = 5$$

$$0.10k_2 + C_2 = 10$$

$$\hline 0.05k_2 = 5$$

MISS B

$$\Rightarrow k_2 = \frac{-5}{-0.05} = 100$$

Putting $k_2 = 100$ into eqn (1)

$$0.05k_2 + C_2 = 5$$

$$= 0.05(100) + C_2 = 5$$

$$5 + C_2 = 5$$

$$C_2 = 5 - 5 = 0$$

Multiplicative constant, $K = \frac{k_1 + k_2}{2} = \frac{100 + 100}{2} = 100$

Additive constant, $C = \frac{C_1 + C_2}{2} = \frac{0 + 0}{2} = 0$

OBSERVATION

- ① I observed that the angle measurements changed as I adjusted the theodolite, affecting the calculated distances and height.
- ② I observed that the values gotten from the stadia reading has a corresponding values of μ . The corresponding difference being 0.05.
- ③ From the calculation I observed that the reading of the top hairs at various distances fell between 1.58 - 1.60.

PRECAUTIONS

- ① Ensured that the theodolite was set up and levelled properly using leveling screws.
- ② Ensured that when taking reading of the face left, the angle reading scale was to zero before.
- ③ Ensured that the ground was even where the staff was levelled accordingly.
- ④ Ensured that we avoided error due to parallax when taking measurements from the stadia rod.

CONCLUSIONS

From the experiment, the tachometric constants k and C were determined to be 100 and 0 respectively. Tacheometry is a fast and efficient method of measuring distances and elevations without using chains or tapes. This method is particularly useful in rough terrain, where direct distance measurement is difficult.

EXPERIMENT 5

TITLE: Triangulation Surveying

AIM: To determine the position of points and measure distances indirectly by forming a series of triangles, using trigonometry and angular measurement.

APPARATUS:

- (1) Theodolite for measuring horizontal and vertical angles.
- (2) Field book for recording observation & calculations.
- (3) Linen tape for baseline measurement.
- (4) Tripod stand: A three legged adjustable stand designed to give stability for surveying instruments, primarily theodolites.

THEORY

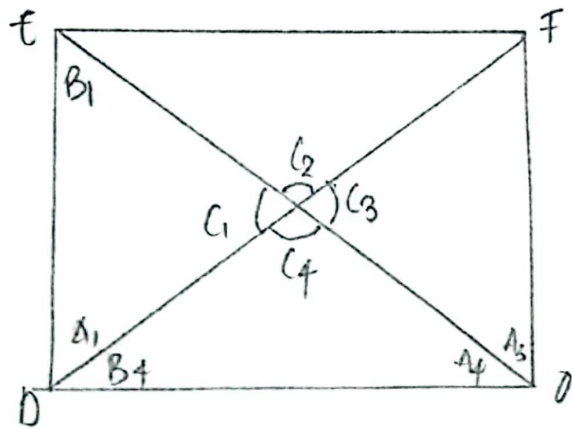
Triangulation surveying is the tracing and measurement of a series of network of triangles to determine distances and relative positions of points spread over an area, by measuring the length of one side of ~~an~~ each triangle and deducing its angles and length of other two sides by observation from this baseline. The main disadvantage of triangulation is the accumulation of error in the lengths and direction of lines.

Applications of Triangulation Surveying

- △ Establishing accurately located control points for plane and geodetic survey of large areas.
- △ Establishing accurately located control points in connection with aerial surveying amongst others.
- △ 'Triangulation Systems': This is a system consisting of triangulation stations connected by a chain of triangles. The complete fig is called Triangulation System.

PROCEDURES

1) Points E, F, D and D were selected as the corners of the polygon.



