AS-4029
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DEPARTMENT OF CIVIL ENGINEERING
B.TECH 2nd YEAR, IIIrd SEMESTER
SUBJECT: SURVEYING-I

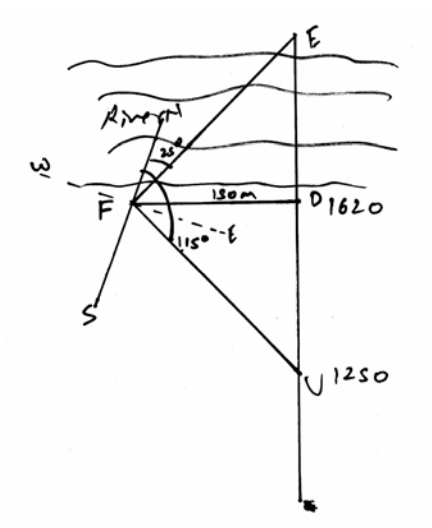
SECTION-A

1. Choose the correct answer:

i. (c) Mutually intervisible
ii. (d) 51^o
iii. (a) Datum
iv. (d) All of the above
v. (d) 2467 cu. m.
vi. (d) All of the above.
vii. (c) Intersection
viii. (a) Radiation
ix. (d) 120^o
x. (a) Long chord

SECTION-B

Solution 2:



Chaining of $D = 1620$ m
Chainage of $C = 1250$ m

$\therefore$ The length $CD = 1620 - 1250 = 370$ m
Bearing of $FC = 115°$
Bearing of $FE = 25°$

$\therefore$ ΔEFC = Bearing of FC – Bearing of FE
$= 115° - 25° = 90°$

From similar Δs EFD and Δ FDC, we get

$$\frac{ED}{FD} = \frac{FD}{DC}$$

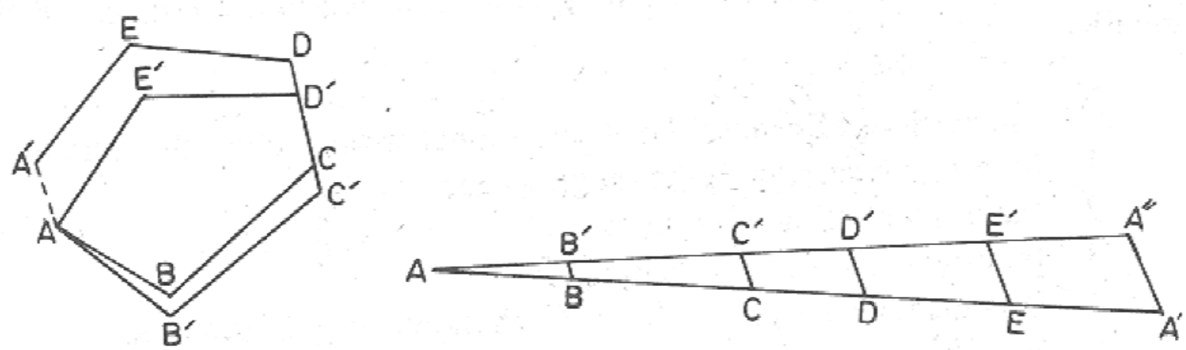
or $$ED = \frac{FD^2}{DC} = \frac{150^2}{370} = 60.81 \text{ m}$$

$\therefore$ Chainage of E = Chainage of $D + ED$
$= 1620 + 60.81 = \mathbf{1680.81\ m}$ **Ans.**

Solution 3:

When a closed traverse is plotted from the field measurements, the end station of a traverse generally does not coincide exactly with its starting station. This discrepancy is due to the errors in the field observations *i.e.* magnetic bearings and linear distances. Such an error of the traverse, is known as *closing error* or *error of closure.*

When the angular and linear measurements are of equal precision, graphical adjustment of the traverse may be made. This method is based on the Bowditch's rule. Corrections are applied to lengths as well as to bearings of the lines in proportion to their lengths. Graphical method is also sometimes known as *proportionate method* of adjustment.



Graphical adjustment of a traverse.

Method. The adjustment of a compass traverse graphically, may be made as under :

Let $ABCDEA'$ be a closed traverse as plotted from the observed magnetic bearings and linear measurements of the traverse legs. A is the starting station and A' is the location of the station A as plotted. Hence, $A'A$ is the closing error.

