Chapter 3

Theodolite, Traverse Survey and Omitted Measurements

CHAPTER HIGHLIGHTS

- *Theodolite survey*
- *Traverse surveying and omitted measurements*

Theodolite Survey

Introduction

Horizontal angles can be measured by compass. But to get precise readings and to measure horizontal and vertical angles another instrument called theodolite is used. It can be used for laying off horizontal angles, locating points on line, prolonging survey lines, establishing grades, determining difference in elevation, setting out curves, etc.

Theodolites

1. **Transit theodolite or transit:** In transit theodolite the line of sight can be reversed by revolving the telescope through 180° in the vertical plane and is commonly used.
2. **Non-transit theodolite:** These are either plain theodolites or Y-theodolites in which the telescope cannot be transited.

Parts of Transit Theodolite

1. **Telescope:** It is mounted on a spindle known as horizontal axis or trunnion axis and internal focusing type is widely used.
2. **Vertical circle:** It is a circular graduated arc attached to the trunnion axis of the telescope and operated by means of vertical circle clamp and its corresponding slow motion or tangent screw. The circle is graduated from 0°–360° in clockwise or it is divided into four quadrants.
3. **Index frame (T-frame or vernier frame):** It is T-shaped frame consisting of a vertical leg known as clipping arm and a horizontal bar known as vernier arm or index arm whose two extremities are fitted with verniers to read vertical circle. Clip screw is used for slight adjustment. Altitude bubble is placed on the top of the index frame.
4. **The standards (or A-frame):** Two resembling letter 'A' are mounted on the upper plates. The trunnion axis, T-frames and the arm of vertical circle clamp are attached to the A-frame.
5. **Levelling head:** It consists of two parallel triangular plates known as plates. Its functions are:
   (a) To support main part of instrument.
   (b) To attach the theodolite to the tripod.
   (c) To provide a means for leveling the theodolite.
6. **Lower plate (or scale plate):** Lower plate carries a lower clamp screw and a corresponding tangent screw to rotate the plate and fix at any position. Size of theodolite is represented by the size of scale plate.
7. **Upper plate (or vernier plate):** This is connected to inner axis and carries two verniers and also an upper clamp screw and a corresponding tangent screw.

- On clamping upper and unclamping the lower clamp, instrument rotates on its outer axis without any relative motion between the plates.
- Lower clamp is clamped and upper unclamped, instrument rotates on inner axis with relative motion between vernier and scale.

- For using any tangent screw, its corresponding clamp screw must be tightened.

8. **Plate levels:** These are carried by the upper plates which are perpendicular to each other with one of them parallel to turnion axis. These help the telescope to settle in exact vertical position.
9. **Tripod:** It is a stand on which theodolite is mounted
10. **Plumb bob:** It is tool a having a cone shaped weight attached to a long thread. The weight is hanged using thread from centre of tripod stand and centering of the odilite is done.
11. **Compass:** Simpler theodolites may contain circular compass box in the centre of upper plate. It is useful when we select north as the reference meridian.

Definitions and Terms

1. **Vertical axis:** This is the axis about which the instrument can be rotated in a horizontal plane. Lower and upper plates rotate about this axis. It is also known as **azimuth axis**.
2. **Horizontal axis or trunnion axis:** is the axis about which the telescope and the vertical circle rotate in the vertical plane.
3. **Line of sight or line of collimation:** is the line passing through the intersection of the horizontal and vertical cross-hairs and the optical centre of the object glass and its continuation.
4. **Axis of level tube or bubble line:** It is a straight line tangential to the longitudinal curve of the level tube at its centre. It is horizontal when the bubble is central.
5. **Transiting:** also known as plunging or reversing. It is the process of turning the telescope in vertical plane through 180° about the trunnion axis.
6. **Swinging the telescope:** The process of turning the telescope in horizontal plane. If rotated clockwise, it is called right swing. If rotated in anticlockwise direction, it is called left swing.
7. **Face left observation:** If the face of vertical circle is to the left of the observer, the observation angle is called as face left observation.
8. **Face right observation:** If the face of vertical circle is to the right of the observer.
9. **Telescope normal or direct:** Telescope is said to be normal when the face of the vertical circle is to the left side and the bubble is up.
10. **Telescope inverted or reversed:** When face of vertical circle is to the right and the bubble down.
11. **Changing face:** It is an operation of bringing the face of the telescope from left to right and vice versa.