2) C is the center of the polygon

(measures angle A, B, C, A₂, B₂, C₂, A₃, B₃, C₃ and A₄, B₄, C₄ by either repetition or reiteration method)

The mean of angular values obtained using repetition or reiteration method. The angle are then adjusted by the following checks.

$$\angle A_1 + \angle B_1 + \angle C_1 = 180$$

$$\angle C_1 + \angle C_2 + \angle C_3 + \angle C_4 = 360$$

$$2 \log \sin \frac{A}{2} = 2 \log \sin \frac{B}{2} = 2 \log \sin \frac{C}{2}$$

Calculation / Field Report

EXERCISES

Field Work Results

Two Stations	Distance (m)
P-A	7.64m
P-B	6.60
P-C	8.20
P-D	8.51
C-D	10.70
D-A	13.94
B-C	13.57
A-B	7.60

ANGULAR READINGS

MISS B

Angle	Initial	Final	θ
$A_1 B$	$1^{\circ} 15' 39''$	$59^{\circ} 59' 20''$	$58^{\circ} 43' 49''$
$B_2 C$	$59^{\circ} 59' 28''$	$192^{\circ} 13' 4''$	$132^{\circ} 13' 36''$
$C_3 D$	$192^{\circ} 13' 4''$	$242^{\circ} 08' 19''$	$49^{\circ} 55' 15''$
$D_4 A$	$242^{\circ} 08' 19''$	$361^{\circ} 19' 43''$	$119^{\circ} 9' 24''$

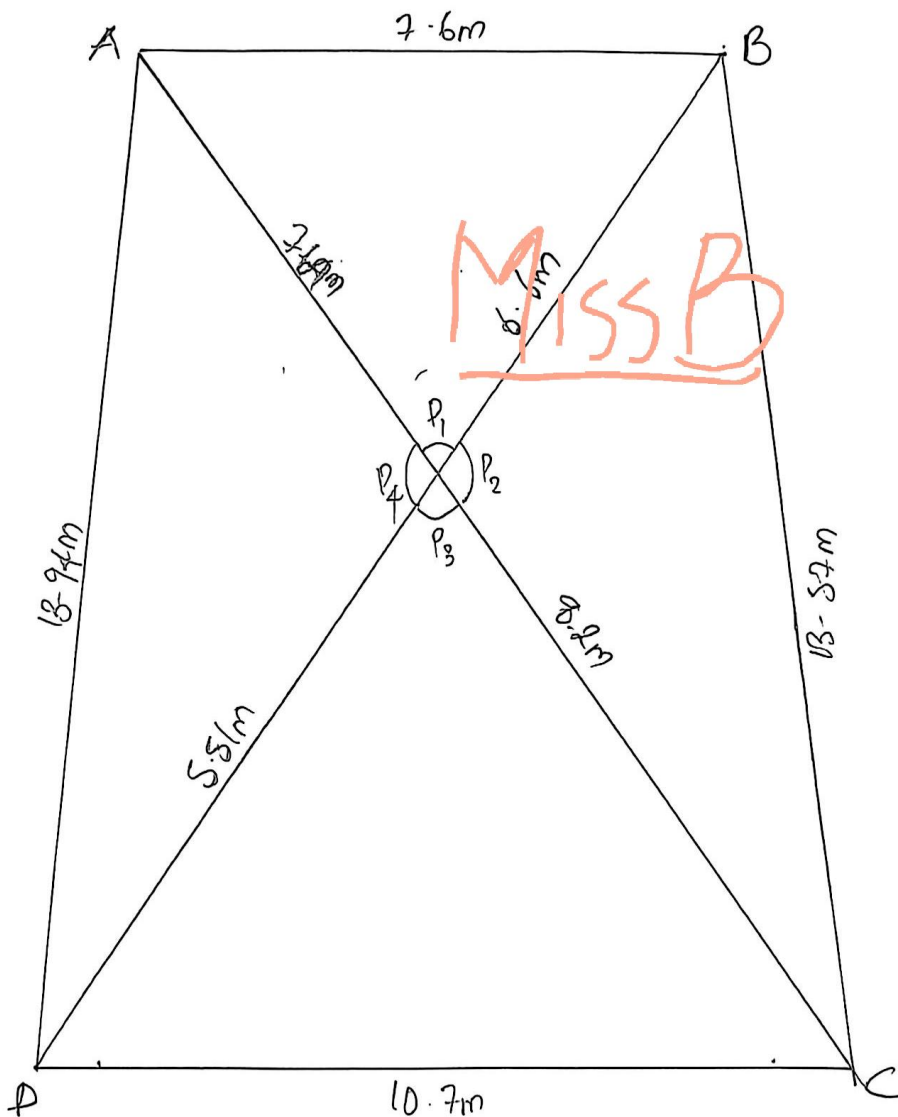
Angle	Initial	Final	θ
$A_2 D$	$361^{\circ} 09' 59''$	$241^{\circ} 58' 01''$	$119^{\circ} 11' 58''$
$D_3 C$	$241^{\circ} 58' 01''$	$192^{\circ} 07' 16''$	$49^{\circ} 56' 45''$
$C_2 B$	$192^{\circ} 01' 16''$	$59^{\circ} 48' 56''$	$132^{\circ} 12' 20''$
$B_1 A$	$59^{\circ} 48' 56''$	$1^{\circ} 06' 07''$	$58^{\circ} 42' 49''$

