

* Surveying

Surveying is the art of determining the relative position of different objects on the surface of earth by measuring the horizontal distances between them and by preparing a map to any suitable scale.

* Object of surveying

The aim of surveying is to prepare a map to show the relative position of objects on the surface of the earth.

It shows the natural features of a country, such as town, villages, roads, railway, rivers etc.

* Uses of surveying

1) To prepare a topographical map which shows the hills, valleys, rivers, villages, town, forest etc.

2) To prepare a Cadastral map showing the boundaries of fields houses other properties

3) To prepare a Contour map to determine the best possible routes for roads & railways.

4) To prepare a eng map shows the details of eng works such as irrigation, Canal, railway.

*Classification of Surveying

- 1- plane Surveying
 - 2- Geodetic Surveying
- } Primary Classification

Plane Surveying

7) As we know that the shape of earth is spherical. Now the surface is obviously is curve.

7) In plane surveying, the curvature of earth is not taken into consideration.

This is because plane surveying is ~~is the~~ ~~easy~~ carryout in small area. Show the surface the earth is consider plane.

7 In such surveying, a line joining any two points is consider straight. The triangle formed by any 3 points is consider a plane triangle and the angles of the triangles are assumed to be plane angles.

7 plane surveying is conducted by state agencies like the irrigation department, railway department etc.

7 plane surveying done on an area of less than 250 km^2 .

Geodetic surveying

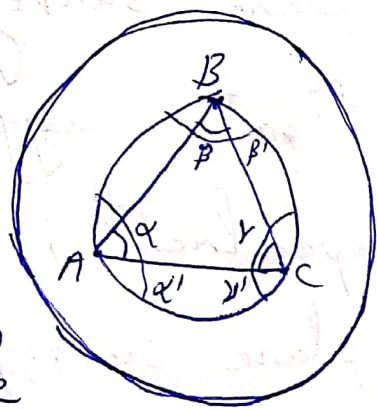
7 In this type of surveying, the curvature of earth is taken into consideration. It is

- Carried out over a large area,
- The line joining any two points is considered a curve line.
 - The triangles formed by any 3 points is considered spherical and the angles of the triangle assumed to be spherical angle.

→ This survey is conducted by the survey of India department and carried out over an area exceeding 250 km².

α', β', γ' → Geodetical Spherical angle

α, β, γ → plane, spherical angle



Plane and Geodetic surveying different? between

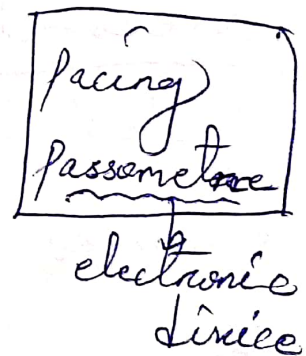
Secondary Classification

1- Based on Instrument

- a- Chain surveying
- b- Theodolite surveying
- c- Compass surveying
- d- Tacheometric surveying
- e- plane table surveying
- f- photographic surveying

2- Based on Method

- a- Triangulation surveying
- b- Traverse surveying



Methods of Linear Measurement

Pacing or Stepping (fast step)

For rough & speedy work, distances are measured by pacing

that is by counting the number of working steps, of a man.

Pedometer — foot step
electronic device

- A small instrument, just like a stop watch the pedometer we use the count of number of step automatically by some mechanical device.
- It offers and improvement over the normal pasing method, when a very long distances.

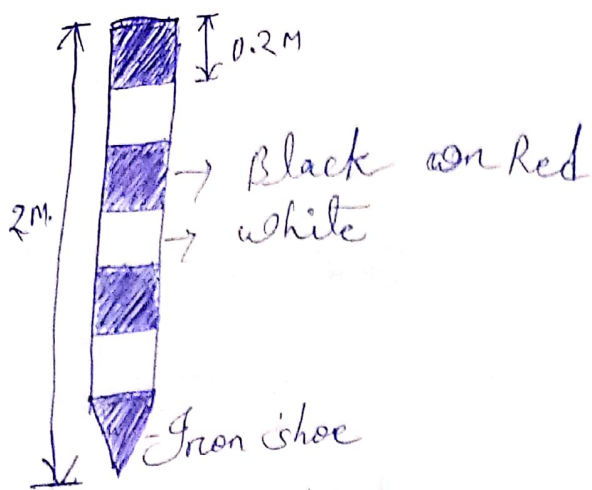
Speedometer

Used in automobile for recording distances.

Chaining

This is an accurate and common method for measuring distances.

Instrument for linear measurement



(Ranging rod)

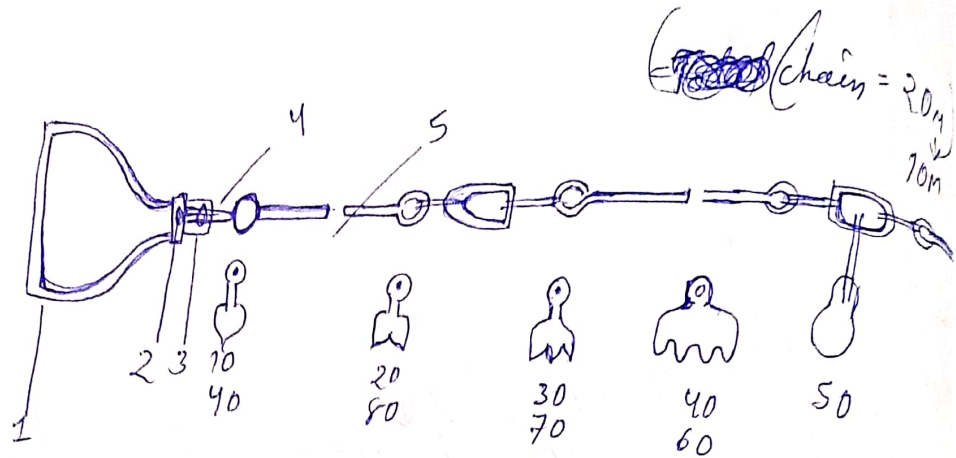
(That is the process of making a line state) Ranging 2 types ^{direct and indirect} from a line are known as ranging rod.

Such rods are made of ~~season~~ ^{seasoned} timber or seasoned bamboo.

~~Sometimes~~ They are generally circular in section of 25mm diameter and 2m length. The rod is divided into equal parts of 20cm each and the divisions are painted black & white or red & white alternating. Show that the rod is visible from long distance. The lower ~~and~~ end of the rod is pointed.

with an iron shoe.

Chain



~~3 circle~~ 3 circle - 1 link

- > A chain with prepared with ~~150~~ 100 or 150 galvanized mild steel on 4mm dia metre.
- > The ends of the pieces are bends the form a loop. Then the pieces are connected together with the help of 3 oval ring, which make the chain flexible.
- > Two brush handle are provide at the two ends of the chain.
- > Tallies are provided at every 10 or 25 links for facility of counting.

"One link" means the distance between the centre of adjacent middle ring.

7 There are 5 Types of chain.

1- Metric chain

2- Engineers chain

3- Gunter's chain

4- Revenue chain

5- steel ~~chain~~ band

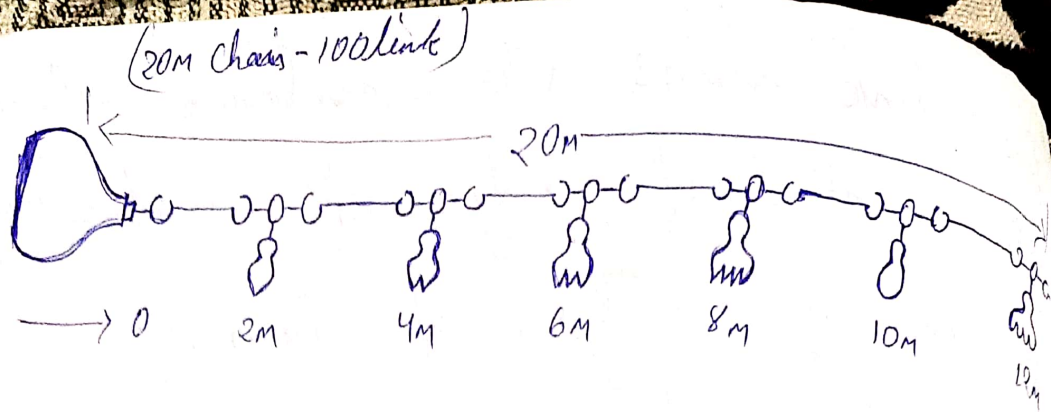
1- Metric chain

7 metric chains are available in length of 20m and 30m. The 20m chain is divided into 100 links, is of 0.2m or 20cm.

7 Tallies are provided at every 10 links = (2m). This chain is suitable for measuring distances along fairly ground surface.



Tallies



dt-20.12.12

1- Metric chain $\left\{ \begin{array}{l} 20m \text{ (100 link)} \\ 30m = \frac{(30 \times 100)}{20} = 150 \text{ link} \end{array} \right.$

2- Engineer's chain = 100ft (100 link)
= 1 link is 1ft

3- Gunter's chain = 66 ft long
= 100 link
= 1 link is $\frac{66}{100} = 0.66 \text{ ft}$

4- Revenue chain = 33 ft long
= 16 link

Chains have the following advantages

- 1- They can be read easily and quickly
- 2- They can withstand wear & tear

3- They can be easily repair and rectified in the field.

Chains have the following disadvantages

1- They are heavy and take too much time to open or fold.

2- They become longer or shorter due to continuous use.

* Tapes (Distance Measurement)

Tapes 1- There are following types of Tapes.

1- Cloth or linen Tape

2- Metallic Tape.

3- Steel Tape

4- Invar Tape

1- Cloth or linen Tape

It is 15mm wide and available in length of 10m & 15m.

2- Metallic Tape

Available in length of 15m, 20m, 30m.

It is used for all survey work.

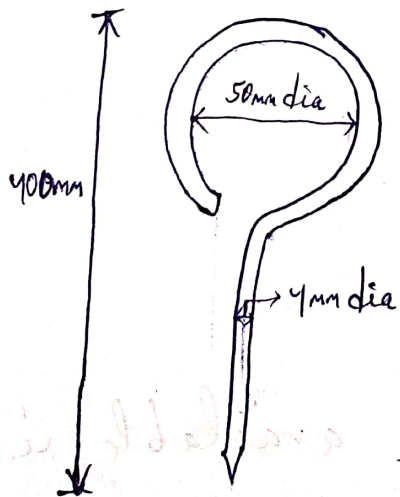
3- Steel tape

Made of steel ribbon of width varying from 6mm to 16mm. It is available in length of 10m, 15m, 20m, 30m & 50m.

4- Invar tape

Made of alloy of steel and nickel. It is available in length of 30m, 50m & 100m.

* Arrow



→ Arrows are made of steel wear of 4mm dia,
→ One end of the arrow is bent into a ring of 50mm dia and other end is pointed.

→ Its overall length is 400mm.

Arrows are used for counting the number of chain while measuring a chain line.

Ranging

- 1- Direct Ranging
- 2- Indirect Ranging or Reciprocal Ranging

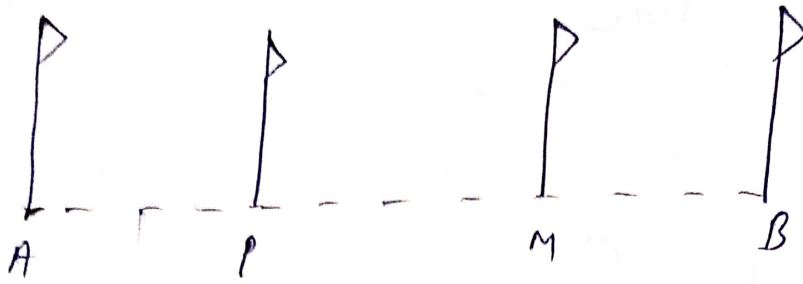
Ranging → The process of establishing intermediate points on a straight line between two end points is known as Ranging.

Ranging is of two types :-

1- Direct Ranging

When intermediate ranging rods are fixed on a straight line by direct observation from end stations, the process is known as Direct ranging.

Direct ranging is possible when the end stations are intervisible.



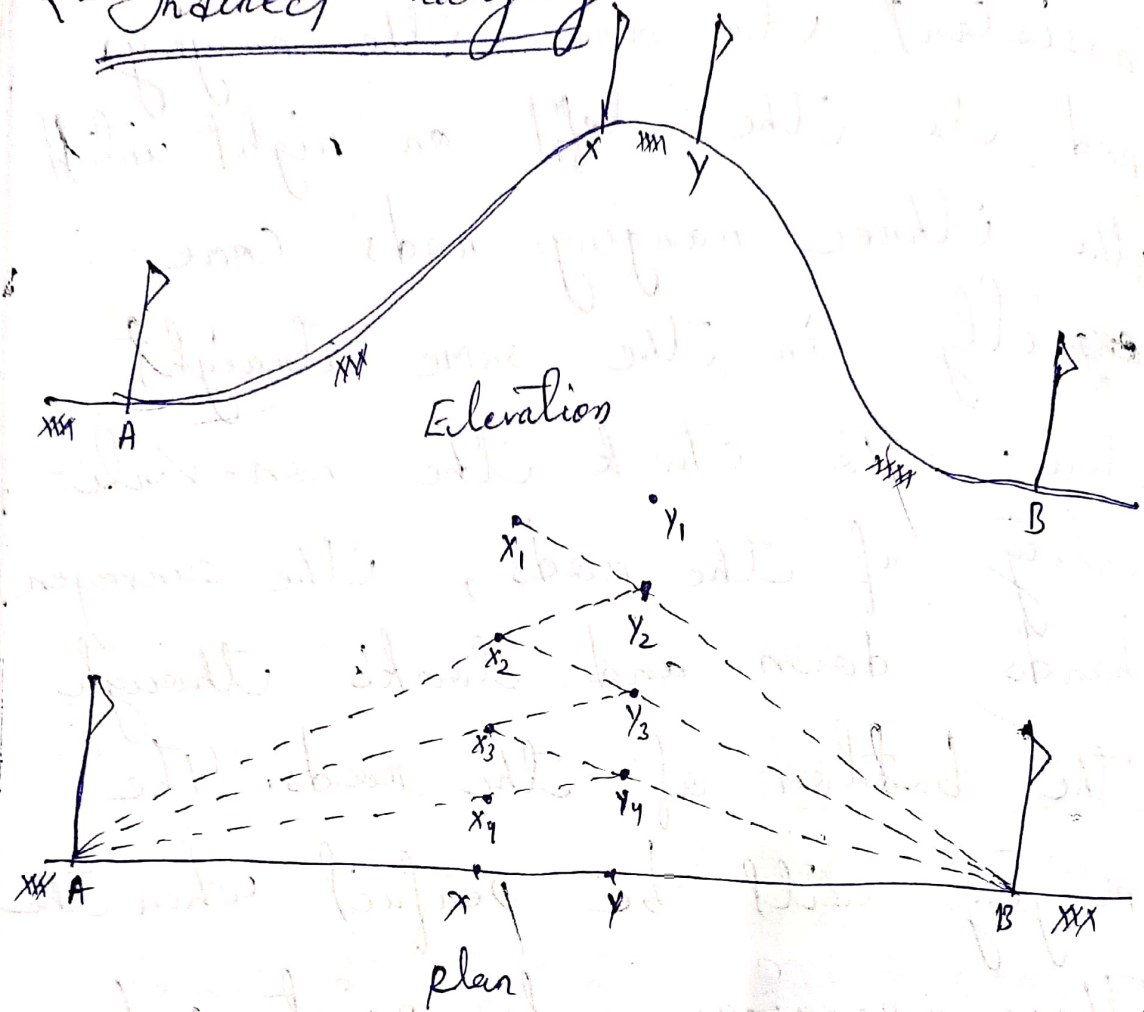
Assume that 'A' and 'B' are two end stations of a chain line, where two ranging rods are already fixed. Suppose it is required to fix a ranging rod at the intermediate point 'P' on the chain line in such a way that the points A, P, & B are in the same straight line. The surveyor stands about two metres behind the ranging rod at point 'A' by looking to words the line A, B. The assistant holds a
→

ranging rod at P vertically.