Adjustment. Proceed as under :

(1) Draw a straight line AA' equal to the perimeter of the traverse to any suitable scale. Set off along it the distances AB, BC, CD, DE and EA' equal to the lengths of the sides of the traverse.

(2) Draw $A'A''$ parallel and equal to the closing error $A'A$. & Join AA"

(3) Draw parallel lines through points B, C, D, and E to meet AA'' at B', C', D' and E'.

(4) Draw parallel lines through the plotted stations B, C, D, E and plot the errors equal to BB', CC', DD' in the direction of A'A"

(5) Join the points $AB'C'D'E'A$ to get the adjusted traverse.

Solution 4:

Contour A *contour* is an imaginary line on the ground joining the points of equal elevation. It is a line in which the surface of ground is intersected by a level surface.

contour line is a line on the map representing a contour. a pond with water at an elevation of 101.00 m as shown in the plan by the water mark. If the water level is now lowered by 1 m, another water mark representing 100.00 m elevation will be obtained. These water marks may be surveyed and represented on the map in the form of contours.

A topographic map presents a clear picture of the surface of the ground. If a map is to a big scale, it shows where the ground is nearly level, where it is sloping, where the slopes are steep and where they are gradual. If a map is to a small scale, it shows the flat country, the hills and valleys, the lakes and water courses and other topographic features.

CONTOUR INTERVAL

The vertical distance between any two consecutive contours is called *contour interval*. The *contour interval* is kept constant for a contour plan, otherwise the general appearance of the map will be misleading. The horizontal distance between two points on two consecutive contours is known as the *horizontal equivalent* and depends upon the steepness of the ground. The choice of proper contour interval depends upon the following considerations:

(*i*) **The nature of the ground**

The contour interval depends upon whether the country is flat or highly undulated. A contour interval chosen for a flat ground will be highly unsuitable for undulated ground. For every flat ground, a small interval is necessary. If the ground is more broken, greater contour interval should be adopted, otherwise the contours will come too close to each other.

(*ii*) **The scale of the map**

The contour interval should be inversely proportional to the scale. If the scale is small, the contour interval should be large. If the scale is large, the contour interval should be small.

(*iii*) **The purpose and extent of the survey**

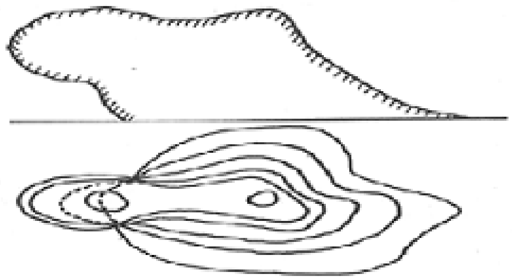
The contour interval largely depends upon the purpose and the extent of the survey. For example, if the survey is intended for detailed design work or for accurate earth work calculations, small contour interval is to be used. The extent of survey in such cases will generally be small. In the case of location surveys, for lines of communications and for reservoir and drainage areas, where the extent of survey is large, a large contour interval is to be used.

(*iv*) **Time and expense of field and office work**

If the time available is less, greater contour interval should be used. If the contour interval is small, greater time will be taken in the field survey, in reduction and in plotting the map.

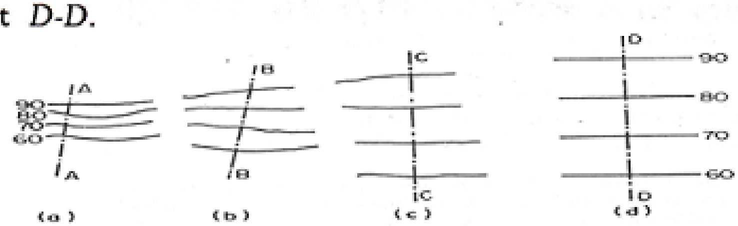
CHARACTERISTICS OF CONTOURS

1. Two contour lines of different elevations cannot cross each other. If they did, the point of intersection would have two different elevations which is absurd. However, contour lines of different elevations can intersect only in the case of an overhanging *cliff* or a cave



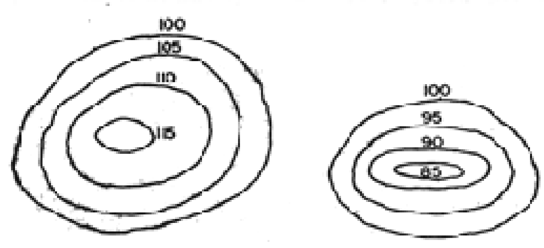
2. Contour lines of different elevations can unite to form one line only in the case of a vertical cliff.