Adjustments in Theodolite

Temporary Adjustments of Theodolite

- **Setting:** The instrument to be set over the station, centering by a plumb bob and approximate levelling with the help of tripod legs.
- **Levelling:** Done using leveling screws or foot screws to make the vertical axis truly vertical.
- **Elimination of parallax:** Parallax is a condition arising when the image formed by the objective is not in the plane of the cross hairs.

It is done in two steps:

1. **Focusing the eye-piece:** For distinct vision of the cross hairs.
2. **Focusing the objective:** Focusing screw is turned till the image appears clear and sharp and is in the plane of cross hairs.

Permanent Adjustments of Theodolite

1. **Adjustment of plate level:** To make the axis of plate bubble perpendicular to the vertical axis when the bubble is central.
2. **Adjustment of line of sight:** Line of sight should coincide with optical axis of the telescope.
3. **Adjustment of horizontal axis:** Horizontal axis should be perpendicular to the vertical axis. Spire test is done.
4. **Adjustment of altitude level and vertical index frame:** Clip and tangent screws are used for adjusting vertical frame and levelling of altitude.

Operations done with Theodolite

Measurement of Horizontal Angle

Repetition Method Used to measure horizontal angle to a finer degree of accuracy than that obtained with the least count of vernier.

Errors eliminated:

1. Errors due to eccentricity of verniers and centres are eliminated by taking both vernier readings.
2. Errors due to in adjustment of line of collimation and the trunnion axis are eliminated by taking both face readings.
3. Error due to inaccurate graduations are eliminated by taking the readings at different parts of the circle.
4. Errors due to inaccurate bisection of the object, eccentric centering, etc., may be to some extent counter-balanced in different observations.
5. Errors due to slip, displacement of station signals and want of verticality of the vertical axis, etc., are not eliminated since they are all cumulative.

Direction Method or Reiteration Method This is also known as method of series and is suitable for the measurement of the angles of a group having a common vertex point and finally the horizon is closed such that sum of angles equal to 360°.

1. Measurement of vertical angles.
2. Measuring magnetic bearing of a line.

3. Measuring direct angles and deflection angles.
4. To prolong a straight line.
5. To locate point of intersection of two straight lines.
6. To lay off a horizontal angle.
7. To lay off an angle by repetition.

Fundamental Lines and Their Desired Relations

1. Vertical axis
2. Horizontal axis (trunnion or transit axis)
3. Line of collimation (line of sight)
4. Axis of plate level
5. Axis of altitude level

When the theodolite is in proper adjustment:
- The axis of the plate level must lie in a plane perpendicular to the vertical axis.
- The line of collimation must be perpendicular to the horizontal axis at its intersection with the vertical axis.
- Horizontal axis must be perpendicular to vertical axis.
- Axis of altitude level (telescope level) must be parallel to line of collimation.
- Vertical circle vernier must read zero when the line of collimation is horizontal.