Now the surveyor direct the assistant to move the ranging rod to the left or right until the three ranging rods come ~~exactly~~ in the same straight line. To check the non-verticity of the rods, the surveyor bends down and looks through the bottom of the rods. The ranging will be perfect when the three ranging rods point side and appear as a single rod. When the surveyor is satisfied then the ranging is perfect, he signal the assistant to fix the ranging rod on the ground. Following the same process the other ranging

roads may be fixed on the line.

2- Indirect ranging



Dt-23.12.19

Indirect ranging or Reciprocal ranging

When the end stations are non-Intervisible, due to some ~~obstacle~~ between them. The ranging which are done is known as

Indirect ranging or reciprocal ranging,

→ Suppose A & B are two end stations which are not intervisible due to high ground existing between them. Suppose it is required to find intermediate point between A & B. Two chain ~~men~~ men take up position at x_1 & y_1 with ranging rods in their hands. The chain man at x_1 stands with his face towards point B show that he can see the ranging rods at y_1 . Again the chain man at y_1 stands with his face towards A show that he can see the ranging rods at x_1 and A. Then the chain men proceed to range the

line by directing is other alternately. The chainmen at x_1 direct the chainmen at y_1 to come to the position y_2 . Show that x_1 , y_2 and B are in the same straight line. Again the chainmen at y_2 direct the chainmen at x_1 to move to the position x_2 . Show that y_2 , x_2 & A are in the same straight line. By directing each other alternately in this manner, they ~~chain~~ change their position every time until they finally come to the position x & y , which are in the straight line AB . This means the point A , x , y & B are in the same straight line.

Leader

The chainmen at the forward end of the chain, who drags the chain forward, is known as the leader.

The duty of the leader are:-

- 1) To drag the chain forward with some arrows and a ranging rod.
- 2) To fix arrows on the ground at the end ~~the~~ of every chain.
- 3) To obey the instructions of the follower.

Follower

The chainmen at the rear end of the chain, who hold the zero end of the chain at the station, is known as the follower.

The duty of the follower are:-

- 1) To direct the leader at

the time of ranging.

2) To carry the rear handle of the chain.

3) To pickup the arrows insutated by the leader.

a) Method of chaining of level ground Df-100. 01.2020

Before starting the chaining operation two ranging rod should be fixed on the chain line, at the end station. The other ranging rod should be fixed near the end of each chain length, during the ranging operation.

To chain the line, the leader moves forward by dragging the chain and by talking with him a ranging rod and ten arrows. The follower stands at the starting station by

holding the other end of the chain. When the chain is fully extended, the leader holds the ranging rod vertically at arm's length. The follower directs the leader to move his rod to the left or right until the ranging rod is exactly in line. Then the follower holds the zero end of the chain by touching the station peg. The leader stretches the chain by moving it up and down with both hands, and finally places it on the line. He then inserts an arrow on the ground at the end of the chain and marks with a cross ($\times$).

Again the leader moves forward by dragging the chain with nine arrows and the leader has none left with him. The follower hands them over to the leader, this should be noted by the surveyor.

To measure the remaining fractional length, the leader should drag the chain beyond. The station and the follower should hold the zero end of the chain at the last arrow. Then the odd links should be counted.

Method of chaining on sloping ground

Horizontal distances are required in surveying. So, in chaining along a sloping ground, the horizontal distance between two stations are measured carefully by applying some convenient methods. The following are the different methods that are generally employed.

A - Direct method or stepping method

B - Indirect method.

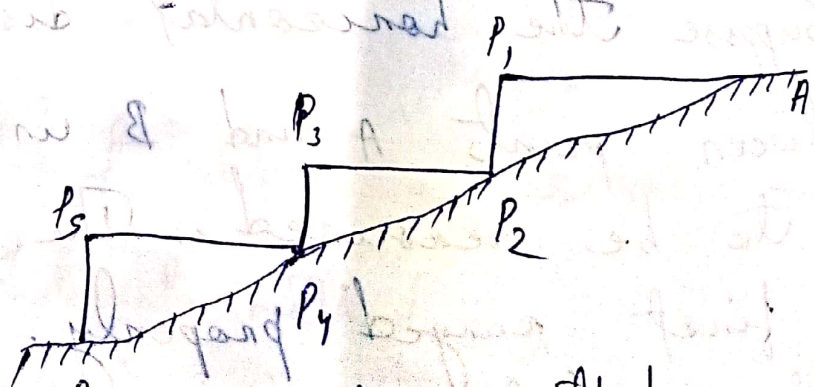
Direct method

This method is applied when the slope of the ground is very ~~steep~~ steep. In this method, the slopping ground is divided into a number of horizontal and vertical strips, like steps. So, this method is also known as the stepping method. The ~~lengths~~ lengths of horizontal portions are measured and added to get the total ~~horizontal~~ horizontal distance between the points. The steps may not be uniform and would depend on the nature of the ground.

Procedure

Suppose the horizontal distance between points A and B in fig. is to be measured. The line AB is first ranged properly. Then, the follower holds the zero end of the tape at A. The leader selects a

suitable length AP_1 , so that P_1 is
 chest height and AP_1 is just horizontal.
 The horizontality is maintained by
 eye estimation, by tri-square or
 by wooden set-square. The point P_2
 is marked on the ground by plumb
 bob so that P_1 is just over P_2 .
 The horizontal length AP_1 is noted.
 Then the follower moves to the
 position P_2 and holds the zero end
 of the tape at that point. Again
 the leader selects a suitable length
 P_2P_3 in such a way that P_2P_3 is
 horizontal and P_4P_5 vertical. Then the
 horizontal length P_2P_3 and P_4P_5 are
 measured.



stepping method.

So, the total horizontal length, $AB = AP_1 + P_2P_3 + P_4P_5$

1) Chain Connection

Df-13.01.2020

1- Connection due to inconnection length
True length (TL) = $\left(\frac{L^*}{L}\right) \times \text{Measured length}_{(ML)}$

where, $L^* = \text{True length} \pm c$

$L = \text{standard chain length}$

$ML = \text{Measured length start.}$

2) Inconnect area

True length (TL) = $\left(\frac{L'}{L}\right)^2 \times \text{measured length}_{(ML)}$

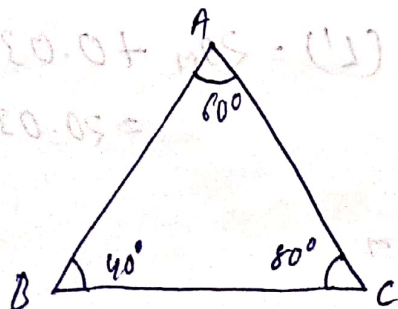
where $L' =$

$L =$

*Well Conditioned & Ill-Conditioned Triangle

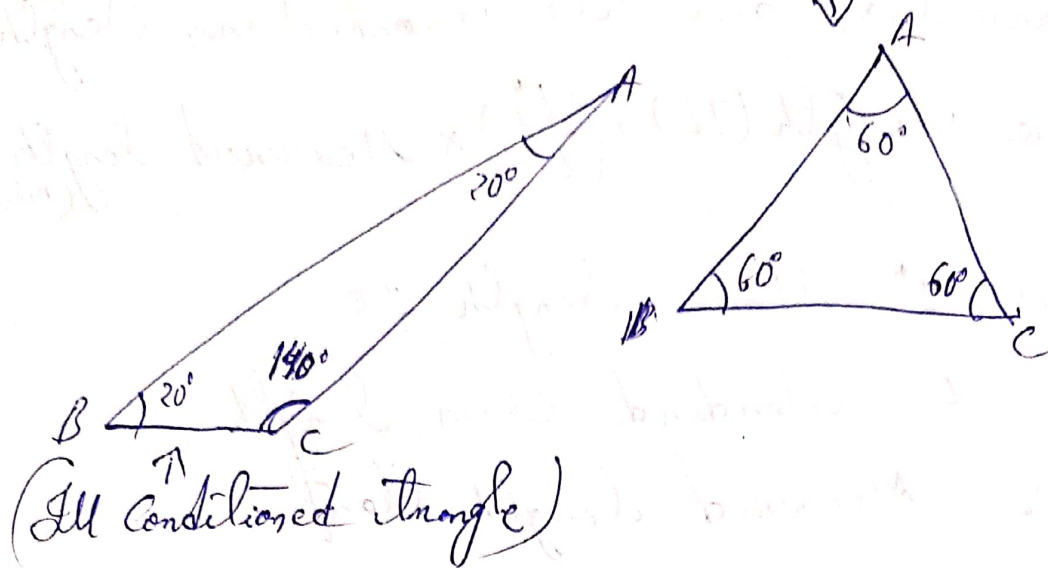
Well Conditioned Triangle

A triangle is said to be well conditioned in which, when no angle in it is less than $< 30^\circ$ or $> 120^\circ$.



(well conditioned triangle)

b) Best Conditioned on Ideal triangle



DT-17-01-2020

Q// The distance between Two point measured with a 20m chain, was recorded as 327 m. It was after words found that the chain was 3cm too long. what was the True distance between the point.

Given,

Standard chain length (L) = 20m

length of chain + error (L') = 20m + 0.03
= 20.03m

measured length = 327m

(approx b)

$$\text{True distance} = \left(\frac{L'}{L}\right) \times \text{measured length}$$

$$= \frac{20.03}{20} \times 327 = 327.49 \text{ m}$$

Q// The distance between two station 1200 m when measured with a 20 m chain. The same distance when measured with a 30 m chain was found to be 1195 m. ~~Now~~ If the 20 m chain was 0.05 m too long, what was the ~~error~~ ^{error} in the 30 m chain.

Given Case-I

$$\text{True length} = \frac{L'}{L} \times \text{measured length}$$

$$L = 20 \text{ m}$$

$$L' = 20 + 0.05 = 20.05$$

$$ML = 1200 \text{ m}$$

$$\frac{20.05}{20} \times 1200 = 1203 \text{ m}$$

Case-II

$$L = 30 \text{ m}$$

$$L' = 30 \text{ m} + e$$

$$ML = 1195 \text{ m}$$

~~1195~~

$$\text{True length} = \left(\frac{L'}{L}\right) \times ML$$

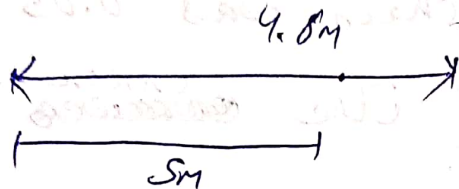
$$\Rightarrow 1203 = \frac{30+e}{30} \times 1195$$

$$e = 0.20 \text{ m}$$

Tape Correction

a) Temperature Correction

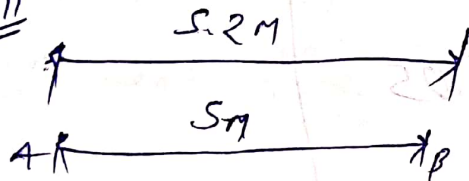
Case-I



$$\begin{aligned} \text{error} &= \frac{\text{measured value}}{\text{value}} - \text{Original value} \\ &= 4.8 - 5 = -0.2 \text{ (-ve)} \end{aligned}$$

$$\text{Correction} = 4.8 + 0.2 = 5 \text{ m positive}$$

Case-II



$$\text{error} = \frac{\text{measured value}}{\text{value}} - \text{Original value}$$

$$= 5.2 - 5 = 0.2$$

$$\text{Correction} = 5.2 - 0.2 = 5 \text{ m negative}$$

when α for the steel tape is not given it is assumed to be $11 \times 10^{-6} / ^\circ \text{C}$

Temperature Correction

$$C_T = L \alpha (T_M - T_0)$$

where, C_T = Temperature Correction

α = Co-efficient of Thermal expansion

T_M = Temperature during measurement
(°C or Celsius)

T_0 = Temperature at which the tape was standardised temperature

L = Length of Tape

1- If $T_M > T_0$, length of tape increase

error = -ve

Correction = +ve

2- If $T_M < T_0$, length of tape decrease

error = +ve

Correction = -ve

b) Pull Correction

$$C_P = \frac{(P_M - P_0)^2}{AE}$$

C_P = pull correction

L = Length of tape in meter

A = crosssectional area of the tape
in C.M. square.

P_M = pull applied during measurement
in kg.

