AU-5029
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INSTITUTE OF TECHNOLOGY
DEPARTMENT OF CIVIL ENGINEERING
B.TECH 2nd YEAR, IIIrd SEMESTER
SUBJECT: SURVEYING-I
COURSE CODE: 21CE02T
Max Marks: 60

Instruction:

(i) All Questions of Section-A are compulsory and carry 2 marks each.
(ii) Attempt any two Questions from each unit of Section-B, carry 8 marks each.
(iii) Draw sketches if necessary.
(iv) Assume suitable data if missing and mention it clearly.

SECTION-A

(i) Give conventional signs for the following:
Ans. a) Bench Mark

b) Building

c) Temple

d) Stream single line

(ii) Define Isogonic lines.
Ans. The imaginary lines joining the places of equal declination either positive or negative, on the surface of the earth, are called Isogonic lines.

(iii) Define Bench-Mark.
Ans. A relatively permanent and fixed reference point of known elevation above the assumed datum, is called a Bench mark.

(iv) Why the horizontal equivalent is not constant?
Ans. Horizontal equivalent is the horizontal distance between any two consecutive contours.
Depending on the steepness or plain nature of the ground the horizontal equivalent depends.
For steeper slope the horizontal equivalent is less than a plain ground for the same difference in elevation. As the slope of the ground between two contour is not constant in all

directions, the horizontal equivalent is not constant.

(v) To the sum of the first and last ordinates, add twice the sum of the remaining odd ordinates and four times the sum of all the even ordinates. The total sum thus obtained is multiplied by one-third of the common distance between the ordinates and the result gives the required area. This rule of finding the area is called _______.

Ans. (d) Simpson's rule

(vi) The error due to ______________ is eliminated by making observations on both the faces and taking the mean value, during the angles measured by the method of repetition.

Ans. (b) Imperfect adjustment of the line of collimation and the trunnion axis.

(vii) Plumbing fork is used for accurate _____________.

Ans. (c) Centering.

(viii) The type of surveying which requires least office work is ___________.

Ans. (c) Plane table surveying.

(ix) When a chord is shorter than normal chord, it is called ________.

Ans. (b) Sub chord.

(x) A curve of varying radius introduced between a straight and a circular curve, is called ____________ curve.

Ans. (d) Transition.

SECTION-B

UNIT-1

2. A closed compass traverse ABCD was conducted round a lake and the following bearings were obtained. Determine which of the stations are suffering from local attraction and give the values of the corrected bearings:

LINE	F.B.	B.B
AB	74^0 20'	256^0 0'
BC	107^0 20'	286^0 20'
CD	224^0 50'	44^0 50'
DA	306^0 40'	126^0 0'

Ans.

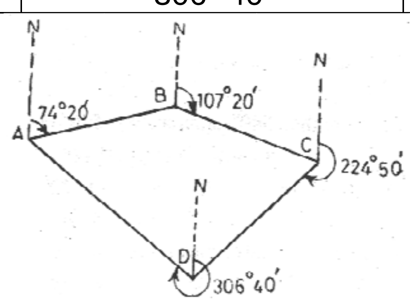


Fig.

On examination we find that fore and back bearings of *CD* differ exactly by 180°. Hence, stations *C* and *D* are free from local attraction. Stations affected by local attraction are *A* and *B*.

Calculation of included angles :

Interior angle at A = bearing of AD -bearing of AB

$= 126° 00' - .74° 20' = 51° 40'$

Exterior angle $A = 360° - 51° 40' = 308' 20'$

Interior angle at B = bearing of BA -bearing of BC

$= 256° 0' - 107° 20' = 148° 40'$

$\therefore$ Exterior angle at $B = 360° 0' - 148° 40' = 211° 20'$

Interior angle at C = bearing of CB -bearing of CD

$= 286° 20' - 224° 50' = 61° 30'$

$\therefore$ Exterior angle at $C = 360° 00' - 61° 30' = 298° 30'$

Exterior angle D = bearing of DA - bearing of DC

$= 306° 40' - 44° 50' = 261° 50'$

Check : Sum of exterior angles of the quadrilateral $ABCD$ $(2 \times 4 + 4) = 12$ right angles. O.K.

Total sum of exterior angles

$= 308° 20' + 211° 20' + 298° 30' + 261° 50'$

$= 1080° = 12$ right angles. O.K.

Calculation of bearings :

Bearing of CD	$= 224° 50'$ (given)
Add traverse angle at D =	$+ 261° 50'$
Sum =	$486° 40'$
Sum is more than 180°, subtract	$= - 180° 00'$
$\therefore$ Bearing of DA =	$306° 40'$
Add traverse angle at A =	$+ 308° 20'$
	$= 615° 00'$
Sum is more than 540°, subtract =	$- 540° 00'$
$\therefore$ Bearing of AB =	$75° 00'$
Add traverse angle at B	$+ 211° 20'$
Sum =	$286° 20'$
Sum is more than 180°, subtract	$- 180° 00'$
$\therefore$ Bearing of BC =	$106° 20'$
Add traverse angle at C	$+ 298° 30'$
Sum	$= 404° 50'$
Sum is more than 180°, subtract	$- 180° 00'$
$\therefore$ Bearing of CD =	$224° 50'$ checked

Result : Corrected bearings of the lines are :