Sources of Error in Theodolite Work

1. Instrumental
2. Personal
3. Natural

Instrumental Errors

These are due to:

1. Imperfect adjustment of the instrument.
2. Structural defects in instrument
3. Imperfections due to wear.
   - Error due to imperfect adjustment of plate levels: The error can be eliminated only by careful leveling with respect to the altitude bubble if it is in adjustment and can be eliminated by double sighting.
   - Error due to line of collimation not being perpendicular to the horizontal axis:

     Error, $e = \beta \sec \alpha$

     β = Error in collimation

     α = Inclination

This error can be eliminated by taking both face observations.
- Error due to horizontal axis not being perpendicular to the vertical axis:

  Error, $e = \beta \tan \alpha$

This error can be eliminated by taking both face observations.
- Error due to non-parallelism of the axis of telescope level and the line of collimation can be eliminated by taking both face observations.
- Error due to eccentricity of inner and outer axes can be eliminated by taking the mean of the two vernier readings.
- Error due to imperfect graduations can be eliminated by taking mean of several readings distributed over different portions of the graduated circle.
- Error due to eccentricity of verniers can be eliminated by reading both the verniers and taking the mean of the two.

Personal Errors

1. **Errors in manipulation:**
   (a) Inaccurate centering
   (b) Inaccurate levelling
   (c) Slip
   (d) Manipulating wrong tangent screw.
2. **Errors in sighting and reading:**
   (a) Inaccurate bisection of points observed.
   (b) Mistakes in setting the vernier.
   (c) Parallax: Due to parallax, accurate bisection is not possible. Error can be eliminated by focusing eye-piece and objective.

Natural Errors

1. Unequal atmospheric refraction due to high temperature.
2. Unequal expansion of parts of telescope and circles due to temperature change.
3. Unequal settlement of tripod.
4. Wind producing vibrations.

Double Sighting

Measurement of horizontal angle or vertical angle twice; once with the telescope in normal condition and once with the telescope in inverted condition is called double sighting.

Traverse Surveying and Omitted Measurements

1. **Introduction:** Traversing is that type of survey in which a number of connected survey lines form the framework and the directions and the lengths of the survey lines are measured with the help of an angle measuring instrument (compass or theodolite) and a tape (or chain) respectively.
   - When the lines form a circuit which ends at the starting point, it is known as **closed traverse**.

This is suitable for locating the boundaries of lakes, woods etc., and for the survey of large areas.
- If the lines of survey ends at a point other than the starting point it is said be an **open traverse**. This is suitable for surveying a long narrow strip of land as required for a road or canal or the coastline.

Methods of Traversing

1. Chain traversing
2. Chain and compass traversing (loose needle method)
3. Transit type traversing
   (a) By fast needle method
   (b) By measurement of angles between the lines
4. Plane table traversing

Traverse surveying is not limited to any particular geometrical figure as in the case of chain surveying which has system of connected triangles.

Chain Traversing

- In this, traversing is done with the chain and tape. Directions of the lines are fixed entirely by linear or tie measurements known as chain angles.
- Not suitable for accurate work and generally chain traversing is not used if an angle measurement instrument such as compass or theodolite are available.

Chain and Compass Traversing

Linear measurements are done with the help of chain or tape and the bearings are measured with compass. Both FB and BB are observed at each station.

Transit Type Traversing

1. **Fast needle method:**
   - Magnetic bearings of traverse lines are measured by a theodolite fitted with a compass with reference to the direction of magnetic meridian established at the first station.
   - In direct method with transiting, telescope will be normal at one station and inverted at the next station.
   - Direct method without transiting is the most satisfactory method in which 180° correction is necessary only at 2nd, 4th and 6th station and so on. Add 180° if the reading of vernier < 180°. Subtract 180° if it is more than 180°.
2. **Direct observation of angles:** Angles are directly measured with theodolites. Traversing is done by:
   (a) Included angles
   (b) Deflection angles
      - Deflection angle is the angle, which a survey line makes with the prolongation of the previous line. More suitable for survey of roads, railways, pipe-lines, etc.
      - If the direction of progress is counter-clockwise and the angles measured clockwise are directly the interior angles.
      - If the direction of progress is clockwise and hence the angles measured clockwise are exterior angles.

Checks in Closed Traverse

Two kinds of errors are involved in traversing.

Linear Error

This shall be rectified by measuring each survey line for second time. Preferably in the reverse direction on different dates and by different parties.