3. Contour lines close together indicate steep slope. They indicate a gentle slope if they are far apart. If they are equally spaced, uniform slope is indicated. A series of straight, parallel and equally spaced contours represent a plane surface. Thus, in Fig. 15.3, steep slope in represented at *A-A*, a gentle slope at *B-B*, a uniform slope at C-C and a plane surface at *D-D*.



4. A contour passing through any point is perpendicular to the line of steepest slope at that point. This agrees with (3), since the perpendicular distance between contour lines is the shortest distance.

5. A closed contour line with one or more higher ones inside it represents a hill similarly, a closed contour line with one or more lower ones inside it indicates a depression without an outlet

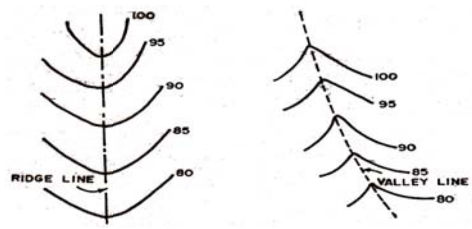


6. To contour lines having the same elevation cannot unite and continue as one line. Similarly, a single contour cannot split into two lines. This is evident because the single line would, otherwise, indicate a knife-edge ridge or depression which does not occur in nature. However, two different contours of the same elevation may approach very near to each other.

7. A contour line must close upon itself, though not necessarily within the limits of the map.

8. Contour lines cross a watershed or ridge line at right angles. They form curves of U-shape round it with the concave side of the curve towards the higher ground

9. Contour lines cross a valley line at right angles. They form sharp curves of V-shape across it with convex side of the curve towards the higher ground



If there is a stream, the contour on either side, turning upstream, may disappear in coincidence with the edge of the stream and cross underneath the water surface.

10. The same contour appears on either sides of a ridge or valley, for the highest horizontal plane that intersects the ridge must cut it on both sides. The same is true of the lower horizontal plane that cuts a valley.

Solution 5:								
Chainage(m)	BS(m)	IS	FS	Rise	Fall	HI	RL	Remarks
0	0.855					100.855	100	BM=100m
20		1.545			-0.69		99.31	
40		2.335			-0.79		98.52	
60		3.115			-0.78		97.74	
80	0.455		3.825		-0.71	97.485	97.03	CP-1
100		1.38			-0.925		96.105	
120		2.055			-0.675		95.43	
140		2.855			-0.8		94.63	
160	0.585		3.455		-0.6	94.615	94.03	CP-2
180		1.015			-0.43		93.6	
200		1.85			-0.835		92.765	
220		2.755			-0.905		91.86	
240			3.845		-1.09		90.77	
Σ	1.895		11.125	0	-9.23			
Checks:								
ΣBS - ΣFS	=	Σrise	-	Σfall	=	LRL	-	FRL
-9.23	=	-9.23			=	-9.23	OK	

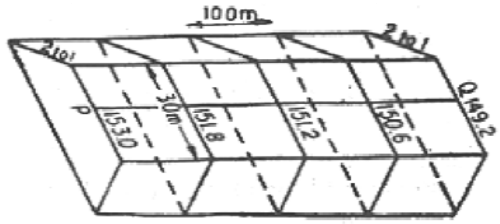
Gradient:The total distance between the starting point and the last point = 260m

Difference in level = -9.23

There fore Down Gradient = 240m/9.23 = 26.002

i.e., 1 In 26.002 or 0.038

Solution 6:



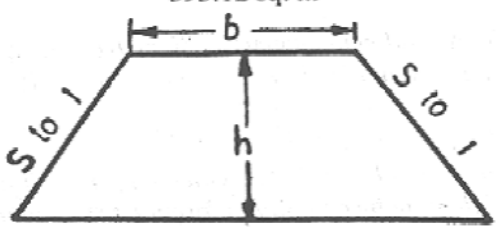
The formation level at $p = 161.4$ m.
Uniform falling gradient is 1 in 50 from P to Q.

$\therefore$ The formation levels at successive cross-sections are obtained by deducting $\frac{1}{50} \times 100 = 2$ m from the level of preceding section.