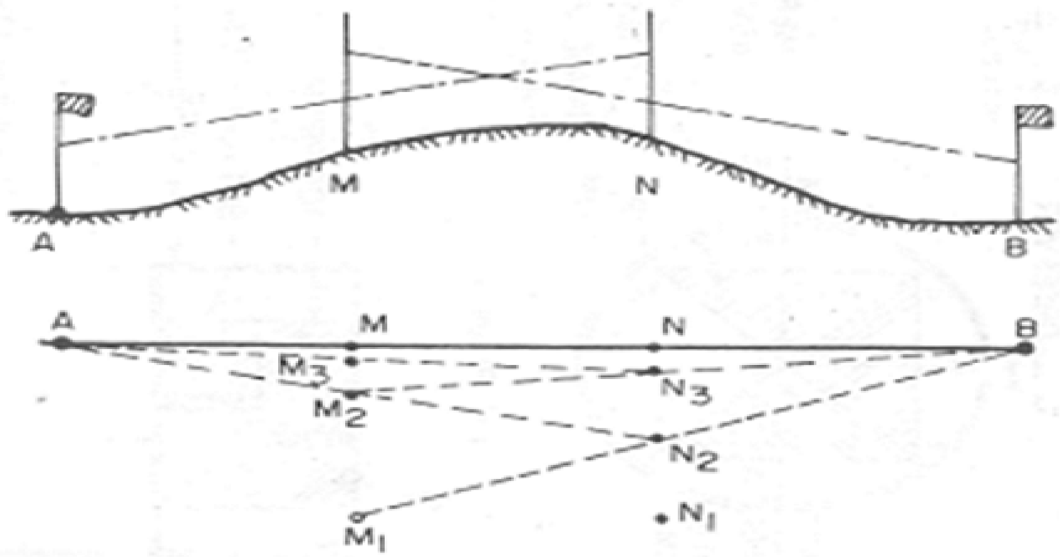
Side	FB	BB
AB	75° 00'	255° 0'
BC	106° 20'	186° 20'
CD	224° 50'	44° 50'
DA	306° 40'	126° 40'

3. What is ranging? Describe how you would range a survey line between two points which are not intervisible due to an intervening raised ground with the help of sketch.

Ans. The process of marking a number of intermediate points on a survey line joining two stations in the field so that the length between them may be measured correctly, is called ranging.

(ii) INDIRECT OR RECIPROCAL RANGING

Indirect or Reciprocal ranging is resorted to when both the ends of the survey line are *not intervisible* either due to high intervening



ground or due to long distance between them. In such a case, ranging is done indirectly by selecting two intermediate points M_1 and N_1 very near to the chain line (by judgement) in such a way that from M_1, both N_1 and B are visible and from N_1, both M_1 and A are visible.

Two surveyors station themselves at M_1 and N_1 with ranging rods. The person at M_1 then directs the person at N_1 to move to a new position N_2 in line with M_1B. The person at N_2 then directs the person at M_1 to move to a new position M_2 in line with N_2A. Thus, the two persons are now at M_2 and N_2 which are nearer to the chain line than the positions M_1 and N_1. The process is repeated till the points M and N are located in such a way that the person at M finds the person at N in line with MB, and the person at N finds the person at M in line with NA. After having established M and N, other points can be fixed by direct ranging.

4. The bearings of the sides of a closed transverse ABCDEA are as follows:

Side	F.B.	B.B
AB	107^o 15’	287^o 15’
BC	22^o 00’	202^o 00’
CD	281^o 30’	101^o 20’
DE	181^o 15’	1^o 15’
EA	124^o 45’	304^o 45’

Compute the interior angles of the traverse and exercise necessary checks.

Ans. (*i*) The included angle A = The difference in bearings of AB and AE.

As the bearing of AB is less than that of AB, add 360^o.

$\therefore$ Included angle A

$= 107^o\,15' + 360^o - 304^o\,45' = 162^o\,30'$. **Ans.**

(*ii*) The included angle at B:

The difference in bearings of BC and BA

$= 22^o\,00' + 360^o - 287^o\,15'$

$\therefore$ Included angle

$B = 94^o\,45'$. **Ans.**

(*iii*) The included angle at C:

The difference in bearings of CD and CB

$= 281^o\,30' - 202^o00' = 79^o\,30'$

$\therefore$ Included angle

$C = 79^o\,30'$. **Ans.**

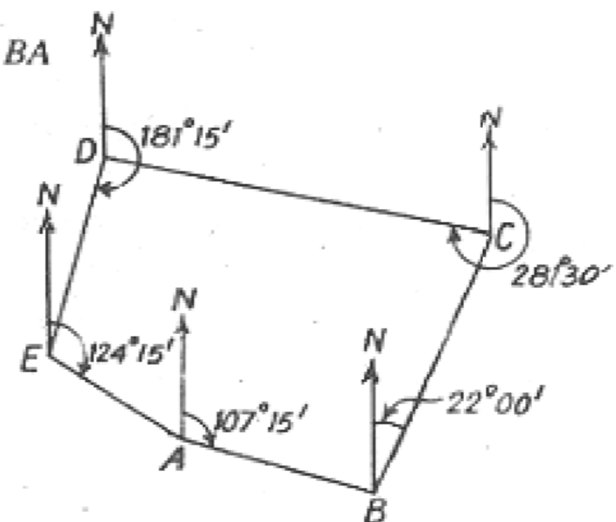


Fig.