Angular Error

1. **Traverse by included angles:**
   - If the interior angles are measured, sum of interior angles = $(2N - 4)\ 90°$.
   - If the exterior angles are measured, sum of exterior angles = $(2N + 4)\ 90°$.
     N = Number of sides of the traverse.
2. **Traverse by deflection angles:**
   Σ Deflection Angles = 360°
   [Right hand deflection angles as '+', Left hand deflection angles as '–']
3. **Traverse by direct observation of bearings:** Last line FB = (Last line BB measured at the initial station ± 180°).

Plotting a Traverse Survey

Angle and Distance Method

This method is suitable for small surveys. Distance between stations are laid off to scale and angles are plotted by one of the following methods:

1. By protractor
2. By the tangent of the angle
3. By the chord of the angle

Coordinate Method

This method is the most practical and accurate one for plotting traverse or any other extensive system of horizontal control. Survey stations are plotted by calculating their co-ordinates. Advantage of this method is that the closing error can be eliminated by balancing prior to plotting.

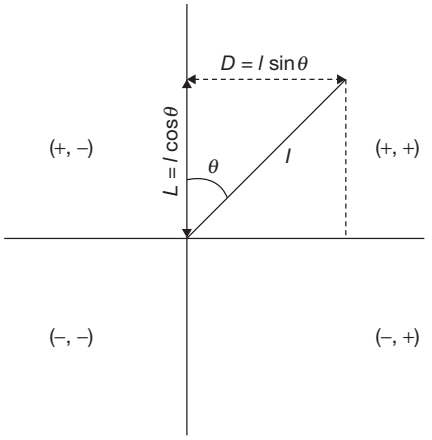
1. **Dependent or consecutive co-ordinates (latitude or departure):**
   - Latitude (L) of a survey line may be defined as its co-ordinate length measured parallel to an assumed meridian direction.
   - Latitude is positive when measured northward (upward) and is termed as northing. It is negative when measured southward (downward) and is termed as southing.

- Departure (D) of survey line may be defined as its co-ordinate length measured at right angles to the meridian direction.
- Departure of the line is positive when measured eastward and is termed as easting. It is negative when measured westward and is termed as westing.

From the figure,

$L = + l\cos\theta$

$D = + l\sin\theta$



2. **Independent co-ordinates:** Total latitude and departure of any point with respect to a common origin are known as independent co-ordinates or total co-ordinates of the point.

Closing Error

If a closed traverse is plotted according to the field measurements, the end point of the traverse will not coincide exactly with the starting point owing to the errors in the field measurements of angles and distances. This error is known as closing error.

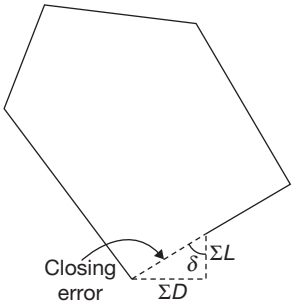
Closing error,

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

Direction of closing error, $\tan\delta = \dfrac{\Sigma D}{\Sigma L}$

Relative error of closure

$$= \frac{\text{Error of closure}}{\text{Perimeter of traverse}} = \frac{e}{p} = \frac{1}{\frac{p}{e}}$$



- For a closed traverse, $\Sigma L = \Sigma D = 0$

SOLVED EXAMPLES

Example 1

A closed traverse was conducted round an obstacle and the following observations were made and length and bearing of DA have been omitted. Calculate length and bearing of the line DA.

Line	Length (m)	Bearing
AB	201.0	85°20′
BC	240.0	22°40′
CD	194.0	220°0′
DA	?	?