The formation level at P, 0 m = 161.4 m
The formation level at 100 m = 159.4 m
The formation level at 200 m = 157.4 m
The formation level at 300 m = 155.4 m
The formation level at 400 m = 153.4 m
The depths of the embankment at various sections
= Formation level − Ground level, *i.e.*
The depth at P, 0 m 161.4 − 153.0 = 8.4 m.
The depth at 100 m = 159.4 − 151.8 = 7.6 m
The depth at 200 m = 157.4 − 151.2 = 6.2 m
The depth at 300 m = 155.4 − 150.6 = 4.8 m
The depth at Q, 400 m = 153.4 − 149.2 = 4.2 m

(*i*) Area of cross-section at P, *0* m. (Fig. 9.20)

$$A_0 = (b + sh)\,h$$
$$= (30 + 2 \times 8.4) \times 8.4$$
$$= 46.8 \times 8.4$$
$$= 393.12 \text{ sq. m}$$



(*ii*) Area of cross-section at 100 m

$A_{100} = (b + sh)h \;= (30 + 2 \times 7.6) \times 7.6 = 45.2 \times 7.6$
$= 343.52$ sq. m

(*iii*) Area of cross-section at 200 m

$A_{200} = (b + sh)\,h = (30 + 2 \times 6.2) \times 6.2 = 42{,}4 \times 6.2$
$= 262.88$ sq. m

(*iv*) Area of cross-sections at 300 m

$A_{300} = (b + sh)\,h = (30 + 2 \times 4.8) \times 4.8 = 39.6 \times 4.8$
$= 190.08$ sq. m

(*v*) Area of cross-section at 400 m

$A_{400} = (b + sh)\,h = (30 + 2 \times 4.2) \times 4.2 = 38.4 \times 4.2$
$= 161.28$ sq. m

Applying the Prismoidal formula, we get

$$V = \frac{d}{3}\text{ [Area of first section + 4 times area of even sections.}$$
$$\text{+ 2 times area of odd sections + Area of last section]}$$
$$= \frac{100}{3}\,[393.12 + 2 \times 262.88 + 4\,(343.52 + 190.08) + 161.28]$$
$$= \frac{100}{3}\,[393.12 + 525.76 + 2134.4 + 161.28]$$
$$= 107152 \text{ cubic metres} \quad \textbf{Ans.}$$

Solution 7:

Temporary adjustment of a vernier theodolite consists of following operations:

i. Setting,
ii. Centering,
iii. Levelling
iv. Focusing.

Setting:The setting operation consists of

a. Fixing the theodolite with the tripod stand
b. With approximate leveling and centering over the station.

For setting up the instrument

i. The tripod is placed over the station with its legs widely spread so that the centre of the tripod head lies above the station point and its head approximately level (by eye estimation).
ii. The instrument is then fixed with the tripod by screwing through trivet. The height of the instrument should be such that observer can see through telescope conveniently.

Centering: The operation involved in placing the vertical axis of the instrument exactly over the station mark is known as centering.First, the approximate centering of the instrument is done by moving the tripod legs radially or circumferentially as per need of the circumstances. Note, that due to radial movement of the legs, plumb bob gets shifted in the direction of the movement of the leg without seriously affecting the level of the instrument. On the other hand, when the legs are moved side-ways or circumferentially, the plumb does not shift much but the level gets affected. Sometimes, the instrument and the tripod have to be moved bodily for centering. It must be noted that the centering and leveling of instrument is done recursively.

Levelling: Levelling of an instrument is done to make the vertical axis of the instrument truly vertical.Three leveling screws are present in a theodolite instrument. Leveling is being achieved by carrying out the following steps