(*iv*) The included angle at D:

The difference in bearings of DE and $DC = 181^o\,15' - 101^o\,30'$

$= 79^o\,45'$

$\therefore$ Included angle $D = 79^o\,45'$. **Ans.**

(*v*) The included angle at E:

The difference in bearings of EA and $ED = 124^o\,45' - 1^o\,15'$

$= 123^o\,30'$

$\therefore$ Included angle $E = 123^o\,30'$. **Ans.**

Check:

Sum of the included angles of a pentagon

$= (2 \times 5 - 4) = 6$ right angles.

And, sum of the included angles $A + B + C + D + E$

$= 162^o\,30' + 94^o\,45' + 79^o\,30' + 79^o\,45' + 123^o\,30'$

$= 540^o\,00'$ or 6 right angles O.K..

UNIT-2

5. What do you understand by interpolation of contours? Explain their importance in location of a hill road.

Ans. The process of drawing contours proportionately between the plotted ground points or in between plotted contours, is known as interpolation of contours. Interpolation of contours between points is done assuming that the slope of the ground between any two points is uniform. It may be done by one of the following methods:

i. Estimation
ii. Arithmetical calculation
iii. Graphical method

6. During fly levelling, the following note is made:

B.S. = 0.62, 2.05, 1.42, 2.63 and 2.42 metres
F.S. = 2.44, 1.35, 0.53 and 2.41 metres

The first B.S. was taken on a B.M. with R.L. 100.00 m. From the last B.S., it is required to set 4 pegs each at a distance of 30 metres on a rising gradient of 1 in 200.

a. Enter these notes in a form of level book.
b. Calculate the R.L. of the top of each peg by Rise and Fall method.
c. Also, calculate the staff readings on each peg and apply the usual checks.

Ans.

Stn.	*B.S.*	*F.S.*	*F.S.*	*Rise*	*Fall*	*R.L.*	*Remarks*
1.	0.62					100.00	B.M.
2.	2.05		2.44		1.82	98.18	C.P.
3.	1.42		1.35	0.70		98.88	C.P.
4.	2.63		0.53	0.89		99.77	C.P.
5.	2.42		2.41	0.22		99.99	C.P.
6.		2.27		0.15		100.14	1st peg
7.		2.12		0.15		100.29	2nd peg
8.		1.97		0.15		100.44	3th peg
9.			1.82	0.15		100.59	4th peg
Total	9.14		8.55	2.41	1.82		

Arithmetic checks :

Σ B.S. $-$ Σ F.S. $= 9.14 - 8.55 = 0.59$

Σ Rise $-$ Σ Fall $= 2.41 - 1.82 = 0.59$

Last R.L. - First R.L. = 100.59-100.00 = 0.59.

Explanation. The difference in level between two consecutive pegs =

$$\frac{d}{r} = \frac{30}{200} = 0.15 \text{ m}$$

Staff reading of the 1st peg $= 99.99 + 0.15 = 100.14$ m

Staff reading of the 2nd peg $= 100.14 + 0.15 = 100.29$ m.

Staff reading of the 3rd peg $= 100.29 + 0.15 = 100.44$ m.

staff reading of the 4th peg $= 100.44 + 0.15 = 100.59$ m.

7. What do you understand by indirect method of contouring? Explain each type of indirect method of contouring in brief with sketch.

Ans.

Indirect Method

In this method sufficient number of points are given spot levels. The locations of such points can be conveniently plotted on a plane table section as these generally form the corners of well, shaped geometrical figures *i.e.* squares, rectangles, triangles, etc. It is seldom possible to have exact spot level of any point on exact value of the contour. The spot levels of important features which represent hill tops, ridge lines, beds of streams and lowest points of the depression are also taken, to depict their correct features while drawing contour lines. The contours in between spot levels are interpolated and drawn. This method of contouring is sometimes known as *Contouring by spot levels.*

Indirect method of contouring is commonly employed in small scale surveys of extensive aseas. This method is cheaper, quicker and less tedious as compared with direct method of contouring.

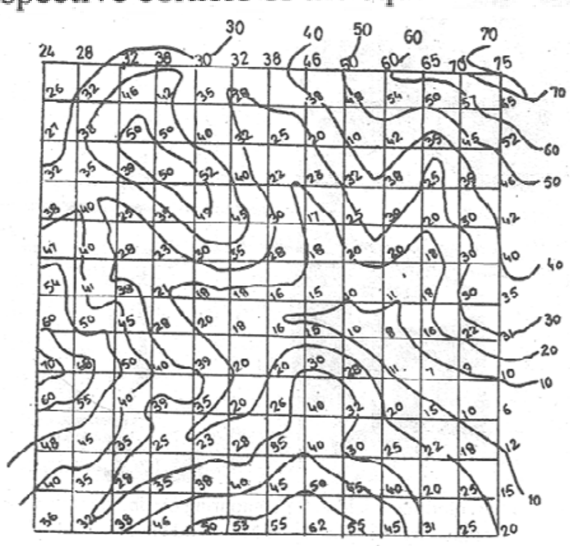
Indirect method of contouring can be employed in three different ways detailed below :

(*i*) By squares method.