P_0 = pull at which the tape was
standardised

E = modulus of elasticity

If E is not given, It is assumed
to be $2.1 \times 10^6 \text{ kg/cm}^2$

1- If $P_M > P_0$ = length of tape increase

error = -ve

Correction = +ve

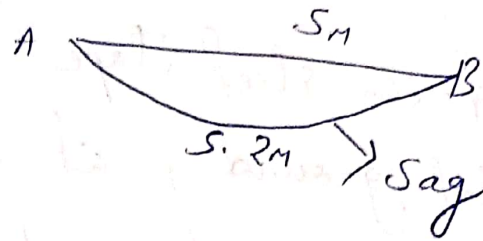
2- If $P_M < P_0$ = length of tape decrease

error = +ve

Correction = -ve

Shape Correction always negative

c) Sag Connection



$$C_{\text{sag}} = \frac{w^2 L}{24 P_m^2}$$

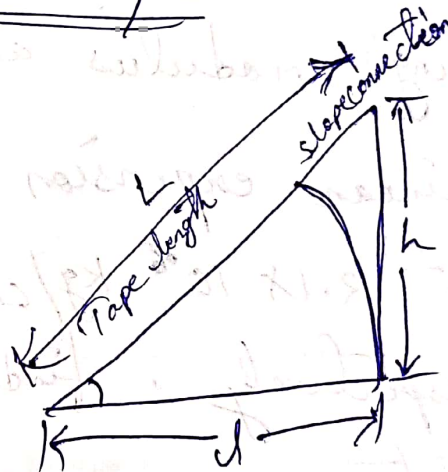
w = Total weight of the tape

L = Length of the tape

P_m = pull applied during measurement

d) Connection due to slope

$$C_s = \frac{h^2}{2L}$$



Slope Connection always negative

* Normal Tension

pull connection = sag connection

$$\frac{(P_m - P_0)K}{AE} = \frac{w^2 K}{24 P_m^2}$$

$$2) \quad (P_m - P_0) = \frac{w^2 AE}{24 P_m^2}$$

A 20m steel tape was standardised on flat ground, at a temperature of 20°C and under a pull of 15 kg . The tape was used in catenary at a temperature of 30°C and under a pull of 10 kg . The cross sectional area of the tape is 0.02 cm^2 and its total weight is 400 g . The young's modulus and coefficient of linear expansion of steel are ~~xxx~~ $2.1 \times 10^6\text{ kg/cm}^2$ and $\alpha = 11 \times 10^{-6}/^{\circ}\text{C}$ respectively. Find the correct horizontal distance.

Given,

$$L = 20\text{ m}$$

$$T_m = 30^{\circ}\text{C}$$

$$A = 0.02\text{ cm}^2$$

$$P_m = 10\text{ kg}$$

$$W = 400\text{ g} = 0.4\text{ kg}$$

$$E = 2.1 \times 10^6\text{ kg/cm}^2$$

$$\alpha = 11 \times 10^{-6}/^{\circ}\text{C}$$

$$T_0 = 20^{\circ}\text{C}$$

$$P_0 = 15\text{ kg}$$

Temperature Correction

$$\epsilon_T = \alpha L (T_m - T_0)$$

$$= (11 \times 10^{-6}) \times 20 (30 - 20)$$

$$= 0.0022 (+ve)$$

2- Pull

$$C_p = \frac{(P_m - P_0)L}{AE}$$

$$= \frac{(10 - 15)20}{0.02 \times 2.1 \times 10^6}$$

$$= -0.00238$$

3- Sag

$$C_{sag} = \frac{w^2 L}{24 P_m^2} = \frac{(0.4)^2 \times 20}{24 \times (10)^2}$$

$$= 0.00133 (-ve)$$

$$\text{Total correction} = 0.0022 - 0.00238 - 0.00133$$

$$= -0.00151$$

$$\text{horizontal distance} = 20 - 0.00151$$

$$(L \times \text{total}) = 19.998$$

A 30m steel tape was standardised at a temperature of 20°C and under a pull of 5kg. The tape was used in Calcutta at a temperature of 25°C and under a pull of p kg. The cross-sectional area of the tape is 0.02 cm^2 . Its weight per unit length is 22 g/m . Young's modulus $= 2 \times 10^6\text{ kg/cm}^2$, $\alpha = 11 \times 10^{-6}\text{ per }^{\circ}\text{C}$. Find the correct horizontal distance, if p is equal to (a) 5 kg, and (b) 11 kg.

Given, $L = 30\text{m}$

$$A = 0.02\text{ cm}^2$$

$$T_0 = 20^{\circ}\text{C}$$

$$E = 2 \times 10^6\text{ kg/cm}^2$$

$$P_0 = 5\text{ kg}$$

$$\alpha = 11 \times 10^{-6}\text{ per }^{\circ}\text{C}$$

$$T_m = 25^{\circ}\text{C}$$

$$w = 22\text{ g/m}$$

$$P = 5\text{ kg}, 11\text{ kg}$$

$$= 22 \times 30$$

$$n = 1$$

$$= 660$$

$$= 1.66\text{ kg}$$

1- Temperature Correction

$$C_T = \alpha L (T_m - T_0)$$

$$= (11 \times 10^{-6}) \times 30 \times (25 - 20)$$

$$= 0.00165 (+ve)$$

2/ pull

$$C_p = \frac{(P - P_0)L}{AE}$$
$$= \frac{(5 - 5)30}{0.02 \times 2 \times 10^6} = 0$$

3- Sag

$$C_s = \frac{LW^2}{24n^2P^2}$$
$$= \frac{30 \times (0.66)^2}{24 \times (5)^2} \quad (n=1)$$
$$= 0.02178 \text{ (-ve)}$$

$$\text{Total correction} = 0.00165 - 0.02178$$
$$= -0.02013$$

$$\text{Horizontal distance} = 30 - 0.02013$$
$$= 29.97987$$

A steel tape was exactly 20m long at 20°C when supported throughout its length under a pull of 5 kg. A line measured with this tape under a pull of 16 kg and at a mean temperature of 32°C was found to be 680m long. Assuming the tape is supported at every 20m.

Find the true length of the wire. Given that (a) cross-sectional area of tape = 0.03 cm^2 (b) $E = 2.1 \times 10^6 \text{ kg/cm}^2$, (c) $\alpha = 11 \times 10^{-6} \text{ per } ^\circ\text{C}$, and (d) weight of tape = 10 g/cc .

Given,

$$L = 20 \text{ m}$$

$$T_0 = 20^\circ\text{C}$$

$$P_0 = 5 \text{ kg}$$

$$T_m = 32^\circ\text{C}$$

$$P_m = 16 \text{ kg}$$

$$M_L = 680 \text{ m}$$

$$A = 0.03 \text{ cm}^2$$

$$\alpha = 11 \times 10^{-6} \text{ per } ^\circ\text{C}$$

$$E = 2.1 \times 10^6 \text{ CM}$$

$$\text{weight} = 10 \text{ g/cc}$$

$$W = 0.03 \times 20 \times 100 \times 10 \\ = 600 \text{ g} = 0.6 \text{ kg}$$

1- Temperature Connection

$$C_T = \alpha L (T_m - T_0)$$

$$= (11 \times 10^{-6}) \times 20 (32 - 20)$$

$$= 0.00264 \text{ (true)}$$

2- Pull

$$C_P = \frac{(P_m - P_0)L}{AE}$$

$$= \frac{(16 - 5) \times 20}{0.03 \times 2.1 \times 10^6}$$

$$= 0.00349 \text{ (true)}$$

3- Sag

$$C_s = \frac{L(w)^2}{24 P_m^2} (n=1)$$

$$= \frac{20 \times (0.6)^2}{24 \times (16)^2}$$

$$= 0.00117 \text{ (-ve)}$$

$$\text{Total Connection} = 0.00264 + 0.00349 - 0.00117$$
$$= 0.00496$$

$$\text{Length of Tape } L' = 20.00496$$

$$\text{True length of line} = \frac{L'}{L} \times ML$$
$$= \frac{20.00496}{20} \times 680$$
$$= 680.169 \text{ m}$$

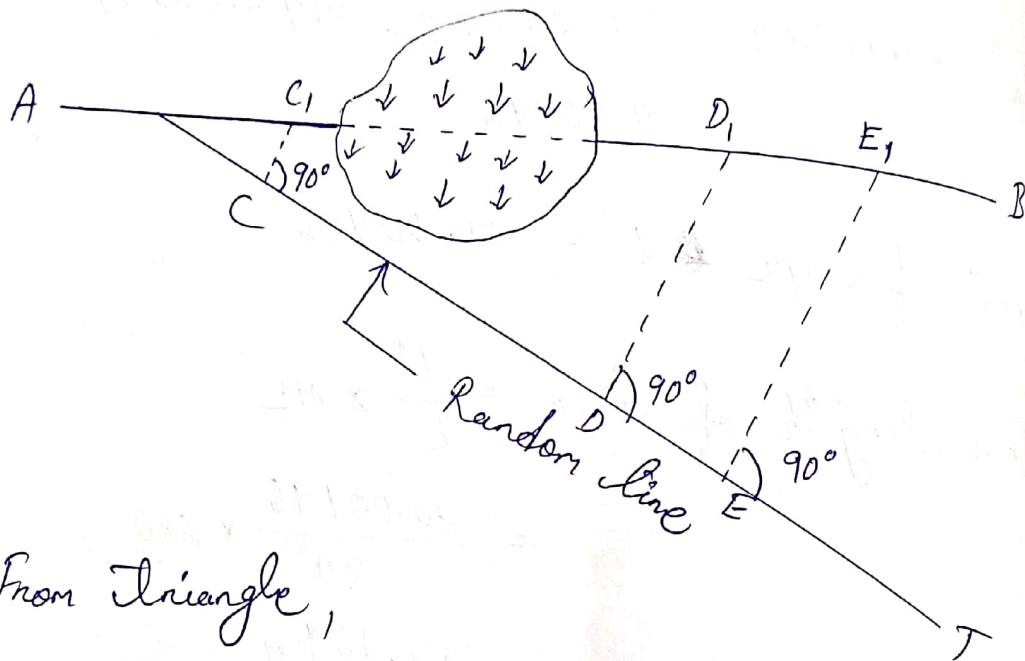
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Conventional symbols

obstacle in chaining

- 1- chaining is free, but vision is obstructed
- 2- chaining is obstructed, but vision is free.
- 3- when chaining & vision both are obstructed.

1- Chaining free but vision obstructed
 when a rising ground or a jungle area interrupts the chain line, such problem is arises.



From Triangle,

$\triangle PDD_1$ & $\triangle PCC_1$

$$\Rightarrow \frac{DD_1}{PD} = \frac{CC_1}{PC}$$

$$\Rightarrow \boxed{DD_1 = \frac{CC_1}{PC} \times PD} \quad \text{--- (1)}$$

$\triangle PEE_1$ and $\triangle PCC_1$

$$\Rightarrow \frac{EE_1}{PE} = \frac{CC_1}{PC}$$

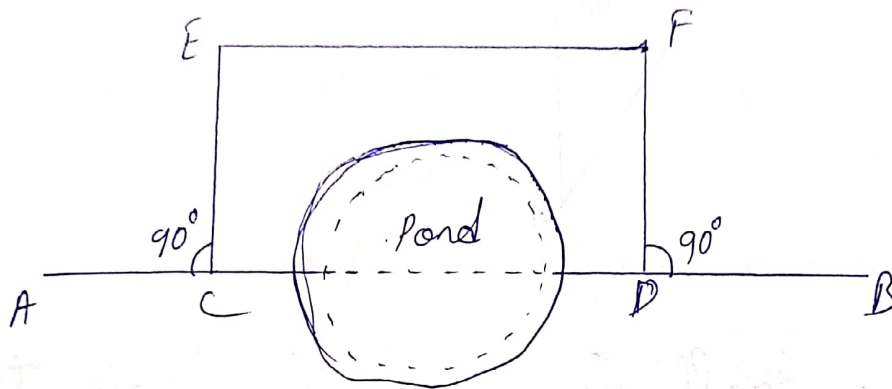
$$\Rightarrow \boxed{EE_1 = \frac{CC_1}{PC} \times PE} \quad \text{--- (2)}$$

from eq (1) and 2, The value of DD_1 and EE_1 Calculate.

There, for distance $PE_1 = \sqrt{(EE_1)^2 + (PE)^2}$

3- Chaining obstructed but vision free.

Case-1



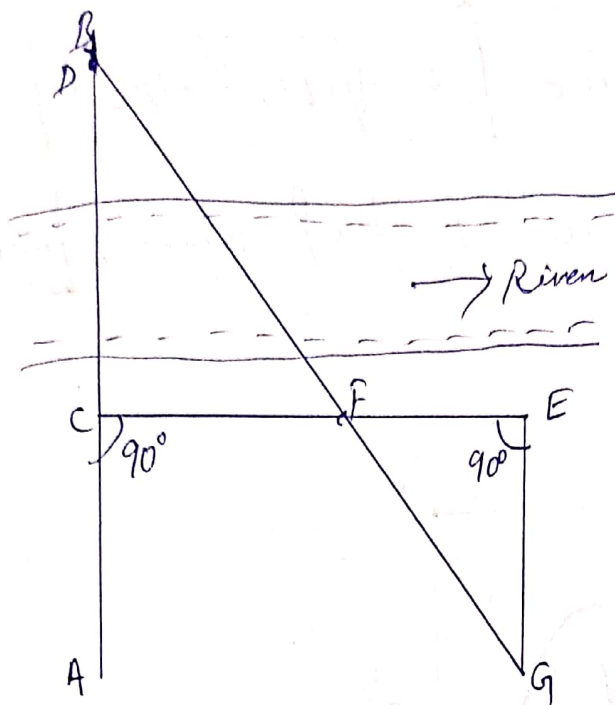
when a pond interrupts the chain line possible to go around the obstruction.

Suppose AB is the chain line. Two points C and D are selected on the opposite banks of the pond. Equal perpendiculars CE and DF are erected from point C and D respectively. The distance EF is measured.