(A) 190.23 m and 242°2′
(B) 87.85 m and 180°28′
(C) 56.71 m and 136°6′
(D) 49.67 m and 44°24′

Solution

Given closed traverse $\Rightarrow \Sigma L = \Sigma D = 0$

Latitude of $AB = AB\cos\theta$

$= +201\cos 85°20'$

Departure of $AB = AB\sin\theta = +201\sin 85°20'$

Line	Latitude (m)		Departure (m)	
	+	–	+	–
AB	16.35		200.33	
BC	221.46		92.49	
CD		148.6		124.7
Sum	237.81	148.6	292.82	124.7
	$\Sigma L' = 89.21$		$\Sigma D' = 168.12$	

Latitude of $DA = -\Sigma L' = -89.21$ m

Departure of $DA = -\Sigma D' = -168.12$ m

Since both latitude and departure are negative. DA lies in SW Quadrant. (IIIQ)

$$\tan\theta = \frac{\text{Departure}}{\text{Latitude}} = \frac{168.12}{89.21} = 1.88$$

$\theta = 62°2'$

Bearing of DA = S62°2′W = 242°2′

$$\text{Length of } DA = \frac{\text{Latitude}}{\cos\theta}$$

$$= \frac{89.21}{\cos(62°2')} = 190.23 \text{ m.}$$

Hence, the correct answer is option (A).

Balancing the Traverse

- The term 'balancing' is generally applied to the operation of applying correction to latitudes and departures so that $\Sigma L = \Sigma D = 0$ and it can be applied only for a closed polygon.

The following are the balancing methods:

Bowditch's method (Compass rule):

- This is based on assumption that the errors in linear measurements are proportional to $\sqrt{l}$ and that in angular measurements are inversely proportional to $\sqrt{l}$, where l is the length of a line.
- Mostly used to balance a traverse where linear and angular measurements are of equal importance.

Correction to latitude (or departure) of any side = Total error in latitude (or departure) $\times \left(\frac{\text{Lenght of that side}}{\text{Perimeter of traverse}} \right)$

$$C_L = \Sigma L \times \frac{l}{\Sigma l} \text{ (or) } C_D = \Sigma D \times \frac{l}{\Sigma l}$$

Where

l = Length of the line

Σl = Perimeter of the traverse

Transit Method

This method is used where angular measurements are more precise than the linear measurements.

$$\text{Correction to latitude (or departure) of any side} = \text{Total error in latitude (or departure)} \times \frac{\text{Latitude (or departure) of that line}}{\text{Arithmetic sum of latitudes (or departures)}}$$

$$C_L = \Sigma L \cdot \frac{L}{L_T} \text{ and } C_D = \Sigma D \cdot \frac{D}{D_T}$$

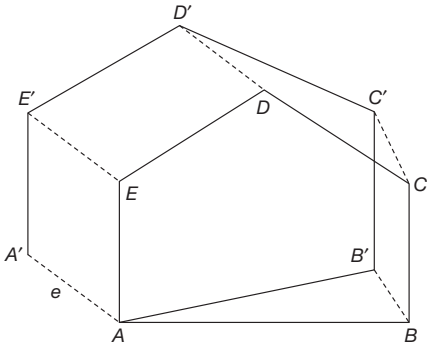
Where

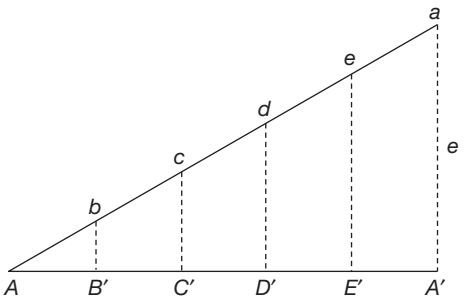
ΣL and ΣD = Total error in latitudes and departures.

L_T and D_T = Arithmetic sum of latitudes and departures.

Graphical Method

- Used for rough survey such as compass survey.
- Bowditch's rule is applied graphically without theoretical calculation.





- $AB'\ C'\ D'\ E'\ A'$ is unbalanced traverse having closing error $A'A$.

Axis Method

- This method is adopted when angles are measured accurately and corrections being applied to lengths only.