(*ii*) By cross sections method.

(*iii*) By tacheometric method.

1. **By Square Method.** In this method, the entire area is divided into a number of squares, the sides of which may vary from 5 m to 25 m, depending upon the nature of the ground, the contour interval and the scale of the plan. The squares may not be of the same size throughout but may vary according to the requirements of the map. The corners of the squares are marked on the ground and spot levels of these points, are given with a level by normal method of levelling. Special care is to be taken to give spot levels to the salient features of the ground such as hill tops, deepest point of the depressions, etc. and their measurements from respective corners of the squares noted.

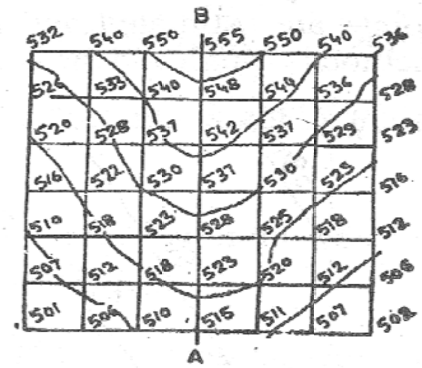


Locating contours by method of squares.

The squares are plotted on the desired scale of the plan and reduced levels of the corners as well as that of the salient features are entered. The contours of desired values are then interpolated.

Suitability. This method is suitable in low undulations without any vegetative covers.

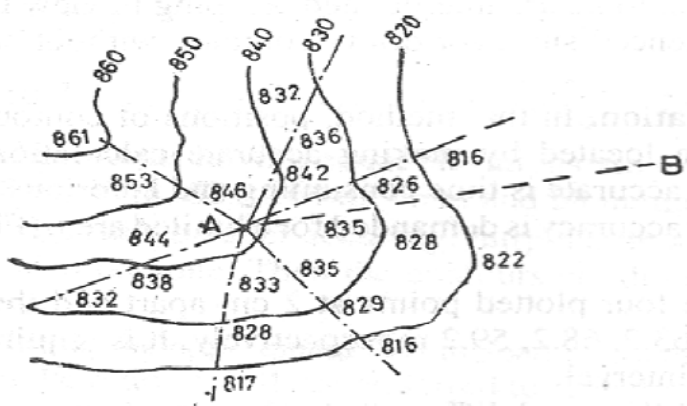
2. **By Cross Section Method.** In this method, cross sections perpendicular to the centre line of the area are set out. The spacing of the cross-section depends upon the contour interval, scale of the plan and the characteristics of the ground. In general, spacing of cross-sections at 20 m in hilly country and 100 m in flat country are adopted. Points of salient features along the centre line and on cross-sections are also located. The layout of the cross-sections need not necessarily be at right angles to the centre line. These may be inclined at suitable angles to the centre if found necessary. First plot the centre line and cross-sections on the desired scale and enter their reduced levels. The contours are then interpolated with respect to these reduced levels.



Locating contours by method of cross-section.

Suitability. This method is suitable for preparing a contour plan of a road, railway or canal alignment.

3. **By Tacheometric Method.** In this method a number of radial lines at known angular interval, are drawn on the ground and the positions of the points at equal distances are marked. Salient points of the ground are also located in the field by observing the vertical angles and the staff readings of the bottom, middle and top wires. Calculations of the reduced levels and the horizontal distances of the points from the instrument position, are done using the tacheometric formulae. . The radial lines, and the positions of the points on each line, are plotted on the desired scale and their spot levels entered. Now interpolation of required contours can be done with respect to the spot levels.



Locating contours by tacheometric method.

Similarly, the instrument is set up at other commanding tacheometric stations such as *B, C, D,* etc. and the entire area is covered.

Suitability. This method is suitable for contouring the area of long strips with mountaneous/undulations where direct chaining is difficult.

8. A road embankment 35m wide at formation level with side slopes 1:1 and with average height of 12 m is constructed with an average gradient 1 in 30 from contour 140 m to 580 m. The ground has an average slope of 12 to 1 in direction transverse to centre line. Calculate (i) Length of the road; (ii) Volume of the embankment.

Ans.

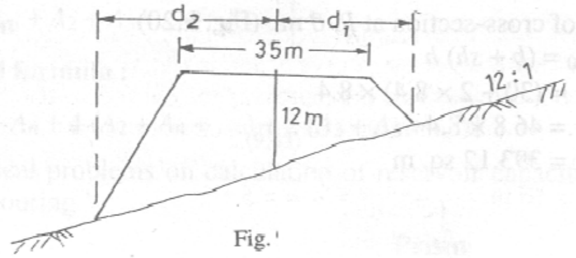


Fig.