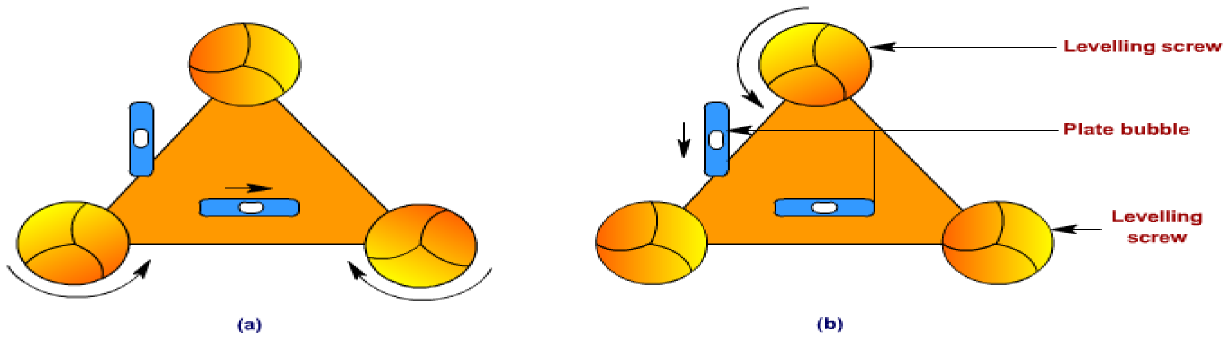
Step 1: Bring one of the level tube parallel to any two of the foot screws, by rotating the upper part of the instrument.

Step 2: The bubble is brought to the centre of the level tube by rotating both the foot screws either inward or outward. The bubble moves in the same direction as the left thumb. [Figure (a)]

Step 3: The bubble of the other level tube is then brought to the centre of the level tube by rotating the third foot screw either inward or outward [Figure (b)]. [In step 1 itself, the other plate level will be parallel to the line joining the third foot screw and the centre of the line joining the previous two foot screws.]

Step 4: Repeat Step 2 and step 3 in the same quadrant till both the bubble remain central.

Step 5: By rotating the upper part of the instrument through 180°, the level tube is brought parallel to first two foot screws in reverse order. The bubble will remain in the centre if the instrument is in permanent adjustment. Otherwise, repeat the whole process starting from step1 to step5.



Operation of Leveling

Focusing: To obtain the clear reading, the image formed by the objective lens should fall in the plane of diaphragm and the focus of eye-piece should also be at the plane of diaphragm. It is Carried out by removing parallax by proper focusing of objective and eye-piece.Focusing operation involves two steps:

a. Focusing of the eye-piece lens
b. Focusing of the objective lens.

Focusing of Eye-piece: The eye-piece is focused to make the appearance of cross hairs distinct and clear.

Focusing of Objective: It is done for each independent observation to bring the image of the object in the plane of cross hairs.

Permanent Adjustments of a Theodolite

The permanent adjustments of a transit theodolite are :

1. Adjustment of the horizontal plate level.
2. Adjustment of the horizontal axis (or trunnion axis).
3. Adjustment of the telescope.
4. Adjustment of the telescope level.
5. Adjustment of the vertical circle index.

1. Adjustment of the horizontal plate level. With this adjustment the axis of the plate levels, is made perpendicular to the vertical axis of the theodolite.

Object. When the plate levels are in perfect adjustment, their bubbles must remain at the centre of their run during a complete revolution of the theodolite in azimuth.

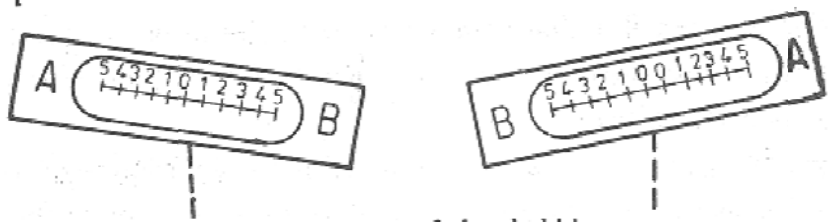
Necessity. For accurate measurement of horizontal and vertical angles, the vertical axis should remain truly vertical.

Test. The following steps are involved.

(1) Set up the theodolite on a firm ground. Clamp the lower plate and turn

the upper plate until the plate level becomes parallel to any pair of foot screws. Bring the bubble to the centre of its run by means of foot screws.

(2) Rotate the instrument about the vertical axis through 180°. The plate level is now again parallel to the same pair of foot screws but with the ends reversed in direction. If the bubble remains central, the vertical axis of the theodolite is perpendicular to the axis of the plate level



Two positions of plate bubble

Adjustment. (1) If the bubble does not remain central, note down the reading of the bubble. It is the apparent error and is twice the actual error of the axis of the plate bubble.

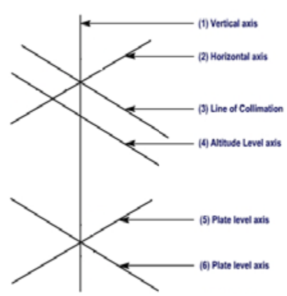
(2) Bring the bubble to the mean position with the help of the same pair of foot-screws.