$$\angle P_1 = \frac{A\hat{P}_1B + B\hat{P}_1A}{2} = \frac{58^\circ 43' 49'' + 58^\circ 42' 49''}{2} = 58^\circ 43' 19''$$

$$\angle P_2 = \frac{B\hat{P}_2C + C\hat{P}_2B}{2} = \frac{132^\circ 13' 36'' + 132^\circ 12' 20''}{2} = 132^\circ 12' 58''$$

$$\angle P_3 = \frac{B\hat{P}_3D + D\hat{P}_3C}{2} = \frac{49^\circ 55' 15'' + 49^\circ 56' 45''}{2} = 49^\circ 56' 0''$$

$$\angle P_4 = \frac{D\hat{P}_4A + A\hat{P}_4D}{2} = \frac{119^\circ 9' 24'' + 119^\circ 11' 58''}{2} = 119^\circ 10' 41''$$



CORRECTION CHECK

Total angles at a point = 360

$$\therefore P_1 + P_2 + P_3 + P_4 = 360^\circ$$

$$\Rightarrow 58^\circ 43' 24'' + 132^\circ 12' 58'' + 49^\circ 55' 55'' + 119^\circ 10' 41'' = 360^\circ 2' 58''$$

$$\text{Correction} = \frac{360 - 360^\circ 2' 58''}{4} = \frac{-0^\circ 2' 58''}{4} = -0^\circ 0' 44.5''$$

Corrected angles;

$$P_1 = 58^\circ 43' 24'' - 0^\circ 0' 44.5'' = 58^\circ 42' 39.5''$$

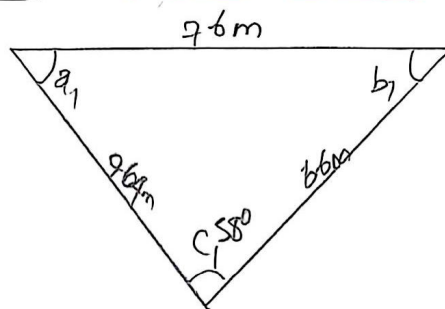
$$P_2 = 132^\circ 12' 56'' - 0^\circ 0' 44.5'' = 132^\circ 12' 13.45''$$

$$P_3 = 49^\circ 55' 55'' - 0^\circ 0' 44.5'' = 49^\circ 55' 10.5''$$

$$P_4 = 119^\circ 10' 4'' - 0^\circ 0' 44.5'' = 119^\circ 9' 19.5''$$

$$\therefore 58^\circ 42' 39.5'' + 132^\circ 12' 13.45'' + 49^\circ 55' 10.5'' + 119^\circ 9' 19.5'' = \underline{\underline{360^\circ}}$$