• EF should be equal to CD

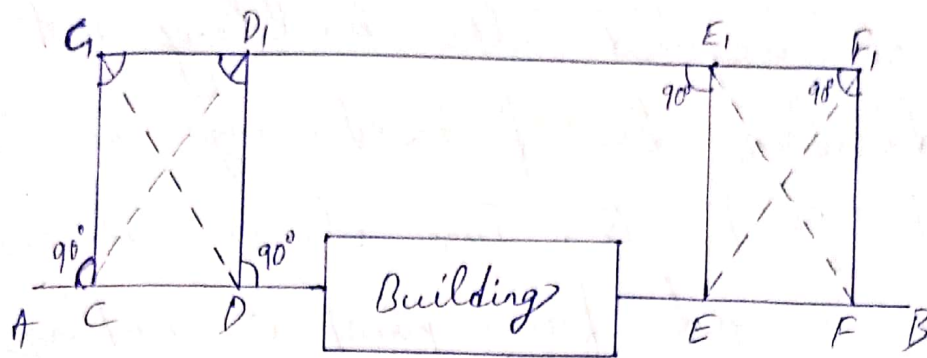
Case 2 When a river cross a chain line

Dt-21.01.21



Imagine a small river comes across the chain line. Suppose AB is the chain line. Two points C and D are selected on the line on opposite banks of the river. At C, a perpendicular drawn CE is erected and bisected at point F. A perpendicular is set out at point E and a point G is so selected on it so that point G, F and D will lie in a straight line.

3 - Chaining and vision both obstructed



Suppose AB is a chain line. Two points C and D are selected on it at one side of the building. Equal perpendiculars CC_1 and DD_1 are erected. The line C_1D_1 is extended ~~and~~ until the building is crossed. On the extended line, two points E_1 and F_1 are selected. Then perpendicular ~~are~~ E_1E and F_1F are so erected that

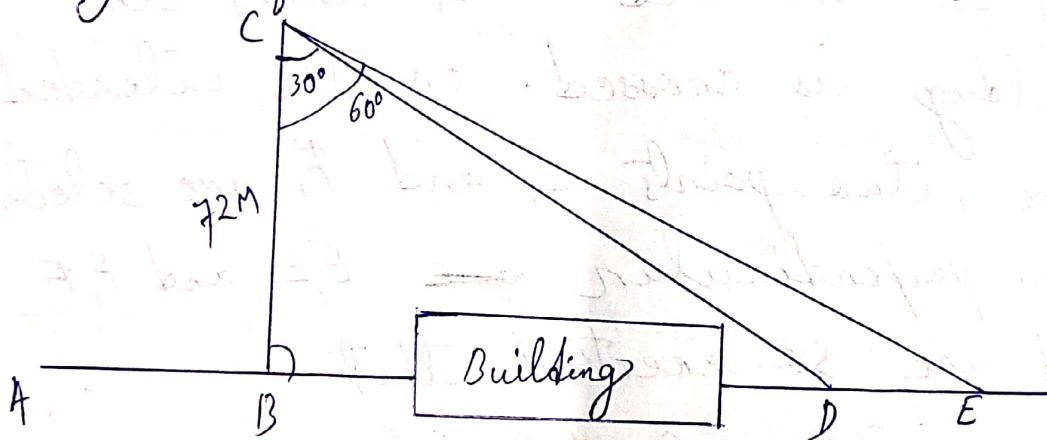
$$E_1E = F_1F = D_1D = C_1C$$

Thus, the points C, D, E and F will come in a straight line AB.

Here, $DE = D_1E_1$,

$$\left\{ \begin{aligned} \sin \theta &= \frac{p}{h}, \cos \theta = \frac{b}{h}, \tan \theta = \frac{\sin \theta}{\cos \theta} = \frac{p}{b}, \cot \theta = \frac{b}{p}, \operatorname{cosec} \theta = \frac{1}{\sin \theta} \\ \sec \theta &= \frac{1}{\cos \theta} \end{aligned} \right.$$

If a survey line AB is obstructed by a high building. To continue the line AB beyond the building, a perpendicular BC of 72m long is set out at point B. Two lines CD and CE are ranged from point C making angles of 30° and 60° respectively with BC. Find out the length of CD and CE such that points A, B, D and E form a straight line. also calculate the length of obstructed chain BD.



$$\cos 30^\circ = \frac{BC}{CD}$$

$$\Rightarrow CD = \frac{BC}{\cos 30^\circ} = \frac{72}{\frac{\sqrt{3}}{2}} = 83.14$$

$$\cos 60^\circ = \frac{BC}{CE}$$

$$\Rightarrow CE = \frac{BC}{\cos 60^\circ} = \frac{72}{\frac{1}{2}} = 144$$

$$BD = \sqrt{(83.14)^2 - (72)^2}$$

$$BD = \sqrt{(83.14)^2 - (72)^2}$$

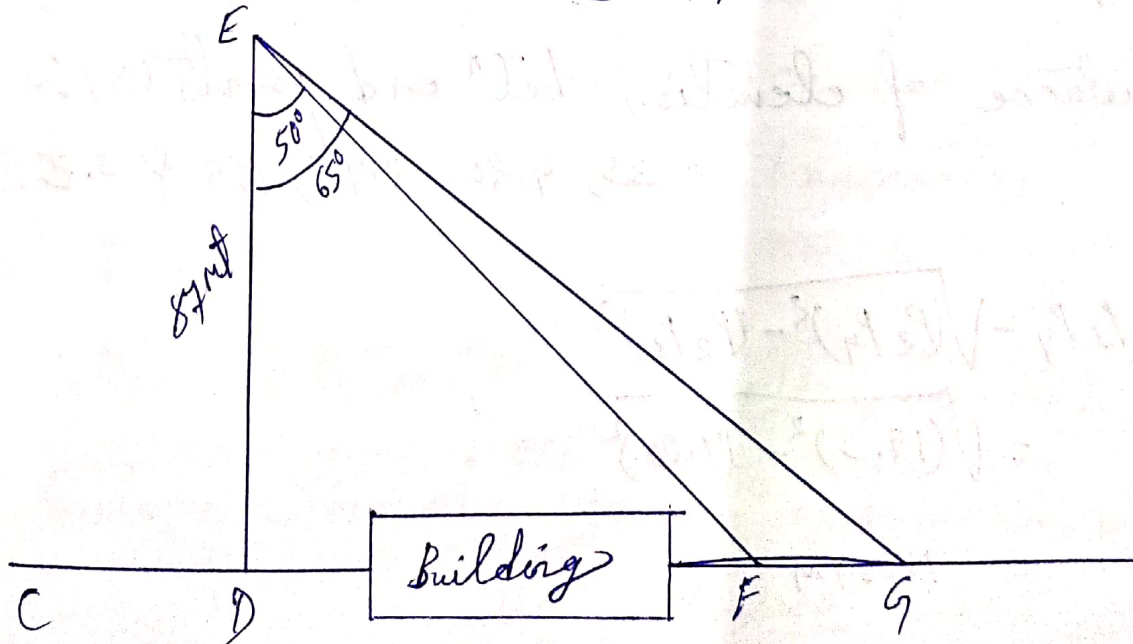
$$= 41.57$$

$$\tan \theta = \frac{BD}{BC}$$

$$\Rightarrow \tan 30^\circ = \frac{BD}{72}$$

$$BD = 72 \tan 30^\circ$$

Q. A survey line CD intersects a building. To overcome the obstacle a perpendicular DE of 87m long is set out at D. From E, two lines EF and EG are set out and angles of 50° and 65° respectively with ED. Find the length of EF and EG such that the points F and G fall on the prolongation of CD. Also find the obstructed distance DF.



$$\cos 50^\circ = \frac{ED}{EF}$$

$$EF = \frac{87}{\cos 50^\circ} = 135.345 \text{ m}$$

$$\cos 65^\circ = \frac{ED}{EG}$$

$$EG = \frac{87}{\cos 65^\circ} = 205.85 \text{ m}$$

~~$$EF = \sqrt{(EF)^2 - (EG)^2}$$~~
~~$$= \sqrt{(135.345)^2 - (205.85)^2}$$~~

=

DT-22.01.2021

$$\text{True Distance} = \frac{I'}{I} \times ML = \frac{19.975}{20} \times 79.71 = 79.61 \text{ m}$$

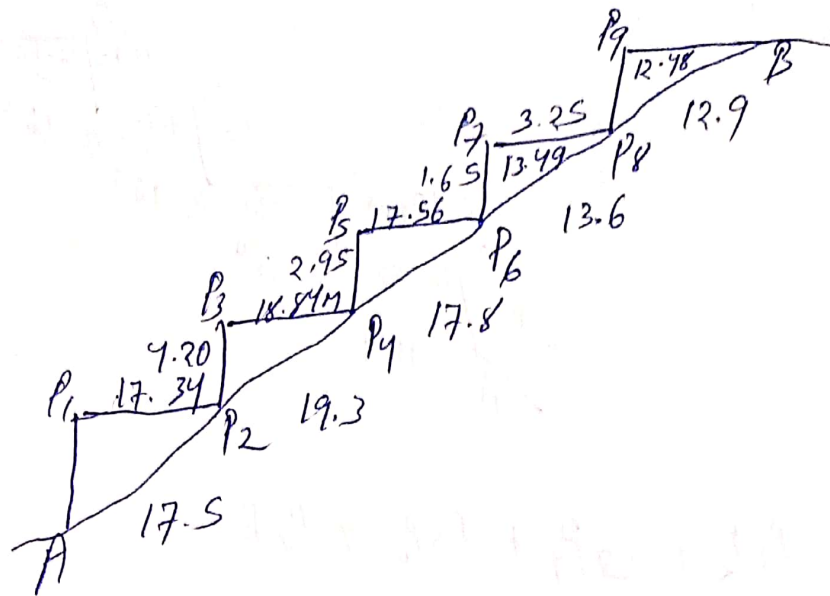
Slope distance (m) :- 17.5, 19.3, 17.8, 13.6 & 12.1

Distance of elevation betⁿ end points (m) :-
2.35, 4.20, 2.95, 1.65 & 3.3.

$$P_3 P_4 = \sqrt{(P_2 P_4)^2 - (P_2 P_3)^2}$$

$$= \sqrt{(19.3)^2 - (4.20)^2}$$

$$= 18.84 \text{ m}$$



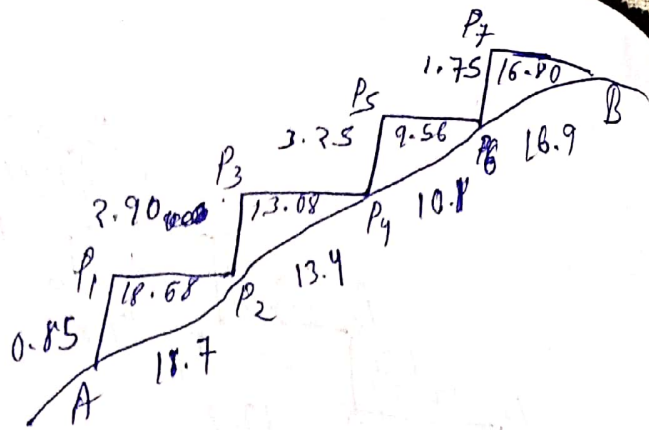
$$\begin{aligned}
 AB &= P_1 P_2 + P_2 P_3 + P_3 P_4 + P_4 P_5 + P_5 P_6 + P_6 P_7 + P_7 P_8 + P_8 P_9 + P_9 B \\
 &= 17.34 + 18.84 + 17.56 + 13.49 + 12.48 + 12.9 + 13.6 + 12.9 + 12.9 \\
 &= 79.71 \text{ m (measured length)}
 \end{aligned}$$

$$\begin{aligned}
 \therefore H' &= 20 - 0.025 = 19.975 \text{ m}
 \end{aligned}$$

Q) The following slope distance were measured along a chain line with a 20m steel tape. It was noted afterwards that the tape was 2.5 cm too long. Find the true total horizontal distance.

Slope distance (m) :- 18.7, 13.4, 10.1, 16.9

Distance the elevation betⁿ end points (m) :-
 0.85, 2.90, 3.25, 1.75

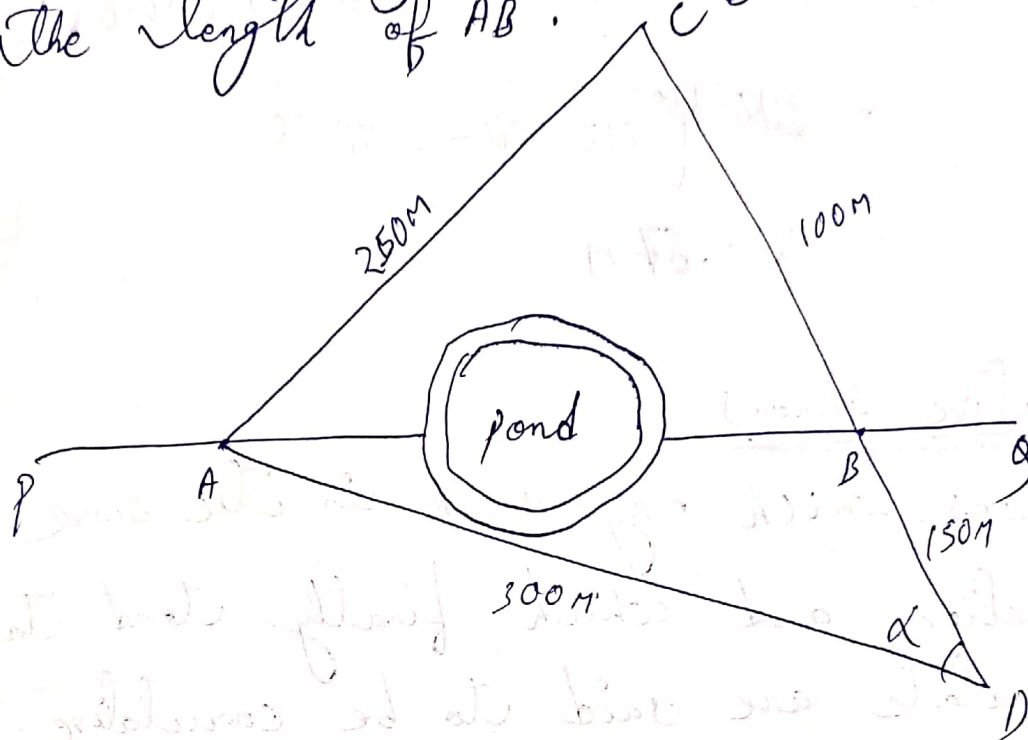


$$\begin{aligned}
 AB &= P_1P_2 + P_2P_3 + P_3P_4 + P_4P_5 + P_5P_6 + P_6P_7 + P_7B \\
 &= 18.68 + 13.08 + 9.56 + 16.80 \\
 &= 58.12 \text{ m}
 \end{aligned}$$

$l' =$

Q// A chain line PQ intersects a pond. Two points A and B are taken on the chain line on opposite side of the pond. A line AC, 250m long, is set out on the left of AB and another line AD, 200m long, is set out on the right of AB. points C, B and D are in the

same straight line. CB and BD are 100 and 150m long respectively, calculate the length of AB.



$$AC = 250m$$

$$AD = 300m$$

$$CB = 100$$

$$CD = 250m$$

Suppose, $\angle ADC = \alpha$.