(3) Remaining half of the correction is corrected by means of the capstan headed screw provided at the end of the level tube.

(4) Repeat the test and adjustment until the bubble remains central at its run during a full rotation of the instrument in azimuth.

The fundamental lines are imagined in a theodolite instrument (Figure) are

a. Vertical Axis
b. Horizontal axis
c. Line of collimation
d. Axis of the altitude level tube
e. Axis of the plate level



Fundamental lines of a Theodolite and their Relationship

Relations among Fundamental Lines

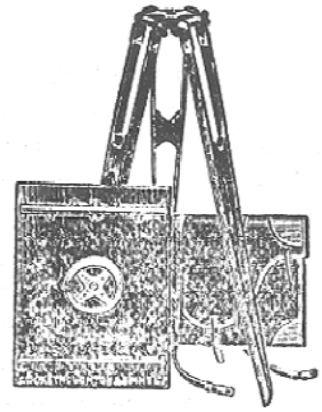
In a perfectly adjusted instrument, the fundamental lines bear relations Figure as follows:

a. The vertical cross hair should lie in a plane perpendicular to the horizontal axis .
b. The axis of each plate level should lie in a plane perpendicular to the vertical axis
c. The horizontal axis should be perpendicular to the vertical axis .
d. The axis of the telescope level should be parallel to the line of sight
e. The line of sight should be perpendicular to the horizontal axis at its intersection with the vertical axis .

Solution 8:

The following instuments are used in plane table survey :

1. The plane table with levelling head having arrangements for (*a*) levelling, (*b*) rotation about vertical axis, and (*c*) clamping in any required position.
2. Alidade for sighting
3. Plumbing fork and plumb bob.
4. Spirit level.
5. Compass.
6. Drawing paper with a rainproof cover.



1. The Plane Table : Three distinct types of tables (board and tripod) having devices for levelling the plane table and controlling its orientation are in common use : the *Traverse* Table, the *Johnson* Table and the *Coast Survey* Table.

The Traverse Table

The traverse table consists of a small drawing board mounted on a light tripod in such a way that the board can be rotated about the vertical axis and can be clamped in any position. The table is levelled by adjusting tripod legs, usually by eye-estimation.

Johnson Table

This consists of a drawing board usually 45×60 cm or 60×75 cm. The head consists of a ball-and-socket joint and a vertical spindle with two thumb screws on the underside.

The ball-and-socket joint is operated by the upper thumb screw. When the upper screw is free, the table may be tilted about the ball-and-socket for levelling. The clamp is then tightened to fix the board in a horizontal position. When the lower screw is loosened, the table may be rotated about the vertical axis and can thus be oriented.

The Coast Survey Table

The table is superior to the above two types and is generally used for work of high precision. The levelling of the table is done very accurately with the help of the three foot screws. The table can be turned about the vertical axis and can be fixed in any direction very accurately with the help of a clamp and tangent screw.

2. Alidade

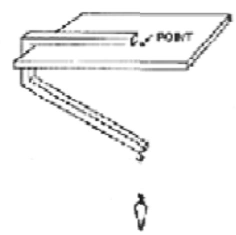
A plane table alidade is a straight edge with some form of sighting device. Two types are used : Plain alidade and telescopic alidade.

Plain Alidade. Fig. shows the simple form and used for ordinary work. It generally consist of a metal or wooden rule with two vanes at the ends. The two vanes or sights are hinged to fold down on the rule when the alidade is not in use. One of the vanes is provided with a narrow slit while the other is open and carries a hair or thin wire. Both the slits thus provide a definite line of sight which can be made to pass through the object to be sighted. The alidade can be rotated about the point representing the instrument station on the sheet so that the line of sight passes through the object to be sighted. A line is then drawn against the working edge (known as the *fiducial edge*) of the alidade. It is essential to have the vanes perpendicular be the surface of the sheet. The alidade is not very much suitable on hilly area since the inclination of the line of sight is limited. A string joining the tops of the two vanes is sometimes provided to use it when sights of considerable inclination have to be taken.