Correction to any side

$$= \text{Length of that side} \times \left(\frac{\frac{1}{2}(\text{closing error})}{\text{Lenght of axis}} \right)$$

- Adjustment is done using axis of adjustment which is the line joining the end points extended to intersect any side.

Degree of Accuracy in Traversing

- It depends on the type of instruments used for the linear and angular measurements and also on purpose of survey.
- If $\delta\theta$ be error in angular measurement e be error in linear measurement.

Allowable angular error, $\delta\theta = \tan^{-1}\left(\frac{e}{l}\right)$

Where

l = Length of the line

$\frac{e}{l}$ = Linear error

- Angular error of closure in theodolite traversing is expressed as $C\sqrt{N}$, where C varies from 15″ to 1′ and N is equal to number of angles measured.

Omitted Measurements

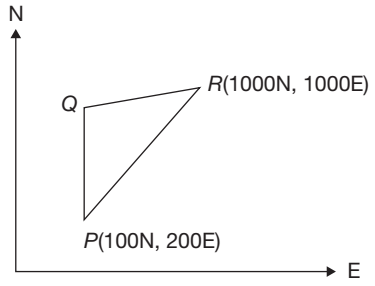
Sometimes in survey, it is not possible to take all the measurements due to obstacles or because of some over-sight. Such omitted measurements can be calculated by latitudes and departures provided the quantities required are not more than two.

There are four general cases of omitted measurements.

1. (a) When the bearing of one side is omitted.
   (b) When the length of one side is omitted.
   (c) When the bearing and length of one side is omitted.
2. When the length of one side and the bearing of another side are omitted.
3. When the lengths of two sides are omitted.
4. When the bearings of two sides are omitted.

Exercises

1. In the figure shown, the lengths PQ (WCB 30°) and QR (WCB 45°) respectively upto three places of decimal are



(A) 273.505, 938.186 (B) 273.205, 551.815
(C) 551.815, 551.815 (D) 551.815, 938.186

2. Two points P and Q located on a map have the following co-ordinates:

	P	Q
Latitude	+40 m	+20 m
Departure	–20 m	+30 m

The length of PQ is _____.

(A) 53.85 m (B) 34.89 m
(C) 34.98 m (D) 12.89 m

3. Consider the following assumptions of Bowditch method:

I. Angular measurements are more precise than linear measurements.
II. Linear measurements are more precise than angular measurements.
III. Errors in linear measurements are proportional to $\sqrt{L}$.
IV. Correction to latitude or departure of any side = Total error in L (or D) $\times \frac{\text{Length of that side}}{\text{Perimeter of traverse}}$

Which of these statements are correct?

(A) I and IV (B) I, II and III
(C) II, III and IV (D) III and IV

4. Consider the following steps:

I. Calculation of ΣL and ΣD.
II. Correction of latitudes and departures.
III. Calculation of bearings.
IV. Calculation of interior angles.
V. Calculation of independent angles.

The correct sequence of these steps in Gale's traverse table calculations is

(A) III, IV, V, II, I (B) IV, III, I, II, V
(C) II, I, III, IV, V (D) IV, III, V, II, I

5. The length of a line measured with a 30 m chain was found to be 734.6 m. It was afterwards found that the chain was 0.05 m too long. The true length of the line was

(A) 630.82 m (B) 680.82 m
(C) 735.82 m (D) 780.92 m

6. In a transit theodolite, any incidental error due to eccentricity of verniers is primarily counteracted by

(A) reading both the verniers.
(B) reading different parts of main scale.
(C) reading right and left faces.
(D) taking both right swing readings.

7. For minor adjustment of horizontal angles measured using a theodolite, the tangential screw is adjusted after

(A) both the plates are unclamped.
(B) the lower plate in clamped and the upper plate is unclamped.
(C) the upper plate is clamped and the lower plate is unclamped.
(D) both the plates are clamped.