(*i*) Difference in elevation = 580 − 140 = 440 m.
For 1 m rise, the length = 30 m

∴ 440 m rise, the length = 30 × 440 = 13200 m

∴ The road length = 13.2 km. **Ans.**

Formation width = 35 m
Side slope $s = 1$
Transverse slope $n = 12$
Average height of embankment = 12 m.

$$d_1 = \left(h + \frac{b}{2s}\right)\left(\frac{ns}{n+s}\right)$$

$$= \left(12 + \frac{35}{2\times 1}\right)\left(\frac{12\times 1}{12+1}\right)$$

$$= \left(\frac{59}{2}\right)\left(\frac{12}{13}\right) = 29.5 \times \frac{12}{13}$$

$$d_2 = \left(h + \frac{b}{2s}\right)\left(\frac{ns}{n-s}\right)$$

$$= \left(12 + \frac{35}{2\times 1}\right)\left(\frac{12\times 1}{12-1}\right)$$

$$= 29.5 \times \frac{12}{11}$$

∴ Average of cross-section $= \dfrac{d_1 d_2}{S} - \dfrac{b_2}{4s}$

$$= 29.5 \times \frac{12}{13} \times 29.5 \times \frac{12}{11} \times \frac{I}{1} - \frac{35^2}{4\times 1}$$

$$= \frac{29.5^2 \times 12^2}{143} - \frac{35^2}{4}$$

$$= 876.33566 - 306.25$$

$$= 570.08566 \text{ m}^2$$

∴ The volume of embankment

$$= 570.08566 \times 13200$$

$$= 7525130.7 \text{ m}^3$$ **Ans.**

9. What is meant by face left and face right of a theodolite? How would you change face? What instrumental errors are eliminated by face right and face left observation?

Ans. Face left: When the vertical circle is on the left of the telescope at the time of observations, the observations of the angles are known as face left.

Face right: When the vertical circle is on the right of the telescope at the time of observations, the observations of the angles are known as face right.

Change face: It is the operation of changing the face of the telescope from left to right and vice versa.

The imperfect adjustment of the line of collimation and the trunnion axis, this error is eliminated by making observations on both faces and taking mean value.

10. A railway embankment is 9 m wide at formation level, with side slope of 2 to 1. Assuming the ground to be level transversely, Calculate the volume of the embankment in cubic metres in a length of 180 m, the centre heights at 30 m intervals being 0.6, 0.8, 1.5, 1.8, 0.75, 0.3 and 0.67 m respectively. Use Trapezoidal method.

Ans.

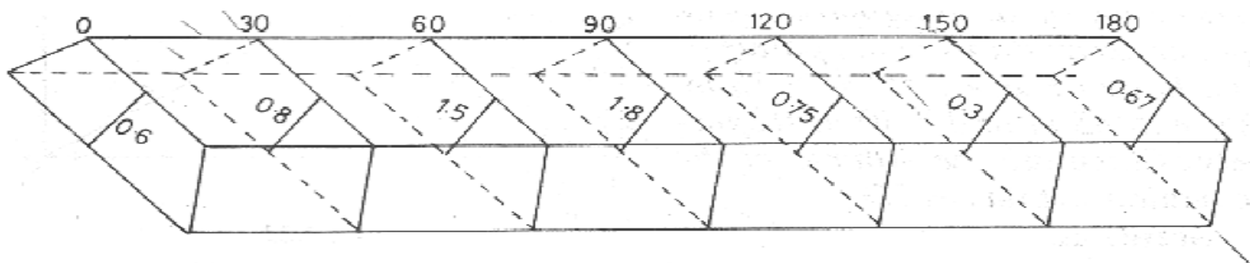


Fig.

1. Area of cross section at 0 m $= (b + sh)\, h$
$= (9 + 2 \times 0.6)\, 0.6 = 6.12 \text{ m}^2$
2. Area of Cross section at 30 m $= (9 + 2 \times 0.8)\, 0.8 = 8.48 \text{ m}^2$
3. Area of Cross section at 60 m $= (9 + 2 \times 1.5)\, 1.5 = 18.0 \text{ m}^2$
4. Area of Cross section at 90 m $= (9 + 2 \times 1.8) 1.8 = 22.68 \text{ m}^2$
5. Area of Cross section at 120 m $= (9 + 2 \times 0.75)\, 0.75 = 7.875 \text{ m}^2$
6. Area of Cross section at 150 m $= (9 + 2 \times 0.3)\, 0.3 = 2.88 \text{ m}^2$
7. Area of Cross section at 180 m $= (9 + 2 \times 0.67) 0.67 = 6.928 \text{ m}^2$

∴ Volume of the embankment by Traperzoidal method.

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

$$= 30\left[\frac{6.12 + 6.928}{2} + 8.48 + 18.0 + 22.68 + 7.88 + 2.88\right]$$

$$= 1993.35 \text{ m}^3$$ **Ans.**

UNIT-4

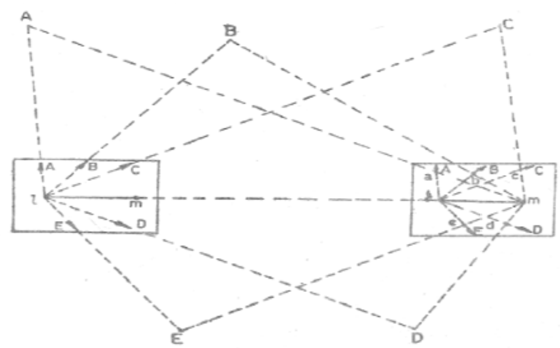
11. Describe with neat sketch, the method of intersection used in plane table survey. When it is used?

Ans. **Intersection Method**:-

When the location of an object is obtained on the sheet of paper by the intersection of the rays drawn after sighting at the object from two plane table stations (previously plotted), it is called intersection method.