Telescopic Alidade. The telescopic alidade is used when it is required to take inlined sights. Also the accuracy and range of sights are increased by its use. It essentially consists of a small telescope with a level tube and graduated arc mounted on horizontal axis. The horizontal axis rests on a A-frame fitted with verniers fixed in position in the same manner as that in a transit. All the parts are finally supported on a heavy rule, one side of which is used as the working edge along which line may be drawn. The inclination of the line of sight can be read on the vertical circle. The horizontal distance between the instrument and the point sighted can be computed by taking stadia readings on the staff kept at the point. The elevation of the point can also be computed by using usual tacheometric relations. Sometimes, to facilitate calculation work, a Beaman stadia are may be provided as an extra. Thus, the observer can very quickly and easily obtain the true horizontal distance from the plane table to a levelling staff placed at the point and the differnce in elevation between them. The same geometric principle apply to the alidade as to the transit, but the adjustments are somewhat modified in accordance with the lower degree of accuracy required.

3. Plumbing Fork

The plumbing fork used in large scale work, is meant for centring the table over the point or station occupied by the plane table when the plotted position of that point is already known on the sheet. Also. in the beginning of the work. it is meant for transferring the ground point on to the sheet so that the plotted point and the ground station are in the same vertical line. The fork consists of a hair pin-shaped light metal frame having arms of equal length, in which a plumb-bob is suspended from the end of the lower- arm. The fitting can be placed with the upper arm lying on the top of the table and the lower arm below it, the table being centred when the plumb-bob hangs freely over the ground mark and the pointed end of the upper arm coincides with the equivalent point on the plan.



4. Spirit Level : A small spirit level may be used for ascertaining if the table is properly level. The level may be either of the tubular variety or of the circular type, essentially with a flat base so that it can be laid on the table and is truly level when the bubble is central. The table is levelled by placing the level on the board in two positions at right angles and getting the bubble central in both positions.

5. Compass : The compass is used for orienting the plane table to magnetic north. The compass used with a plane table is a trough compass in which the longer sides of the trough are parallel and flat so that either side can be used as a ruler or laid down to coincide with a straight line drawn on the paper.

6. Drawing Paper : The drawing paper used for plane tabling must be of superior quality so that it may have minimum effect of changes in the humidity of the atmosphere. The changes in the humidity of the atmosphere produces expansion and contraction in different directions and thus alter the scale and distort the map. To overcome this difficulty, sometimes two sheets are mounted with their grains at right angles and with a sheet of muslin between them. Single sheet must be seasoned previous of the use by exposing it alternatively to a damp and a dry atmosphere. For work of high precision, fibre glass sheets or paper backed with sheet aluminium are often used.

Solution 9:

Three operations are needed

(*a*) *Fixing* : Fixing the table to the tripod.

(*b*) *Setting* : (*i*) Levelling the table

(*ii*) Centring

(*iii*) Orientation.

(*c*) *Sighting the points.*

Levelling : For small-scale work, levelling is done by estimation. For work of accuracy, an ordinary spirit level may be used. The table is levelled by placing the level on the board in two positions at right angles and getting the bubble central in both directions. For more precise work, a Johnson Table or Coast Survey Table may be used.

Centring : The table should be so placed over the station on the ground that the point plotted on the sheet corresponding to the station occupied should be exactly over the station on the ground. The operation is known as centring the plane table. As already described this is done by using a plumbing fork.

Orientation : Orientation is the process of putting the plane-table into some fixed direction so that line representing a certain direction on the plane is parallel to that direction on the ground. *This is essential condition to be fulfilled when more than one instrument station is to be used.* If orientaion is not done, the table will not be parallel to itself at different positions resulting in an overall distortion of the map. The processes of centring and orientaion are dependent on each other. For orientation, the table will have to be rotated about its vertical axis, thus disturbing the centring. If precise work requires that the plotted point should be exactly over the ground point, repeated orientation and shifting of the whole table are necessary.

There are two main methods of orienting the plane table :

(*i*) Orientation by means of trough compass.

(*ii*) Orientaiton by means of backsighting.

(*i*) ***Orientation by trough compass***

The compass, though less accurate, often proves a valuable adjunct in enabling the rapid approximate orientation to be made prior to the final adjustment. The plane table can be oriented by compass under the following conditions :

(*a*) When speed is more important that accuracy.

(*b*) When there is no second point available for orientation.

(*c*) When the traverse is so long that accumulated errors in carrying the azimuth forward might be greater than orientation by compass.

(*d*) For approximate orientation prior to final adjustment

(*e*) In certain resection problems.