8. Theodilite is a measuring device which is included under category of

(A) first order measurements.
(B) second order measurements.
(C) third order measurements.
(D) fourth order measurements.

9. The long and short sides of a rectangle measure 9.32 m and 4.82 m, with errors ±5 mm. Express the area of correct number of significant figures

(A) 44.98 m^2 (B) 44.96 m^2
(C) 44.92 m^2 (D) 44.85 m^2

10. Two distances of 30 and 100 metres were accurately measured out and the intercepts on the staff between the outer stadia webs were 0.176 m at the former distance and 0.892 m at the latter. The tacheometric constant K is

(A) 100 (B) 97.7
(C) 95 (D) 96.2

11. A flag staff of 2 m height was erected on topic of hill (Q) and the observations were made from two stations P and R, 50 metres apart. The horizontal angle measured at P between R and top of flag staff was 50°30′ and that measured at R between the top of the flag-staff P was 50°18′. Angle of elevation to top of staff was measured to be 10°12′ at P. The angle of elevation to top of flag staff and was measured to be 10°48′ at R. Staff readings on BM when the instrument was at P = 1.826 m and that with the instrument at R = 2.285 m. The elevation of the top of hill Q if the BM was 485.065 m is

(A) 485.36 m (B) 488.32 m
(C) 494.22 m (D) 498.32 m

12. The distance between two points *A* and *B* by tachometer fitted with anallactic lens which made a vertical angle of +10°46′ and staff intercept of 1.763 m. Later on the constants of instrument were changed to 100 and 0.5. The percentage error is computed horizontal distance is
(A) 0.287% (B) 0.321%
(C) 0.262% (D) 0.213%

13. In a quadrilateral *ABCD*, the coordinates of points are as follows:

Point	East	North
A	0	0
B	0	–842.8
C	600.1	742.8
D	1023.4	659.3

The area of the figure is
(A) 4.68 hectares (B) 7.06 hectares
(C) 9.12 hectares (D) 12.51 hectares

14. To continue a survey line *AB* past an obstacle, a 400 m long line *BC* was set out perpendicular to *AB* and from *C* angles *BCD* and *BCE* were set out 60° and 45° respectively. Determine the lengths which must be chained off along *CD* and *CE* in order that *ED* may be in line with *AB* produced.
(A) 747 m, 620.4 m
(B) 827 m, 580.3 m
(C) 800 m, 565.6 m
(D) 852 m, 648.3 m

15. In a closed traverse with five sides, the error found from the force bearing and back bearing of the last line is +2°, the correction to the third line will be
(A) 0°24′ (B) 0°48′
(C) 1°12′ (D) 1°36′

16. In a closed loop traverse of 1 km total length, the closing errors in departure and latitude are 0.3 m and 0.4 m. The relative precision of this traverse will be
(A) 1 : 5000
(B) 1 : 4000
(C) 1 : 3000
(D) 1 : 2000

17. **Assertion (A):** Triangulation networks are to be formed by well conditioned triangle.

Reason (R): Triangulation signals should be conspicuous and centered accurately over the station.
(A) Both A and R are individually true and R is the correct explanation of A.
(B) Both A and R are individually true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

18. The bearings and length of sides of a traverse are given below:

Side	Length	Bearing
AB	200 m	0
BC	100 m	60
CD	250 m	180
DE	?	?

The length and whole circle bearing of *DE* is _____.
(A) 50 m and 270 (B) 86.6 m and 270
(C) 50 m and 90 (D) 50 m and 90

19. The latitude and departure of a line *AB* are +79 m and –43.1 m respectively. The whole circle bearing of line *AB* is _____.
(A) 29° (B) 151°
(C) 209° (D) 331°

Previous Years' Questions

1. The following table gives data of consecutive coordinates in respective of a closed theodolite traverse *PQRSP*:

Station	Northing (m)	Southing (m)	Easting (m)	Westing (m)
P	400.75			300.5
Q	100.25		199.25	
R		199.0	299.75	
S		300.0		200.5

The magnitude and direction of error of closure in whole circle bearing are **[GATE, 2007]**
(A) 2.0 m and 45°
(B) 2.0 m and 315°
(C) 2.82 m and 315°
(D) 3.42 m and 45°

2. The lengths and bearings of a closed traverse *PQRSP* are given below.

Line	Length (m)	Bearing (WCB)
PR	200	0°
QR	1000	45°
RS	907	180°
SP	?	?