The method is suitable when the distance between the point and the instrument station is either too large or cannot be measured accurately due to some field conditions as in case of mountainous country. It is also employed for filling up details, locating distant and inaccessible object, locating the broken boundaries as in the case of rivers etc. The method can also be used for checking of plotted points.

The line joining the two instrument stations is known as the base line. No linear measurement other than the base line is made.



Procedure:

1) Select two points L and M in such a way so that all the points to be plotted are visible from them. Now set the table at station, point L in such a position so that the sheet should cover all the points. Level the table and clamp it.
2) Draw the north line in the top corner of sheet by means of trough compass.
3) Now transfer the position of station point L on the sheet as 'l' with the help of plumbing fork so that it is vertically above the instrument station.
4) With the alidade pivoted about 'l' sight the ranging rod fixed at station point M and draw the line in the direction of M. Now measure the distance LM by means of the tape and cut off lm to some suitable scale along the ray drawn toward M; thus fixing the position of 'm' on the sheet corresponding to station point M on the ground. The line lm is called the base line.
5) With the alidade touching the point 'l' sight the objects in the field such as A,B,C,D,E etc. as shown in figure and draw the rays towards them. The direction of each line is marked with an arrow and a letter A, B, C, D, E etc. corresponding to above details.
6) Now shift the table to the station point M and approximately set it in the line with ML. Set it up so that the point 'm' is vertically above the station point 'M' and level it.
7) Orient the table roughly by compass, then finally by placing the alidade along ml and bisecting the ranging rod fixed at station point 'L' i.e by back sighting 'L'. Clamp the table in this position.
8) With the alidade centered at m sight the same object in the field such as A, B, C, D, E etc; and draw rays. The intersection of these rays with the respective rays from l locate the object A,B,C,D,E etc; as a ,b ,c ,d , e etc; on the sheet.

12. Write the statement for three point problem. What are the different methods to solve it? Explain any one method stepwise with sketch.

Ans. "Finding the location of the station occupied by a plane table on the sheet, by means of sighting to three well defined points whose locations have previously ben plotted on the sheet, is known as three point problem".

The different methods to solve it are:

a. Mechanical method or tracing paper method.
b. Graphical method
c. Trial and error method

Mechanical method or tracing paper method:

Let ABC are the three well defined points on the field. The well defined points are plotted on the drawing sheet using suitable scale.

1. Set up the plane table on the station P. Orient it roughly with the help of a magnetic compass or by eye adjustment so that ab parallel to AB.

2. Fix a tracing paper large enough to include the locations of all the four points on the sheet.

3. Mark a point p' on the tracing paper to represent the instrument position P with the help of plumbing fork.

4. Pivoting the alidade about p', sight A, B, C in turn and draw rays, p'a', p'b' and p'c' on the tracing paper. These lines will not pass through a, b and c as the orientation is approximate or rough.

5. Now loose the tracing paper and rotate it on the drawing paper in such a way that lines p'a', p'b' and p'c' are made to pass through the plotted locations a, b and c respectively. Transfer p' on to the sheet and represent it as p. Remove the tracing paper and join pa, pb and pc.

6. Keep the alidade on pa. The line of sight will not pass through A as the orientation has not yet been corrected. To correct the orientation, loose the clamp and rotate the plane table so that the line of sight passes through A. Clamp the table. The table is thus oriented.

7. To test the orientation, keep the alidade along pb. If the orientation is correct, the line of sight is pass through B. Similarly, the line of sight will pass through C when the alidade is kept on pc.

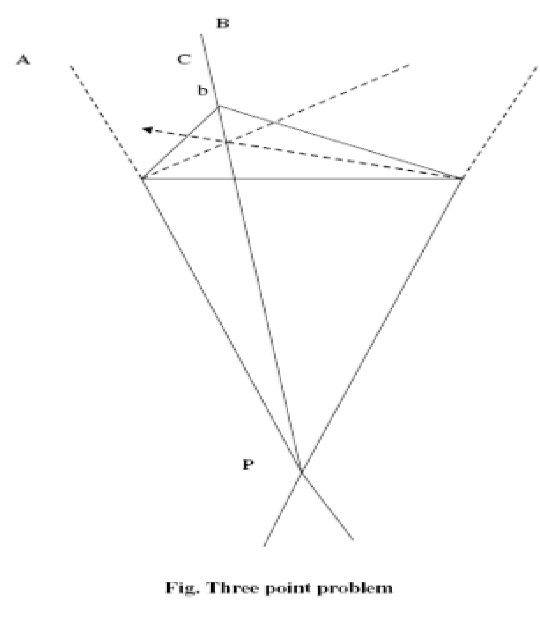


Fig. Three point problem

13. a. Narrate the working operations of plane tabling at each station and describe each one briefly

b. Describe the method of orientation with a back ray.

Ans.

Working Operations

Following three operations are carried out at each plane table station.

(*i*) Fixing the planetable on the tripod.

(*ii*) Setting up the planetable.

(*iii*) Sighting the ground stations and intersected points.

1. Fixing the plane table on the tripod. In this operation, leather strap of the tripod, is unfolded and legs of the tripod are well spread. The tripod is held so that its top height is roughly 1.2 m above the ground level. The bolt is removed from the brass annular ring and table top is placed on the top of the tripod so that it fits well with the clamping assembly of the tripod. The bolt with a washer is then tightened.