In $\triangle ADC$,

$$AC^2 = AD^2 + DC^2 - 2AD \times DC \cos \alpha$$

$$\cos \alpha = \frac{AD^2 + DC^2 - AC^2}{2AD \times DC}$$

$$= \frac{300^2 + 250^2 - 250^2}{2 \times 300 \times 250}$$

$$\cos \alpha = 0.6$$

$$\angle ADB = AB^2 = AD^2 + DB^2 - 2AD \times DB \cos \alpha$$

$$AB = \sqrt{300^2 + 150^2 - 2 \times 300 \times 150 \times 0.6}$$

$$= \sqrt{112,500 - 54,000}$$

$$= 241.87 \text{ m}$$

Cumulative Errors

Errors which may occur in the same direction and which finally tend to accumulate are said to be cumulative. They seriously affect the accuracy of the work, and are proportional to the length of the line (L). The error is may be positive or negative.

Positive Errors

When the measured length is more than the actual length is more than the actual length, the error is said to be positive. Such errors occur due to

a) The length of chain or tape being shorter than the standard length.

- b) Slope correction not being applied,
- c) Correction for sag not being made.
- d) Measurement being taken with faulty alignment, and
- e) measurement being taken in high winds with the tape in suspension.

Negative Error

When the measured length of the line is less than the actual length, the error is said to be negative. These errors occur when the length of the chain or tape is greater than the standard length due to the following reasons.

- a) The opening of ring joints
- b) The applied pull being much greater than the standard pull.
- c) The temperature during measurement being much higher than the standard temperature.
- d) Wearing of connecting rings, and
- e) Elongation of the links due to heavy pull.

Mistake

Errors occurring due to the carelessness of the chairman are called mistakes. The following are a few common mistakes.

a) ~~Out~~ Displacement of arrows :-

Once an arrow is withdrawn from the ground during chaining, it may not be replaced in proper position, if required due to some reason.

b) A full chain length may be omitted or added. This happens when arrows are lost or wrongly counted.

c) A reading may be taken from the wrong end of the chain. This happens when the length of the tally is noted without observing the ~~correct~~ central tally.

d) The numbers may be read from the wrong direction, for instance, a '6' may be read as a '9'.

e) Some numbers may be called wrongly, for Example, 50.2 may be called "fifty-two" without the decimal point being mentioned.

f) while making entries in the field book, the figures may be interchanged due to carelessness: for instance, 245 may be entered instead of 254.

chapter-2

Chain Surveying

Dt-24.01.2020

Principle of chain surveying

1) The principle of the chain surveying is Triangulation. That means the area to be surveyed is divided into number of small triangles which should be well-conditioned.

Chain surveying is recommended when,

- 1- The area is small
- 2- A ground surface is more or less level.
- 3- well-conditioned triangle can be

easily formed.

4- There should be minimum undulation.

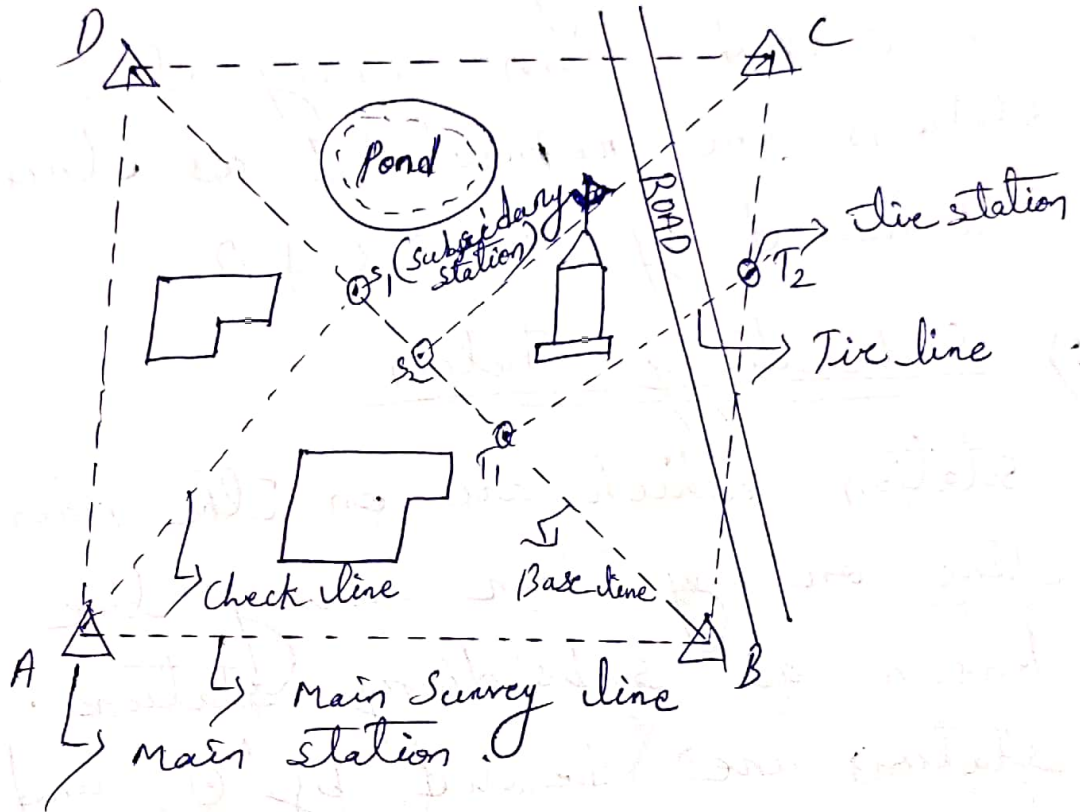
Reconnaissance

Before the commencement of any ^{survey} work, the area to be surveyed ^{is} thoroughly examined by the surveyor, who then thinks about the possible arrangement of the framework of ^{survey}. This primary investigation of the area is known as reconnaissance survey.

During the reconnaissance survey the surveyor should walk over the area and note the various obstacles and whether or not the selected stations are intervisible. The main stations should be selected that they enclose the whole area. The surveyor should also take care that the triangles formed are well condition.

Index sketch

The neat hand sketch of the area which is prepared during reconnaissance survey is known as Index sketch.



Survey station

Survey stations are the points at the beginning and the end of a chain line. Such stations may be of 3 types.

- 1- Main stations.
- 2- Subsidiary station
- 3- Tie station.

Main station

Stations taken along the boundary of an area is known as main stations. The line joining the main stations are called main survey line. Main stations are represented as triangles and named by A, B, C & D.

2) Subsidiary station

Station which are on the main survey line or any other survey line are known as subsidiary stations. The stations are denoted by 'O' and named as S_1, S_2, S_3 etc. These stations are taken to run subsidiary line for dividing the area into triangles.

3) Tie station

These are also subsidiary stations taken on the main survey line. Lines joining the tie stations are known as tie lines. Tie lines are mainly

taken to fix the directions of adjacent side of the chain survey map. These are also taken to form chain angles in chain traversing, when triangulation is not possible. Sometimes tie lines are taken to locate interior details. It is denoted by 'O', and named by T_1, T_2 etc.

Base line

The line on which the framework of the survey is built is known as base line. Generally, the longest of the main survey line is considered as the base line. This line should be taken through fairly level ground, and should be measured very carefully and accurately.

Check line

The line joining the apex point of a triangle to some fixed point on its base is known as check line.

It is taken to check the accuracy of the triangles. Sometimes its help to locate the interior details.

- 1- perpendicular offset
- 2- oblique offset

Offset
The linear measurement taken from an object to the chain line is known as offset.
Offset two types are

Expt - 7 offset

Calculation

For perpendicular offset

<u>Sl. No.</u>	<u>Chainage</u>	<u>offset</u>	<u>Distance</u>	<u>Remark</u>
1.	AB	offset (1) tree	3-4-5	3-4-5 method
2.	AB	store	—	3-4-5 method

For oblique offset

<u>Sl. No.</u>	<u>Chainage</u>	<u>offset</u>	<u>Distance</u>	<u>Remark</u>
1.	AB	Building Corner (P)	Px = — Py = —	Oblique offset

2. AB Building
Corner (O) OP = —
OG = —

3. AB Building
Corner R RM = —
RN = —

- cross staff
- optical square

Selection of survey station

- 1- whole to part
- 2- linear measurement or angular measurement
(Chain or Tape) (Compass, theodolite)

- 1- The stations should be so selected that the general principle of surveying can be followed.
- 2- The stations should be intervisible.
- 3- The stations should be selected in such a way that well-conditioned triangle should be formed.

4- The base line should be the ^{longest} of the main survey line.

5- The survey line should be taken through fairly level ground.

6- The main survey lines should ^{pass} ~~be~~ close to the boundary line of the area ~~should~~ ^{1st} be surveyed.

7- The survey line should be taken close to the object show that they can be located by short offset.

8- The line station should be suitably selected to find the directions of adjacent sides.

9- The subsidiary station should be suitably selected to ~~find~~ for taking ~~check~~ check line.

10- Stations should be so selected show that obstacles to chaining can be avoided as far as possible.

11- The survey line should not be very close to the main roads, as survey work may be interrupted by traffic.

- 1- General principle of surveying
 - 2- field book (p. 1 & p. 3)
 - 3- cross staff
- H.W

fractional distance measurement
(tally)

*General principle of surveying

The general principle of surveying are given below,

- To work from the whole to the part, and
- To locate a new station by at least two measurements (linear and angular) from fixed reference points.

1) According to the first principle, the whole area is first enclosed by main stations and main survey lines. The area is then divided into a number of parts by forming well-conditioned triangles.

A nearly equilateral triangle is considered the best well-conditioned triangle.

The main survey lines are measured ^{very} ~~accumulation~~ ~~of error~~ accurately with a standard chain. Then the sides of the triangles are measured. The purpose of the process of working is to prevent accumulation of error. During the procedure, if there is any error in the measurement of any side of a triangle then it will not affect the whole work. The error can always be detected and eliminated.

But, if the reverse process is followed then the minor errors in measurement will be magnified in the process of expansion and a stage will come when these errors will become absolutely uncontrollable.

2) According to the second principle the new stations should always be fixed by at least two measurements from fixed

reference points. Linear measurement refers to horizontal distance measured by chain or tape. Angular measurements refer to the magnetic bearing or horizontal angle taken by a prismatic compass or theodolite.

In chain surveying, the positions of main stations and directions of main survey lines are fixed by tie lines and check lines.

Cross-staff

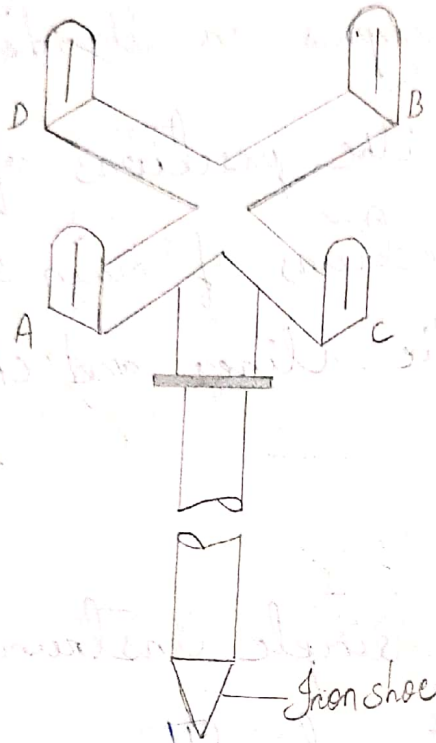
The cross-staff is a simple instrument for setting out right angles. There are three types of cross-staves.

- 1- Open
- 2- French
- 3- Adjustable

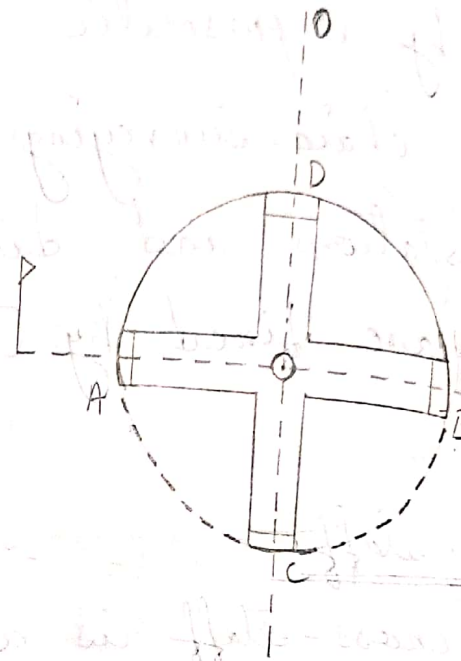
1- Open cross staff

The open cross staff consists of four metal arms with vertical slits. The two pairs of arms are at right angles to each other. The vertical slits are meant for sighting the object and the ranging rods.

The cross-staff is mounted on a wooden pole of 1.5m length and 2.5 cm diameter. The pole is fitted with an iron shoe.



(a) POLE



(b) movement of cross-staff

For setting out a perpendicular on a chain line, the cross-staff is held vertically at the approximate position. Suppose slits A and B are directed to the ranging rods (R, R_1) fixed at the end stations. Slits C and D are directed to the object (O). Looking through slits A and B, the ranging rods are bisected. At the

same time, looking through slits C and D, the object O is also bisected. To bisect the object and the ranging rods simultaneously, the cross-staff may be moved forward or backward along the chain line.