The missing length and bearing, respectively of the line SP are **[GATE, 2008]**
(A) 270 m and 270°
(B) 707 m and 270°
(C) 707 m and 180°
(D) 907 m and 270°

3. The observations from a closed loop traverse around an obstacle are: **[GATE, 2011]**

Segment	Observation from Station	Length (m)	Azimuth (Clockwise from Magnetic North)
PQ	*P*	Missing	33.75°
QR	*Q*	300.00	86.3847°
RS	*R*	354.524	169.3819°
ST	*S*	450.000	243.9003°
TP	*T*	268.00	317.5000°

What is the value of the missing measurement (rounded off to the nearest 10 mm)?

(A) 396.86 m (B) 396.79 m
(C) 396.05 m (D) 396.94 m

4. The latitude and departure of a line *AB* are +78 m and –45.1 m, respectively. The whole circle bearing of the line *AB* is **[GATE, 2013]**

(A) 30° (B) 150°
(C) 120° (D) 330°

5. List I lists tool/instrument while List II lists the method of surveying. Match the tool/instrument with the corresponding method of surveying. **[GATE, 2014]**

	List I		List II
P.	Alidade	**1.**	Chain Surveying
Q.	Arrow	**2.**	Levelling
R.	Bubble tube	**3.**	Plane table surveying
S.	Stadia hair	**4.**	Theodolite surveying

Codes:

P Q R S P Q R S

(A) 3 2 1 4 (B) 2 4 3 1
(C) 1 2 4 3 (D) 3 1 2 4

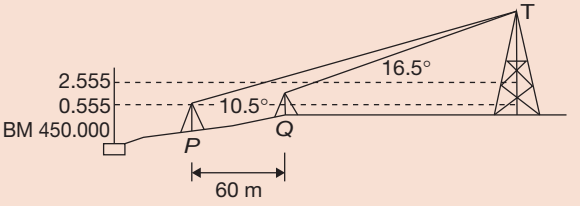
6. In a closed loop traverse of 1 km total length, the closing errors in departure and latitude are 0.3 m and 0.4 m, respectively. The relative precision of this traverse will be **[GATE, 2015]**

(A) 1 : 5000 (B) 1 : 4000
(C) 1 : 3000 (D) 1 : 2000

7. The bearing of two inaccessible stations, S_1 (Easting 500 m, Northing 500 m) and S_2 (Easting 600 m, Northing 450 m) from a station S_3 were observed as 225° and 153°26′ respectively. The independent Easting (in m) of station S_3 is **[GATE, 2015]**

(A) 450.0 (B) 570.71
(C) 550.0 (D) 65.0

8. The vertical angles subtended by the top of a tower T at two instrument stations set up at P and Q, are shown in the figure. The two stations are in line with the tower and spaced at a distance of 60 m. Readings taken from these two stations on a leveling staff placed at the benchmark (BM = 450.000 m) are also shown in the figure. The reduced level of the top of the tower T (expressed in m) is _____. **[GATE, 2016]**



Answer Keys

Exercises

1. A	**2.** A	**3.** D	**4.** B	**5.** C	**6.** A	**7.** D	**8.** B	**9.** C	**10.** B
11. C	**12.** A	**13.** B	**14.** C	**15.** C	**16.** D	**17.** D	**18.** B	**19.** D	

Previous Years' Questions

1. C	**2.** B	**3.** B	**4.** D	**5.** D	**6.** D	**7.** C	**8.** 476.7