2. Setting up the plane table. The setting up operation consists of the following :

(*i*) Levelling the plane table

(*ii*) Centering the plane table

(*iii*) Orienting the plane table.

(1) Levelling. In this operation, the table top is made truly horizontal. For rough and small scale work, levelling can be done by eye estimation whereas for accurate and large scale work, levelling is achieved with an ordinary spirit level. The levelling is specially important in hilly terrain where some of the control points are situated at higher level and some other at lower level. The dislevelment of the plane table, throws the location of the point considerably out of its true location.

Procedure : Following steps are involved :

(*i*) Set up the planetable at the convenient height (nearly 1.2 metres) by spreading the legs to keep the table approximately levelled, ensuring that location of the occupied station, is also roughly centered over its ground position.

(*ii*) Rotate the plane table about its vertical axis till its longer edge is parallel to the line joining the shoes of any two legs of the tripod. Place the step third leg pointing towards the observer in between his / her legs.

(*iii*) Place a spirit level on the plane table such that its longitudinal axis is parallel to longer edge of the table. With the help of the third leg, by moving it right or left, bring the bubble of the spirit level central.

(*iv*) Next place the spirit level perpendicular to its previous position. With the help of the third leg, by moving it forward or backward, bring the bubble of the spirit level central.

(*v*) Rotate the table top through $180°$. Check if the bubble remains central in all positions.

(*vi*) Repeat the above procedure if found, necessary.

(2) Centering. In this operation, the location of the plane table station on the paper, is brought exactly vertical above the ground station position. For rough and small scale work, exact centering of the station, is not necessary and only centre of the table may be centered over the ground position.

Procedure. Place one end of the U-fork touching the plotted location and the plumb bob hanging from the other end below the table, points towards the ground point. In case it does not, shift the plane table bodily such that the plumb bob is exactly over the ground station without disturbing levelling. Before centering is done, the table should be roughly oriented otherwise centering might be disturbed when orientation is done.

(3) Orientation. In this operation, the plane table is set at a station such that its edges make a fixed angle with a fixed direction. The fixed direction is known as the *meridian*. In case, the table is not correctly oriented at each station, the locations of detail points obtained by any one of the methods of planetabling *i.e.* Radiation, Resection or Intersection described in article No. 5.5., will not represent their correct relative positions. *The main principle of planetabling is based on the fact that the lines joining the locations of the ground stations on the sheet, are made parallel to their respective ground lines.* This is achieved by the process of orientation which involves rotation of the table about its vertical axis in azimuth. The operation of orientation is sometimes called "*Setting the plane table*". As already discussed, the process of orientation disturbs the centering and *vice versa*. For accurate and large scale work, centering must be checked before orientation. Sometimes, both the processes of centering and orientation, are repeated till the two required conditions are statisfied.

Orientation of a planetable may be done by the following methods :

1. Orientation with a magnetic compass
2. Orientation with a back ray.

Method 1. Orientation with a Magnetic Compass. In case true north is not known at the plane table station, a magnetic north is sometimes used as reference *i.e. meridian*. At the starting station, the table is set such that the entire area falls on it. Place a box magnetic compass such that its magnetic needle rests in N-S direction. Draw a pencil line along the longer edge of the box. On subsequent stations after levelling and centering the table over the ground mark, the magnetic compass is laid along the drawn magnetic north. The table is then rotated until the needle rests in N-S direction. Clamp the table. The table is correctly oriented in magnetic meridian if the plane table station is free from local attraction.

Method 2. Orientation with a Back Ray. In this method, a ray is drawn from the plotted location of the instrument station to the next forward station. Its extremities are marked on both the ends of the alidade. On arrival at the forward station, the alidade is laid along the ray drawn from the previous station. The table is rotated until the line of sight intersects the previous station. This operation is termed "*setting by the back ray*". This method is independent of the defects of magnetic compass and local attraction. It is essential that the same edge of the alidade is used for drawing lines. It may also be ensured that the line *i.e.* back ray remains vertically above the ground position of the forward station.

UNIT-5

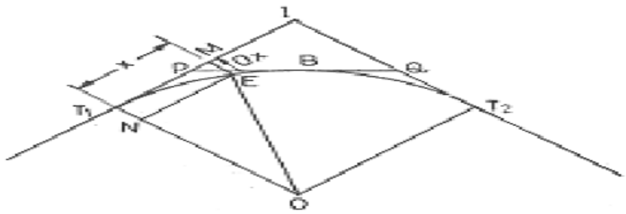
14. Describe the methods of setting out simple circular curves by perpendicular offsets from tangents.

Ans. **Offsets from the Tangents**

Limitation of the Method. This method can be used conveniently if the deflection angle and radius of the curve are comparatively small.

The offsets from the tangents may be either, perpendicular or radial.

(1) Perpendicular Offsets.



Perpendicular Offsets.

Let any point M on the back tangent of a curve of radius R be at a distance of x from T_1. Length of the offset ME to the curve perpendicular to the tangent $T_1 I$ be Ox.

Construction. Drop EN perpendicular to OT_1.