The field book

The notebook in which field measurements are noted is known as the 'field-book'. The size of the field book is $20\text{cm} \times 12\text{cm}$ and it opens lengthwise. Field books may be of two types.

1- single-line

2- Double line:

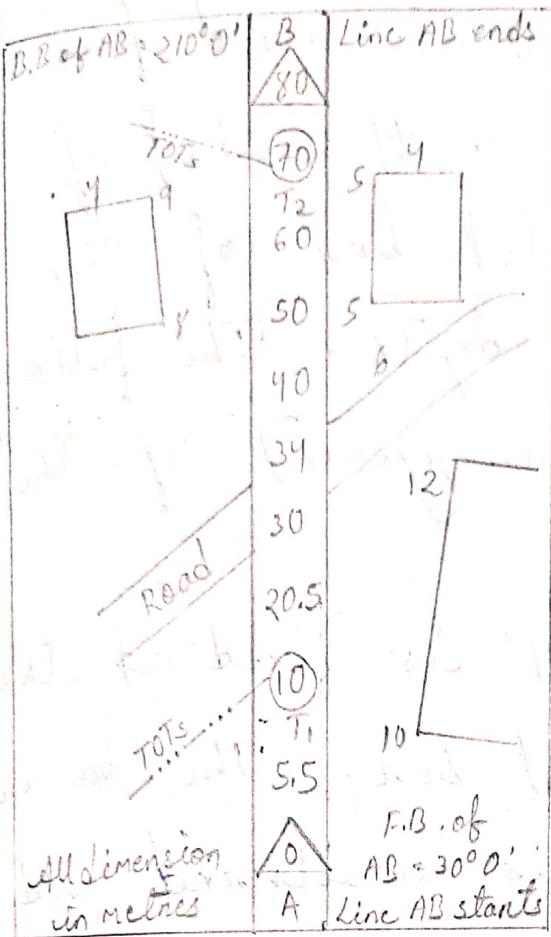
Single line

In this type of field book, a single red line is drawn through the middle of each page. This line represents the chain line, and the chainages are written on it. The offsets are recorded, with sketches, to the left or right

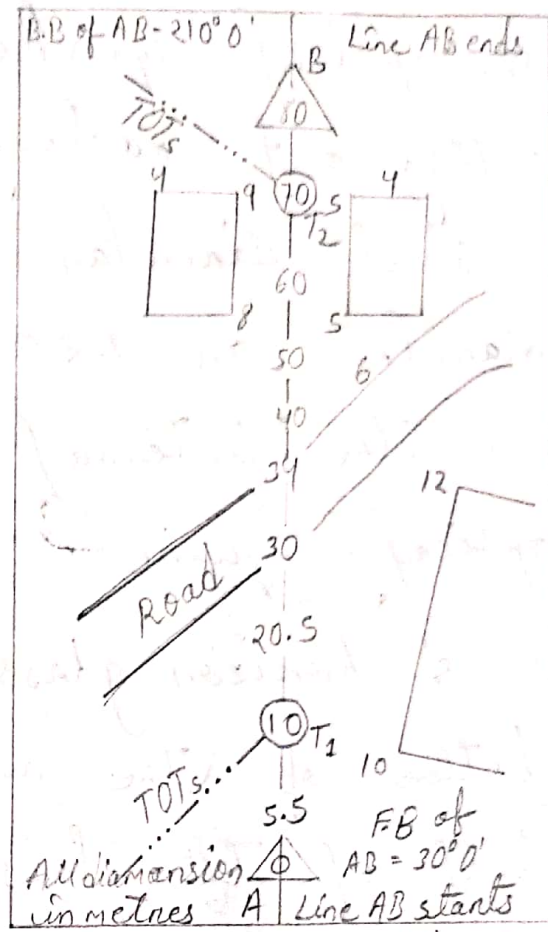
of the chain line. The recording of the field book is started from the last page and continued towards the first page. The main stations are marked by 'S' and subsidiary stations or tie stations are marked by 'O'.

2- Double-line field book

In this type of field book, two red lines, 1.5 cm apart, are drawn through the middle of each page. This column represents the chain line, and the chain ~~ages~~ are written in it. The offsets are recorded, with sketches, to the left or right of this column. The recording is begun from the last page and continued toward the first. The main stations are marked by 'S' and subsidiary or tie stations by 'O'. This type of field book is commonly used.



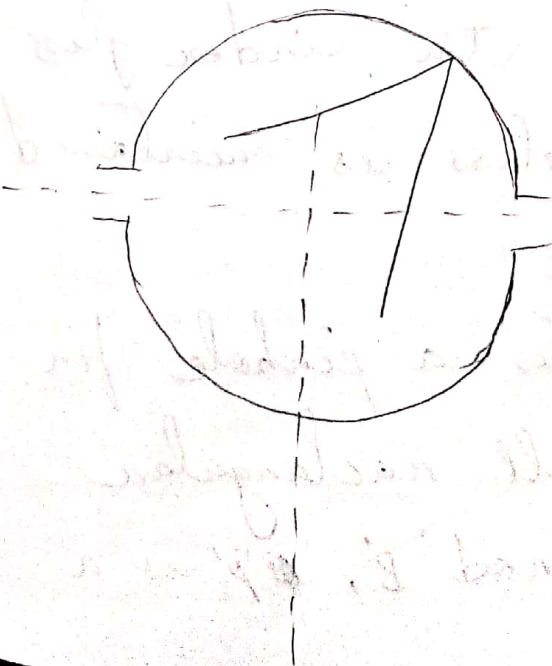
Double-line field book



Single-line field book

Optical Square

Df-31.01.2020



An optical square is also used for setting out rectangle. It consists of a small circular metal box of 5 cm diameter and 1.25 cm depth. The following are the internal arrangements of the optical square.

1. A horizon glass 'H' is fixed at the bottom of the metal box. The lower half of the glass is unsilvered and the upper half of the glass is silvered.

2. An index glass 'I' is also fixed at the bottom of the box which is completely silvered.

3. The angle between the index glass and the horizon glass is maintained 45° .

4. The opening 'C' is a pinhole for eye 'E', 'B' is a small rectangular hole for ranging rod 'B', 'P' is a

large rectangular hole for object 'P'.

5) The line EB is known as horizon sight and IP is known as index sight.

6) The horizon glass is placed at an angle of 120° with the horizon sight.

The index glass is placed at an angle of 105° with the index sight.

7) The ray of light from P is first reflected from I, then it is further reflected from H, after which it ultimately reaches to the eye E.

Principle

According to the principle of reflection,

setting up the perpendicular by optical square

- a) The observer should stand on the chain line and approximately at the position where the perpendicular is to be set up.
- b) The optical square is held by the arm at the eye level. The ranging rod at the forward station P is observed through the unsilvered portion on the lower part of the horizon glass.
- c) Then the observer looks through the upper silvered portion of the horizon glass to see the image of the object P .
- d) Suppose the observer finds the ranging rod B and the image of object P do not coincide. Then he should move forward or backward

along the chain line until the ranging rod B and the image of object P exactly coincide.

c) At this position, the observer marks a point on the ground to locate the foot of the perpendicular.

Chapter-4 Plane Table surveying

Principle of plane Table surveying

The principle of plane Table surveying is parallelism, means the ray drawn from station to object on the paper are parallel to the lines from the station to the object on the ground.

Accessories of a plane Table

1- The plane table

The plane table is a drawing board of 750mm x 600mm size made of well-seasoned wood like Teak, pine etc.

The top surface surface of the Table is well levelled. The bottom surface consist of a Threaded circular plate for fixing the Table on the Tripod stand by a wing nut.

The ^{plate} table is meant for fixing a drawing sheet over it. The positions of the objects are located on this sheet by drawing rays and plotting to any suitable scale.

2- The Alidade

There are two type of alidade -

i- plane alidade

ii- Telescopic

i) plain Alidade

The plain alidade consists of a metal or wooden ruler of length about 50 cm. One of its edges is bevelled, and is known as the fiducial edge. It consists of two vases at both ends which are hinged with the ruler. One is known

as the object vane and carries a horse hair, the other is called the sight vane and is provided with a narrow slit.

ii) Telescopic Alidade

The Telescopic alidade consists of a Telescope meant for inclined sight on sighting distant object clearly. This alidade has no vanes at the ends, but is provided with fiducial edge.

The function of the alidade is to sight objects. The rays should be drawn along the fiducial edge.

3- The spirit level

The spirit level is a small metal tube containing a small bubble of spirit. The bubble is visible on the top along a graduated glass tube.

The spirit level is meant for levelling the plane table.

4- The Compass

There are two kinds of Compass -

a) The Trough Compass

b) The circular box Compass

a) The Trough Compass

The Trough Compass is a rectangular box made of non-magnetic metal containing a magnetic needle pivoted at the centre. This Compass consists of a '0' mark at both ends to show the N-S direction.

b) The circular box Compass

It carries a pivoted magnetic needle at the centre. The circular box is fitted on a square base plate. Sometimes two bubble tubes are fixed at right angles to each other on the base plate. The compass is meant for marking the north direction of the map.

5- ~~U-fork~~ U-fork on plumbing, fork with
~~plumb bob~~ plumb bob.

The U-fork is a metal strip bent in the shape of a 'U' having equal arm lengths. The top arm is pointed and the bottom arm carries a hook for suspending a plumb bob.

This is meant for centring the table over a station.

Orientation

The method of setting up the plane table at each of the successive stations parallel to the position it occupied at the starting stations is known as orientation.

Orientation must be done when the plane table is set up at more than one station. As already stated, plane tabling is based on the principle of parallelism. So, the relative positions of the objects on the map

will be accurate only if the orientation is proper. But if orientation is not done then the map will not represent the actual positions of the objects.

Orientation may be done by magnetic needle and backsighting.

Orientation by magnetic needle

This method is suitable when local attraction is not suspected in the area.

Procedure

As suppose A and B are two stations.

The plane table is set up at the station A, and levelled by spirit level.

The centring is done by U-fork and plumb bob so that point a is just over the station A. Then the trough

Compass or circular box compass is placed on the right-hand top corner of the sheet in such a way that

the needle coincides with '0-0' mark, After this, a line representing the north line is drawn through the edge of the compass box. The Table is then clamped.

b) with the alidade touching the point a, the ranging rod at B is bisected and a ray is drawn. The distance AB is measured and plotted to any suitable scale.

c) The table is shifted and centred over B, so that the point b is just over B. The Table is levelled. Now the trough Compass is placed exactly along the north line drawn previously. The table is then turned clockwise or anticlockwise until the needle coincides exactly with the 0-0 mark of the Compass. while turning the table, care should be taken not to disturb the centring. In case it is, should

be adjusted immediately.

d) When the centring and levelling are perfect and the needle is exactly at 0-0, the orientation is said to be perfect.

Orientation by Backsighting

This method is accurate and is always preferred.

Procedure

a) Suppose A and B are two stations. The plane table is set up over A. The table is levelled by spirit level and centred by V-bank so that the point a is just over station A. The north line is marked on the right-hand top corner of the sheet by a rough compass.

b) With the alidade is tracing a, the ranging rod at B is bisected and a ray is drawn. The distance AB is

measured and plotted to any suitable scale. So, the point b represents station B .

9) The table is shifted and set up over B . It is levelled and centred so that b is just over B . Now the alidade is placed along the line ba , and the ranging rod at A is bisected by turning the table clockwise or anticlockwise. At this time the centring may be disturbed, and should be adjusted immediately if required. When the centring, levelling and bisection of the ranging rod at A are perfect then the orientation is said to be perfect.

Procedure of setting up a plane table over a station

1- Fixing the table on the tripod stand

The tripod stand is placed over the required station with its legs well apart. Then the table is fixed

on it by a wing nut at the bottom.

2- Levelling the Table

The Table is levelled by placing the spirit level at different corners and various positions on the Table. The bubble is brought to the centre of its run at every position of the Table by adjusting the legs.

3- Centring the Table

The drawing Sheet is fixed on the Table. A suitable point P is selected on the sheet to represent the station P on the ground. A pin is then fixed on this selected point. The upper pointed end of the V-fork is made in contact with the station pin and the plumb bob which is suspended from the hook at the lower end is brought just over the station P by turning the Table clockwise or anticlockwise.

on slightly adjusting the legs. This operation is called centring. The Table is then clamped. Care should be taken not to disturb the levelling.

4- Marking the North line

The trough compass is placed on the right-hand top corner with its north end approximately towards the north. Then the compass is turned clockwise or anticlockwise so that the needle coincides exactly with the 0-0 mark. Now a line representing the north line is drawn through the edge of the compass. It should be ~~e~~-ensured that the table is not turned.

5- Orientation

When plane table survey is to be conducted by connecting several stations the orientation must be performed at every successive station. It may be done

by a magnetic needle or by the back-sighting method. The backsighting process is always preferred, because it is reliable. During orientation, it should always be remembered that the requirement of centring, levelling and orientation must be satisfied simultaneously.

Method of plane table

The following are 4 methods of plane tabling.

- 1 - Radiation
- 2 - Intersection
- 3 - Traversing
- 4 - Resection

1- Radiation

This method is suitable for locating the object from a single station.

In this method, rays are drawn from the station to the objects, and

The distances from the station to the objects are measured and plotted to any suitable scale along the respective rays.

procedure

a) Suppose P is a station on the ground from where the objects A, B, C and D are visible.

b) The plane table is set up over the station 'P'. A drawing sheet is fixed on the table, which is levelled and centred. A point P is selected on the sheet to represent the station.

c) The north line is marked on the right-hand top corner of the sheet with trough compass or circular box compass.

d) Find the total corrections per tape length with following details.