For triangle A P₁ B



Applying Sine rule

$$\frac{\sin a_1}{6.6} = \frac{\sin 58}{7.6}$$

$$\sin a_1 = \frac{6.6 \times \sin 58}{7.6} = 0.74$$

$$a_1 = \sin^{-1}(0.74) = 47^\circ 43' 53''$$

Also $\frac{\sin b_1}{7.64} = \frac{\sin 58}{7.6}$

$$\sin b_1 = \frac{7.64 \times \sin 58}{7.6} = 0.85$$

$$b_1 = \sin^{-1}(0.85) = 58^\circ 12' 42''$$

Check

$$a_1 + b_1 + P_1 = 180$$

$$58^\circ 42' 34.5'' + 49^\circ 43' 53'' + 58^\circ 12' 42'' \neq 180$$

Error

180° - Total angle

$$180^\circ - 163^\circ 56' 35'' = 16^\circ 3' 25''$$

Correction

$$\frac{16^\circ 3' 25''}{2} = 8^\circ 1' 42.5''$$

Corrected Values

$$a_1 = 49^\circ 43' 53'' + 8^\circ 1' 42.5'' = 55^\circ 45' 35.5''$$

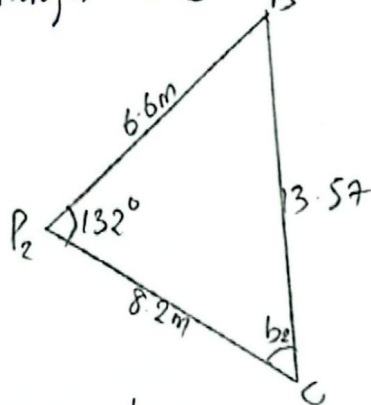
$$b_1 = 58^\circ 12' 42'' + 8^\circ 1' 42.5'' = 66^\circ 14' 24.5''$$

Check

$$a_1 + b_1 + P_1 = 180$$

$$55^\circ 45' 35.5'' + 66^\circ 14' 24.5'' + 58^\circ 42' 34.5'' = 180$$

FOR Triangle $B_1 C_1$



Applying Sine rule.

$$\frac{\sin a_2}{8.2} = \frac{\sin 132}{13.57}$$

$$\Rightarrow \sin a_2 = \frac{8.2 \times \sin 132}{13.57} = 0.45$$

Miss B

$$a_2 = \sin^{-1}(0.45) = 26^\circ 44' 37.26''$$

Also

$$\frac{\sin b_2}{6.6} = \frac{\sin 132}{13.57}$$

$$\Rightarrow \sin b_2 = \frac{6.6 \times \sin 132}{13.57} = 0.36$$

$$b_2 = \sin^{-1}(0.36) = 21^\circ 6' 0.71''$$

Check

$$a_2 + b_2 + P_2 = 180$$

$$26^\circ 44' 37.26'' + 21^\circ 6' 0.71'' + 132^\circ 12' 13.45'' \neq 180$$

$$\text{Error} = 180^\circ - \text{Total angle}$$

$$= 180^\circ - 180^\circ 26' 51.42'' = -0^\circ 2' 51.42''$$

Correction

$$\frac{-0^\circ 2' 51.42''}{2} = -0^\circ 1' 25.71''$$

Corrected Values

$$a_2 = 26^\circ 44' 37.26'' - 0^\circ 1' 25.71'' = 26^\circ 43' 11.55''$$

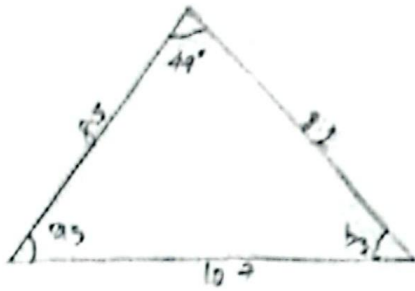
$$b_2 = 21^\circ 6' 0.71'' - 0^\circ 1' 25.71'' = 21^\circ 4' 35''$$

Check

$$a_2 + b_2 + P_2 = 180$$

$$26^\circ 43' 11.55'' + 21^\circ 4' 35'' + 132^\circ 12' 13.45'' = 180^\circ 0' 0''$$

For triangle (P_3D)



Applying Sine Rule

$$\frac{\sin a_3}{8.2} = \frac{\sin 49^\circ 55'}{10.7}$$

$$\Rightarrow \sin a_3 = \frac{8.2 \times \sin 49^\circ 55'}{10.7} = 0.59$$

$$\therefore a_3 = \sin^{-1}(0.59) = 36^\circ 9' 25.23''$$

Also

$$\frac{\sin b_3}{8.5} = \frac{\sin 49^\circ 55'}{10.7}$$

$$\Rightarrow \sin b_3 = \frac{8.5 \times \sin 49^\circ 55'}{10.7} = 0.61$$

$$\therefore b_3 = \sin^{-1}(0.61) = 37^\circ 35' 22.21''$$

Check

$$a_3 + b_3 + P_3 = 0$$

$$36^\circ 9' 25.23'' + 37^\circ 35' 22.21'' + 49^\circ 55' 10.5'' \neq 180$$

Error $\neq 0$

$$\begin{aligned} & 180 - \text{Total angle} \\ &= 180 - 123^\circ 39' 57.94'' \\ &= 56^\circ 20' 2.06'' \end{aligned}$$