Now $$OE^2 = NE^2 + NO^2$$

$$R^2 = x^2 + (R - Ox)^2$$

$$(R - Ox)^2 = R^2 - x^2$$

$$R - Ox = \sqrt{R^2 - x^2}$$

$$Ox = R - \sqrt{R^2 - x^2} \quad \text{(Exact)}$$

$$Ox = R - R\left[1 - \left(\frac{x}{R}\right)^2\right]^{\frac{1}{2}}$$

$$= R - R\left(1 - \frac{x^2}{2R^2} - \frac{x^4}{8R^4}\right)$$

(Expanding binomially)

$$= \frac{Rx^2}{2R^2} - \frac{Rx^4}{8R^4}$$

or $$Ox = \frac{x^2}{2R} \quad \text{(Approx.)}$$

ignoring higher powers of x.

Note : The following points may be noted.

(*i*) One-half of the curve may be conveniently set out from the back tangent $T_1 I$. The other half of the curve is to be set out from the forward tangent $T_2 I$.

(*ii*) If the curve is long, the offsets will also be long. In such cases it is advisable to set the middle third of the curve by calculating offsets from a tangent at the mid point B of the curve.

Field Operations. Before setting out a curve of radius say 250 m, a table of offsets corresponding to a number of points on the tangents may be made as shown in Table 15.1.

Table 15.1

S. N.	*X (metres)*	*Ox (metres)*
1	10	0.20
2	20	C.80
3	30	1.80
4	40	3.20
5	50	5.00

Procedure. From the point of commencement T_1, measure distances x_1, x_2, x_3, etc., along the tangent $T_1 I$. Erect perpendiculars equal in lengths of the offsets corresponding to distances x_1, x_2, x_3, etc., with the help of an optical square.

As the offsets of the points, equidistant from point of commencement T_1 and point of tangency T_2 are equal, the table 15.1 may also be used for offsets from the forward tangent.

15. Two roads BA and CA intersect at a point A which falls in the bed of a river. These are to the connected by a simple circular curve of radius 200 m. To do this, a line MN connecting these tangents at points M and N respectively is measured to be 170 m. The angle BMN = 105^0 and angle CNM = 135^0. The chainage of point M is 1815 m. determine the chainage tangents joints and the length of the curve.

Ans.

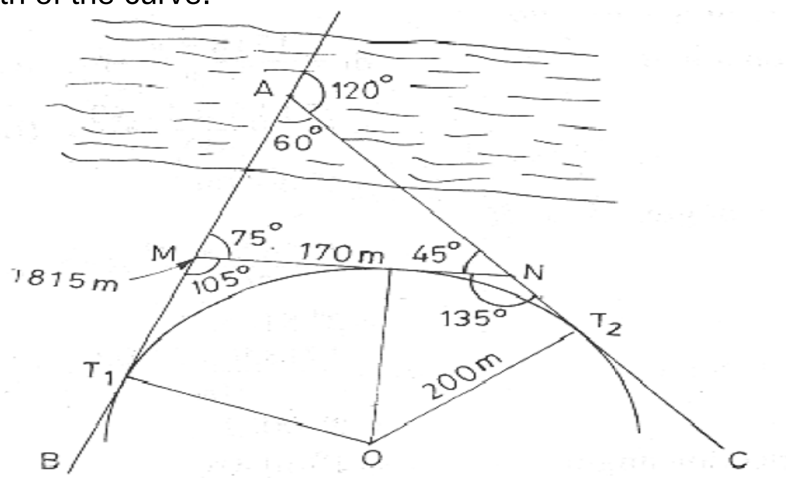


Fig.

In ΔMAN we get

$$\angle AMN = 180° - 105° = 75°$$

$$\angle ANM = 180° - 135° = 45°$$

$$\therefore \quad \angle MAN = 180° - (75° + 45°) = 60°$$

and angle of deflection $= 180° - 60° = 120°$.

Let T_1 and T_2 be the points of tangency.

$$\therefore \quad AT_1 = R \tan \frac{\Delta}{2} = 200 \times \tan \frac{120°}{2} = 346.41 \text{ m}$$

Applying sine rule to ΔMAN we get

$$\frac{AM}{\sin 45°} = \frac{170}{\sin 60°}$$

$$\therefore \quad \frac{AM\ 170 \sin 45°}{\sin 60°} = 138.80 \text{ m}$$

Chainage of A = chainage of $M + MA$
$= 1815 + 138.80 = 1953.8$ m

Chainage of T_1 = Chainage of $A - AT_1$
$= 1953.80 - 346.41 = 1607.39$ m.

Length of the curve $= \dfrac{\pi R\Delta}{180}$

$$= \frac{\pi \times 200 \times 120}{180} = 418.88 \text{ m}$$

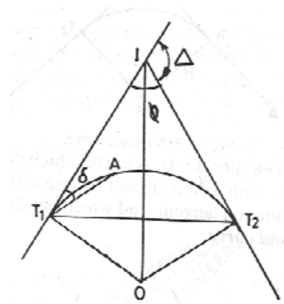
Chainage of T_2 = chainage of T_1 + length of the curve
$= 1607.39 + 418.88 = 2026.27$ m.

Chainage of $T_1 = 1607.39$ m
Chainage of $T_2 = 2026.27$ m
Length of curve $= 418.88$ m
Ans.

16. Explain the following terms with the help of neat sketch

a. Point of Intersection
b. Angle of deflection
c. Radius of curve
d. Long chord

Ans.



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 commencement and point of tangency, is called long chord.