Length of tape = 30m

weight of tape = 1.20

df-03.02.2020

temperature at tape which tape is standardised = 14°C
pull at which the tape is standardised = 10 kg

field temperature = 32°C

pull applied in field = 15 kg

density of steel = 7.86 g/cm^3

modulus of elasticity of tape (E) = $2.1 \times 10^6\text{ kg/cm}^2$

co-efficient per thermal expansion = $0.0000035/^{\circ}\text{C}$

weight of tape = $A \times \text{Length} \times \text{Density}$

$$1.2 = A \times 30 \times 100 \times 7.86$$

$$A = \frac{30 \times 100 \times 7.86 \times 10^{-3}}{1.2}$$

$$A = 0.051\text{ cm}^2$$

$$C_p = \frac{(P_1 - P_0)L}{AE}$$

$$= \frac{(15 - 10) \times 30}{0.051 \times (2.1 \times 10^6\text{ kg/cm}^2)}$$

$$= 1.4 \times 10^{-3}$$

$$= 0.0014\text{ m (+ve)}$$

$$C_T = \alpha \Delta (T_M - T_0) L$$

$$= \cancel{60} (0.0000035 \times 30) \cancel{L}$$

$$= 0.0000035 (32 - 14) \times 30$$

$$= 1.89 = 0.002 \text{ m (ve)}$$

$$C_S = \frac{L W^2}{24 P M^2}$$

$$= \frac{(30 \times 1.2)^2}{24 \times (15)^2}$$

$$= 0.008 \text{ (-ve)}$$

$$\text{Total correction} = \cancel{0.004} C_P + C_S + C_T$$

$$= 0.0014 - 0.008 + 0.002$$

$$= -0.0046 \text{ m (Ans)}$$

49// A line was measured with a steel tape of 30m length which was standardizing for pull of 5kg. The length of line was found to be 670m. If the actual pull during measurement was 10kg, determine the true length of line. The

Cross-sectional area of tape $\approx 0.02 \text{ cm}^2$ and modulus of elasticity of tape is $\approx 2.1 \times 10^6 \text{ kg/cm}^2$.

Q. In the above problem, the temperature at which tape was standardised is 18°C and the field temperature is 34°C , find the total correction.

Assume coefficient of thermal expansion $0.0000035/^\circ\text{C}$.

Given, $L = 30 \text{ m}$

$$P_0 = 5 \text{ kg}$$

$$\Delta P = \frac{(P_m - P_0)L}{AE}$$

$$= \frac{(10 - 5)30 \text{ m}}{0.02 \times 2.1 \times 10^6 \text{ kg/cm}^2}$$

$$= 0.0035 \text{ (+ve)}$$

Correction length of tape $\approx 30 + 0.0035$

$$(L') = 30.0035$$

Given,

$$T_0 = 18^\circ\text{C}$$

$$T_M = 34^\circ\text{C}$$

$$L =$$

$$\text{True length of line} = \frac{L'}{L} \times ML$$

$$= \frac{30.0035}{30} \times 670$$

$$= 670.078$$

$$\Delta L = L (T_M - T_0) \times \alpha$$

$$= 0.000035 \times (34 - 18) \times 30$$

$$= \cancel{0.00168} \quad 0.00168$$

$$\text{Correction length of tape} = 30 + 0.00168$$

$$L' = 30.00168$$

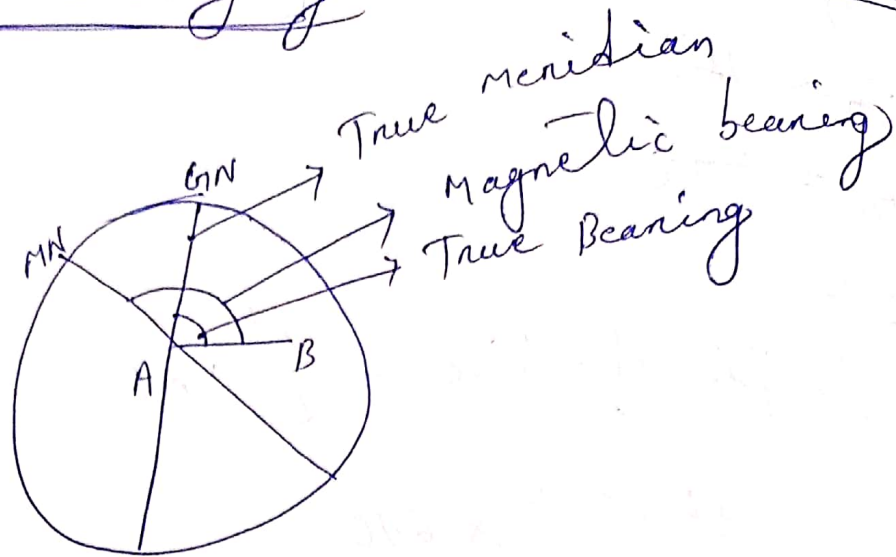
$$\text{True length of line} = \frac{L'}{L} \times 670$$

$$= \frac{30.00168}{30} \times 670$$

$$= 670.03752$$

Compass Surveying

Df-06-02-2020



Compass Traversing

Df-07-02-2020

Compass surveying is a type of surveying in which the direction of surveying lines are determined with a magnetic compass and the length of surveying lines are measured with a chain & tape. The compass is generally used to run a traverse line.

Principle of Compass Surveying

The principle of compass surveying is traversing, which involves a series of connected lines. The magnetic bearing of the lines are measured by prismatic compass & the distance

(length) of the area measured.

Meridian

The direction of line is expressed in terms of horizontal angle which the line makes with the reference line.

The fixed reference line is called meridian. There are 4 types of meridian.

① True meridian

The true meridian is the plane that passes through true north pole & true south pole at the spot of the observer.

The angle between the true meridian and a line is known as true bearing. It is also known as azimuth.

② Magnetic Meridian

When a magnetic needle is suspended freely and balanced properly unaffected by magnetic substances, it indicates a direction. The angle between magnetic meridian and a line is known as

magnetic bearing or simply a bearing of the line.

③ Arbitrary meridian

Some times for the survey of a small area, a convenient direction is assume as a meridian, known as arbitrary meridian.

The angle between the arbitrary meridian and ϕ a line is known as arbitrary bearing of the line.

④ Grid meridian

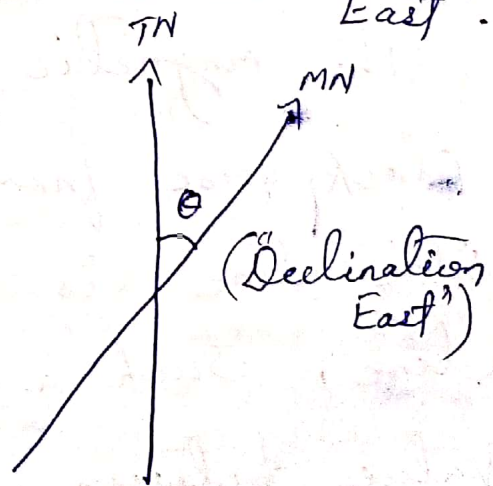
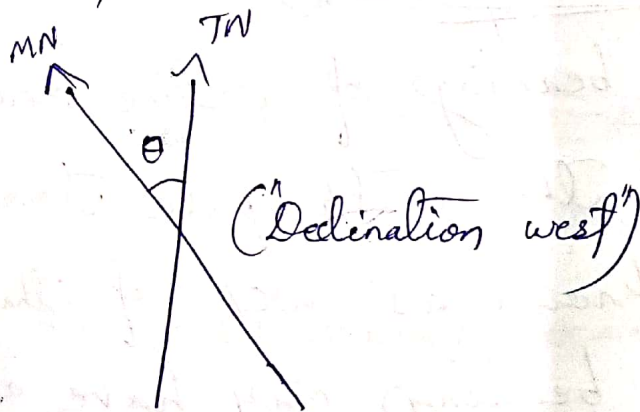
Some time for preparing a map, a state agencies assume several line parallel to the true meridian for a particular zone. These lines are termed as grid lines. ϕ the centre lines are called grid meridian.

The bearing of a line w.r.t grid meridian is known as the grid bearing of line.

Magnetic Declination

The horizontal angle between the magnetic meridian and the true meridian is known as magnetic declination. When the north end of the magnetic needle is pointed towards the west side of the true meridian the position is termed "Declination west".

When the north end of the magnetic needle is pointed towards the east side of the true meridian the position is termed "Declination East".

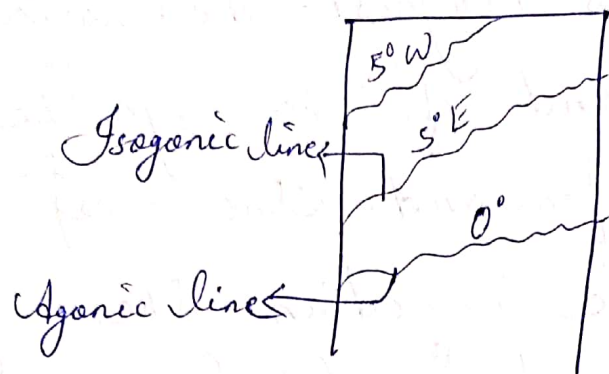


Isogonic Line

The line passing through points of equal declination are known as Isogonic line.

Agonic line

The line passing through points of zero declination is known as Agonic line.



Magnetic Bearing

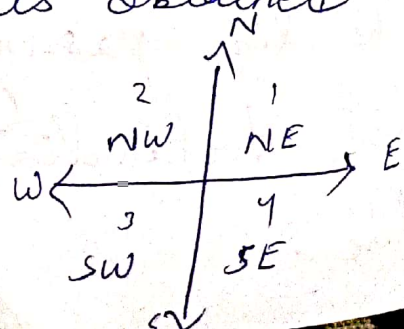
① whole circle bearing (WCB)

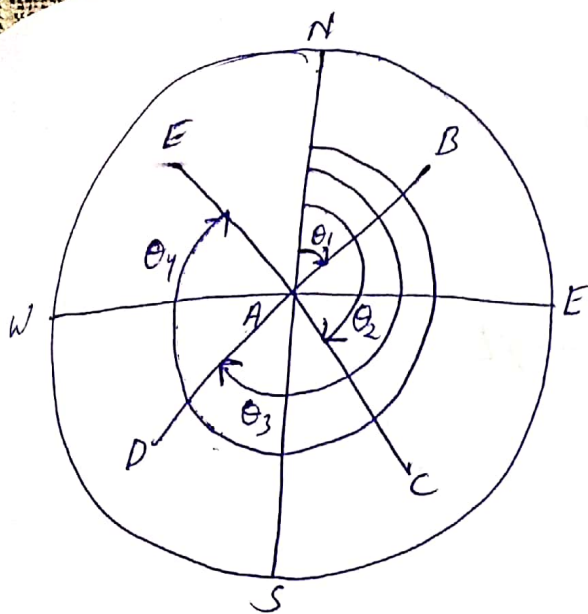
② Quadrantal bearing (QB)

1- whole circle bearing (WCB)

The magnetic bearing of a line measures clock wise from the north pole towards the line. Such a bearing is known as WCB of that line. Such a bearing may have any value between 0° to 360° .

The WCB of a line is obtained by using a magnetic compass.





WCB of AB = θ_1

WCB of AC = θ_2

WCB of AD = θ_3

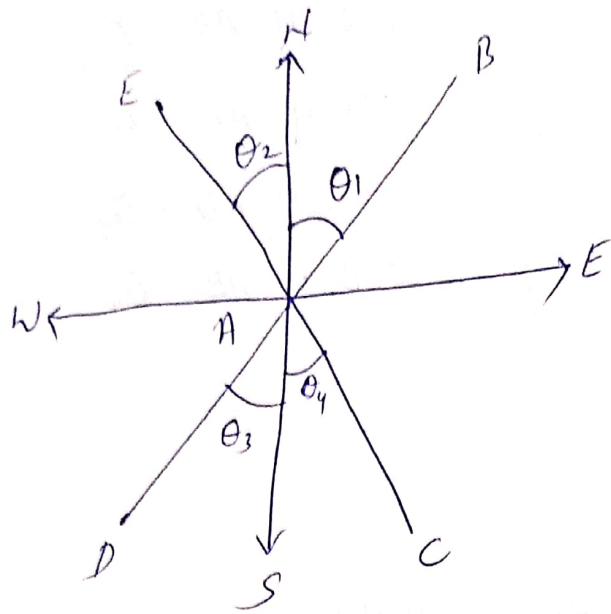
WCB of AE = θ_4

2- Quadrantal bearing ("QB")

The magnetic bearing of a line measured clock wise or anti clock wise from the north pole or south pole (which ever is nearer the line) towards the east or west, is known as quadrantal bearing of the line.

This system consist of four quadrant namely NE, NW, SE & SW. The value of a quadrantal bearing lies betⁿ 0° & 90° , but the quadrants should always be mention.

Quadrantal bearing is obtain through Sunner's Compass.



- Reduced bearing ("RB")
- when the WCB is converted into QB is known as reduced bearing
 - It is also same as QB and the values lie betⁿ 0° & 90°

WCB between	Corresponding "RB"	Quadrant
0° and 90°	$RB = WCB$	NE
90° and 180°	$RB = 180^\circ - WCB$	SE
180° and 270°	$RB = WCB - 180^\circ$	SW
270° and 360°	$RB = 360^\circ - WCB$	NW

Convert the following WCBs to GBs.