Correction

$$\frac{56^\circ 20' 2.06''}{2} = 28^\circ 10' 1.03''$$

$$a_3 = 36^\circ 9' 25.25'' + 26^\circ 10' 1.05'' = 64^\circ 19' 26.26''$$

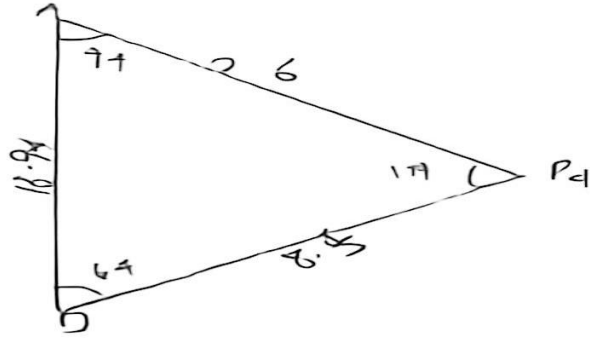
$$b_3 = 37^\circ 35' 28.21'' + 28^\circ 10' 10.8'' = 65^\circ 45' 39''$$

Check

$$a_3 + b_3 + c_3 = 180$$

$$64^\circ 19' 26.26'' + 65^\circ 45' 29'' + 49^\circ 55' 10.54'' = 180^\circ$$

For Triangle DP, A



Applying Sine Rule

$$\frac{\sin a_4}{8.5} = \frac{\sin 119^\circ}{15.94}$$

$$\Rightarrow \sin a_4 = \frac{8.5 \times \sin 119^\circ}{15.94} = 0.533$$

$$a_4 = \sin^{-1}(0.533) = 32^\circ 12' 30.16''$$

$$\text{Also, } \frac{\sin b_4}{7.6} = \frac{\sin 119^\circ}{15.94}$$

$$\sin b_4 = \frac{7.6 \times \sin 119^\circ}{15.94} = 0.48$$

$$b_4 = \sin^{-1}(0.48) = 28^\circ 41' 7.45''$$

Check

$$a_4 + b_4 + P_4 = 180$$

$$32^\circ 12' 30.16'' + 28^\circ 41' 7.45'' + 119^\circ 9' 19.5'' = 180$$

∴ Correction is not needed. $180^\circ 2' 57.11'' \neq 180$

MISS B

Error

$$180 - \text{Total angle} \\ = 180 - 180^{\circ} 2' 57.11'' = -0^{\circ} 2' 57.11''$$

Correction

$$\frac{-0^{\circ} 2' 57.11''}{2} = -0^{\circ} 1' 28.56''$$

Corrected values

$$a_4 = 32^{\circ} 12' 30.16'' - 0^{\circ} 1' 28.56'' = 32^{\circ} 11' 1.6''$$

$$b_4 = 28^{\circ} 41' 7.45'' - 0^{\circ} 1' 28.56'' = 28^{\circ} 39' 38.89''$$

Check

$$a_4 + b_4 + P_4 = 32^{\circ} 11' 1.6'' + 28^{\circ} 39' 38.39'' + 119^{\circ} 9' 19.5'' = 180^{\circ}$$

OBSERVATIONS

- ① I observed that the corrected values calculated are close to zero degrees (0°) indicating a level of accuracy.
- ② I observed that the angle readings from the theodolites differ from one point to another.
- ③ I observed that the theodolite

PRECAUTIONS

- ① We ensured that the theodolite was mounted on a tripod and leveled properly.
- ② We ensured that the poles were bisected by the theodolite before taking our readings.
- ③ We avoided errors due to parallax while taking readings from the theodolite.

CONCLUSION

This experiment validates the aim. ~~which~~ From the experiment we determined the positions of points and measured distances indirectly by forming a series of triangles, using trigonometry and angular measurements.