For orientation, the compass is so placed on the plane table that the needle floats centrally, and a fine pencil line is ruled against the long side of the box. At any other station, where the table is to be oriented, the compass is placed against this line and the table is oriented by turning it until the needle floats centrally. The table is then clamped in position.

Orientation by back sighting

Orientation can be done precisely by sighting the points already plotted on the sheet. Two cases may arise :

(*a*) When it is possible to set the plane table on the point already plotted on the sheet by way of observation from previous station.

(*b*) When it is not possible to set the plane table on the point.

Case (*b*) presents a problem of *Resection.* When conditions are as indicated in (*a*), the orientation is said to be done by *back sighting.*

To orient the table at the next station, say *B*, represented on the paper by a point *b* plotted by means of line *ab* drawn from a previous station *A*, the alidade is kept on the line *ba* and the table is turned about its vertical axis in such a way that the line of sight passes through the ground station *A*. When this is achieved, the plotted line *ab* will be coinciding with the ground line *AB* (provided the centring is perfect) and the table will be oriented. The table is then clamped in position.

The method is equivalent to that employed in azimuth traversing with the transit. Greater precision is obtainable than with the compass, but an error in direction of a line is transferred to succeeding lines.

Solution 10:

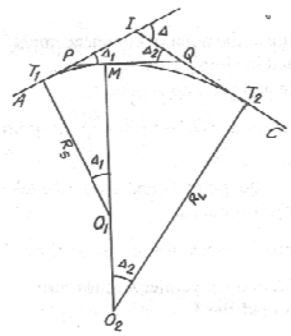
The angle of deflection Δ = Bearing of IC – Bearing of AI

$= 132^\circ - 60^\circ = 72^\circ$

The angle of deflection of the first arc

Δ_1 = Bearing of PQ – Bearing of AI

$= 112 - 60^\circ = 52^\circ$.



$\therefore \quad \Delta_2 = \Delta - \Delta_1 = 72^\circ - 52^\circ = 20^\circ$

Also $\quad R_s = 200$ m ; $R_L = 250$ m. (Given)

The problem refers to Case I.

Substituting the values in Eqn. (16.4), we get

$$T_S = R_S \tan \frac{\Delta_1}{2} + \left(R_S \tan \frac{\Delta_1}{2} + R_L \tan \frac{\Delta_2}{2} \right) \frac{\sin \Delta_2}{\sin \Delta}$$

$$= 200 \tan 26^\circ + (200 \tan 26^\circ + 250 \tan 10^\circ) \frac{\sin 20^\circ}{\sin 72^\circ}$$

$$= 200 \times 0.487733 + (200 \times 0.487733 + 250 \times 0.176327) \times \frac{0.34202}{0.951056}$$

$$= 97.547 + (97.547 + 44.082)\ 0.3596213$$

$$= 97.547 + 50.933$$

$$= 148.48 \text{ m.} \quad \textbf{Ans.}$$

Length of the first arc $= \dfrac{\pi R_S \Delta_1}{180^\circ}$

$= \dfrac{\pi \times 200 \times 52^\circ}{180^\circ}$

$= 181.51$ m

Length of the second arc $= \dfrac{\pi R_L \Delta_2}{180^\circ}$

$= \dfrac{\pi \times 250 \times 20^\circ}{180^\circ} = 87.27$ m

Chainage of point of commencement

= Chainage of point of intersection – T_S

= 1000 – 148.48

= 851.52 m

Chainage of point of double curvature

= Chainage of point of commencement

+ length of the first arc

= 851.52 + 181.51 = 1033.03 m

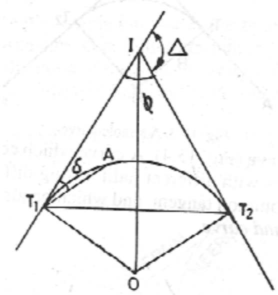
Chainage of the point of tangency

= Chainage of point of double curvature

+length of the second arc

= 1033.03 + 87.27 = 1120.30 m. **Ans.**

Solution 11:



Elements of a curve.

Point of intersection. The point *I* where back tangent when produced forward and the forward tangent when produced backward meet, is called the *point of intersection.*

Angle of Deflection. The angle through which forward tangent deflects, is called *angle of deflection* of the curve. It may be either to the right or to the left.

Long chord. The chord joining the point of the commencement and point of tangency, is called *long chord.*