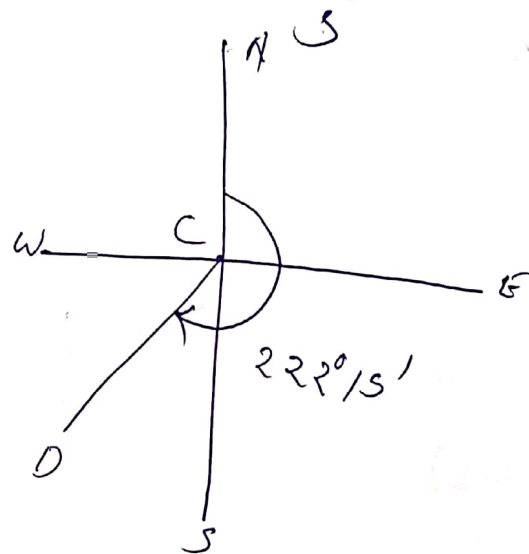
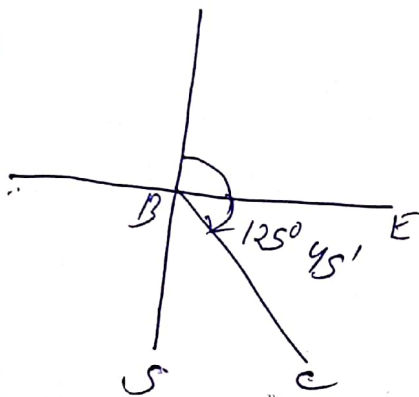
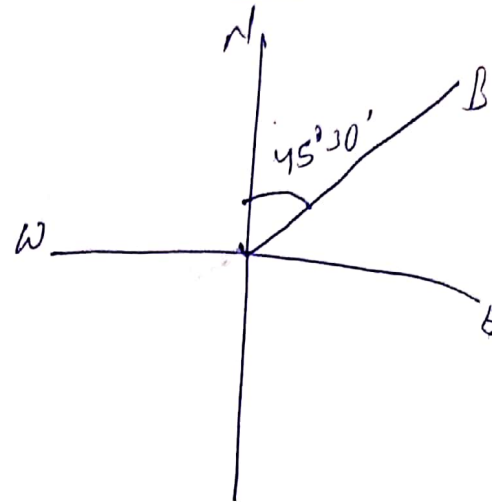
Df-10, 02.6

1- WCB of AB = $45^{\circ}30'$

2- WCB of BC = $125^{\circ}45'$

3- WCB of CD = $222^{\circ}15'$

4- WCB of DE = $320^{\circ}30'$

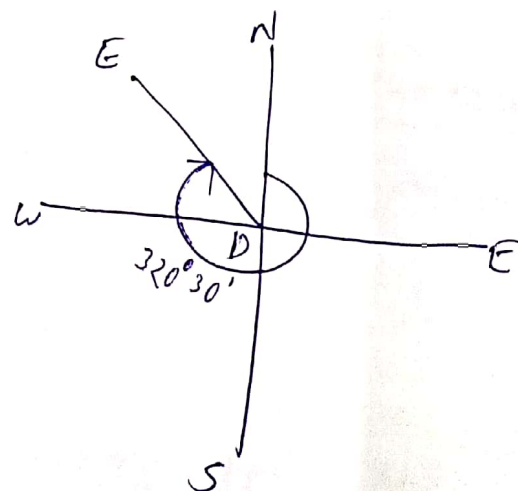


Ans

1- GB = $N45^{\circ}30'E$

2- GB = $S54^{\circ}15'E$

3- GB =



Convert the following GB to WCB

~~① WCB of DE = $320^{\circ}30'$~~

① GB of AB = $S 36^{\circ}30' W$

② " of BC = $S 43^{\circ}30' E$

③ " " CD = $N 26^{\circ}45' E$

④ " " DE = $N 40^{\circ}15' W$

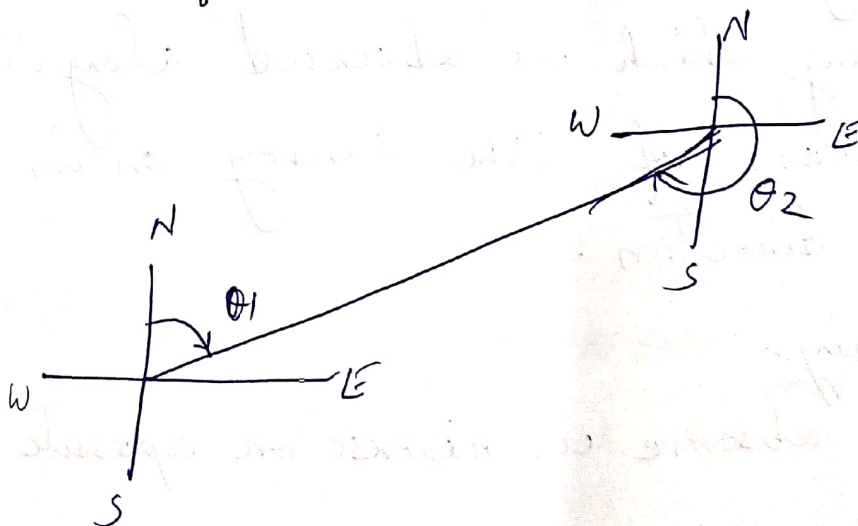
Ans:

① $WCB = 180^{\circ} + 36^{\circ}30' = 216^{\circ}30'$

② $WCB \text{ of } BC = 180^{\circ} - 43^{\circ}30' = 136^{\circ}30'$

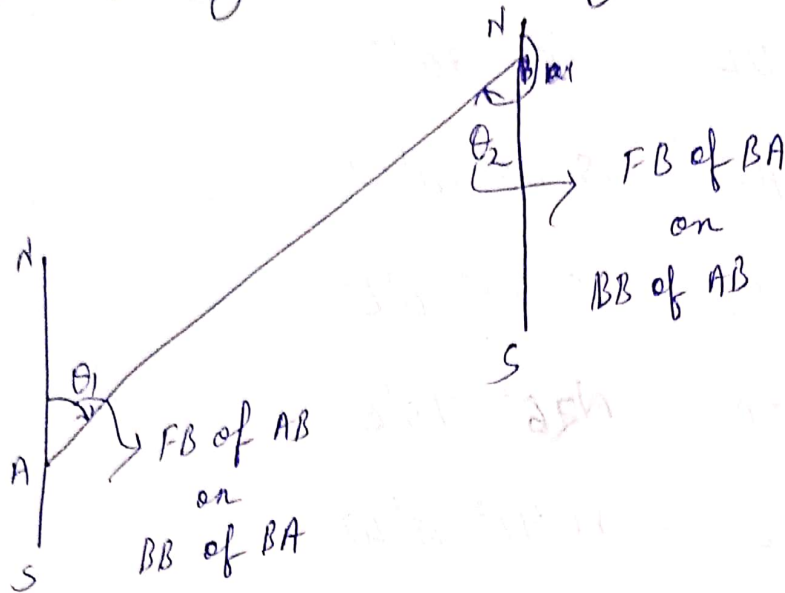
③ $WCB \text{ of } CD = 26^{\circ}45'$

④ $WCB \text{ of } DE = 360^{\circ} - 45^{\circ}15' = 314^{\circ}45'$



Fore bearing & Back bearing

Dt-12.02.20



Every line has two bearing,

- 1- Fore bearing (FB)
- 2- Back bearing (BB)

Fore Bearing

1. The bearing which is observed along the
2. The progress of the survey on its
3. forward direction.

Back bearing

which is observe in reverse or opposite direction.

Consider AB is a line, bearing is measured clockwise from the meridian.

The bearing as measured at A along the forward direction is θ_1 .

So the bearing θ_1 is known as FB of line AB.

Similarly, the bearing is measured at B in the opposite direction of progress of survey (that is A to B) along clockwise direction is θ_2 .

The θ_2 is known as Back bearing of line AB.

Back bearing = Fore bearing $\pm 180^\circ$

$$BB = FB \pm 180^\circ$$

* Use positive sign when FB is $< 180^\circ$

" Negative " " " FB is $> 180^\circ$

* In GB system, the numerical value is same, but only the S is change.

~~Ex~~ i.e FB of AB $N 30^\circ E$

BB of AB $S 30^\circ E$

DT-14.02.2020

Problems on fore and back bearings

The FB of the following lines are given find out it BB.

- Ans
- 1- FB of AB = $310^{\circ} 30'$ $\Rightarrow$ ~~BB of AB~~
 - 2- FB of BC = $145^{\circ} 15'$ $\Rightarrow$
 - 3- FB of CD = $210^{\circ} 30'$ $\Rightarrow$
 - 3- FB of DE = $60^{\circ} 45'$ $\Rightarrow$

- Ans
- 1- BB of AB = $310^{\circ} 30' - 180^{\circ} 0' = 130^{\circ} 30'$
 - 2- BB of BC = $145^{\circ} 15' + 180^{\circ} 0' = 325^{\circ} 15'$
 - 3- BB of CD = $210^{\circ} 30' - 180^{\circ} 0' = 30^{\circ} 30'$
 - 4- BB of DE = $60^{\circ} 45' + 180^{\circ} 0' = 240^{\circ} 45'$

Q FB of the following lines are given find out its BB.

- 1- FB of AB = $S 30^{\circ} 30' E$
- 2- FB of BC = $N 40^{\circ} 30' W$
- 3- FB of CD = $S 60^{\circ} 15' W$
- 4- FB of DE = $N 45^{\circ} 30' E$

Ans

- 1- BB of AB = $N 30^{\circ} 30' W$
- 2- BB of BC = $S 40^{\circ} 30' E$
- 3- BB of CD = $N 60^{\circ} 15' E$
- 4- BB of DE = $S 45^{\circ} 30' W$

Q) BB of following lines are given find out its FB.

1- BB of AB = $40^{\circ} 30'$

2- BB of BC = $310^{\circ} 45'$

3- BB of CD = $145^{\circ} 45'$

4- BB of DE = $215^{\circ} 30'$

Ans

FB of AB = $40^{\circ} 30' + 180^{\circ} 0' = 220^{\circ} 30'$

FB of BC = $310^{\circ} 45' - 180^{\circ} 0' = 130^{\circ} 45'$

FB of CD = $145^{\circ} 45' + 180^{\circ} 0' = 325^{\circ} 45'$

FB of DE = $215^{\circ} 30' - 180^{\circ} 0' = 35^{\circ} 30'$

Q) The FB of a line PQ is 180° find out its BB. ~~Convert the~~

~~Convert~~ the following RB, WCB.

1- RB - WCB
N $30^{\circ} 35' E \Rightarrow 30^{\circ} 35'$

2- S $40^{\circ} 23' W \Rightarrow 223^{\circ} 23'$

3- S $18^{\circ} 28' E \Rightarrow 161^{\circ} 32'$

4- N $25^{\circ} 35' W \Rightarrow 334^{\circ} 25'$

3) WCB - RB

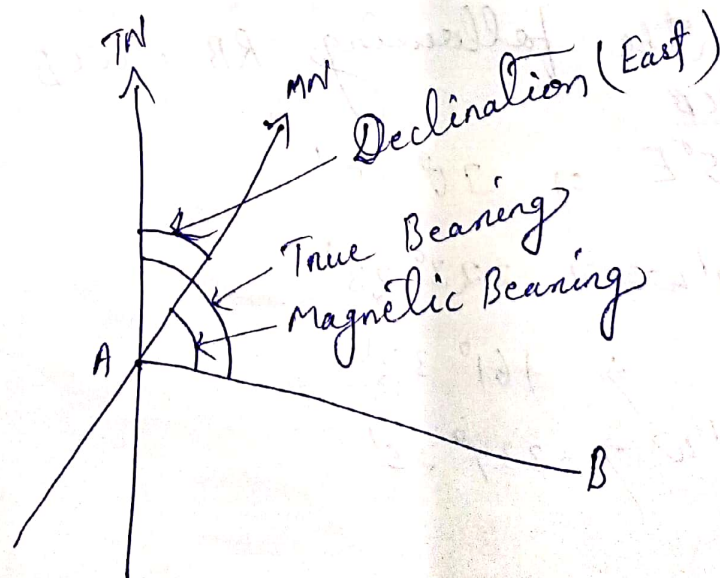
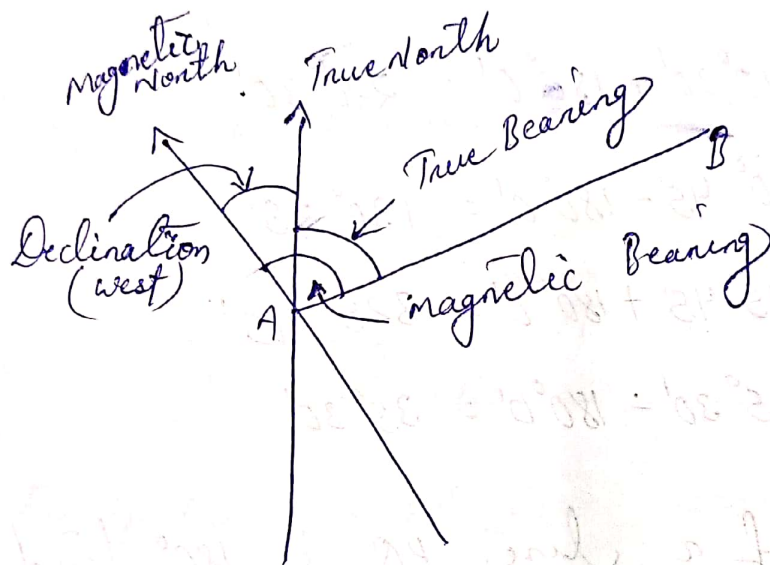
1- $75^{\circ} 38' = N 75^{\circ} 38' E$

2- $143^{\circ} 33' = 143^{\circ} 33' - 180^{\circ} = S 36^{\circ} 27' E$

3- $187^{\circ} 38' = 187^{\circ} 38' - 180^{\circ} = S 7^{\circ} 38' W$

4- $285^{\circ} 14' = 285^{\circ} 14' - 360^{\circ} = N 74^{\circ} 46' W$

Problems on magnetic Declination



a) True bearing = Magnetic bearing + Declination
(Use the positive sign when declination is east).

And negative sign when declination is west)

b) Magnetic bearing = True bearing + Declination
(The positive sign when declination is west
And the negative sign when declination is east)

Q/a) The magnetic bearing of a line AB is $135^{\circ} 30'$. What will be the True bearing if the declination is $5^{\circ} 15' W$.

b) The True bearing of a line CD is $210^{\circ} 45'$. What will be its magnetic bearing if the declination is $8^{\circ} 15' W$.

Ans

a) True bearing of AB

= Magnetic bearing - Declination

= $135^{\circ} 30' - 5^{\circ} 15'$

= $130^{\circ} 15'$

Magnetic bearing = True bearing + declination
= $210^{\circ} 45' + 8^{\circ} 15' = 219^{\circ} 0'$

Q// The magnetic of a line CD is $50^{\circ} 30' + 15' W$ 27-17-02-2022
 find its true bearing if the declination
 is $10^{\circ} 15' E$

$$= RB = S 30^{\circ} 15' + 180^{\circ} = 210^{\circ} 15'$$

$$= \text{Declination } 210^{\circ} 15' - 180^{\circ} \\ = 220^{\circ} 30'$$

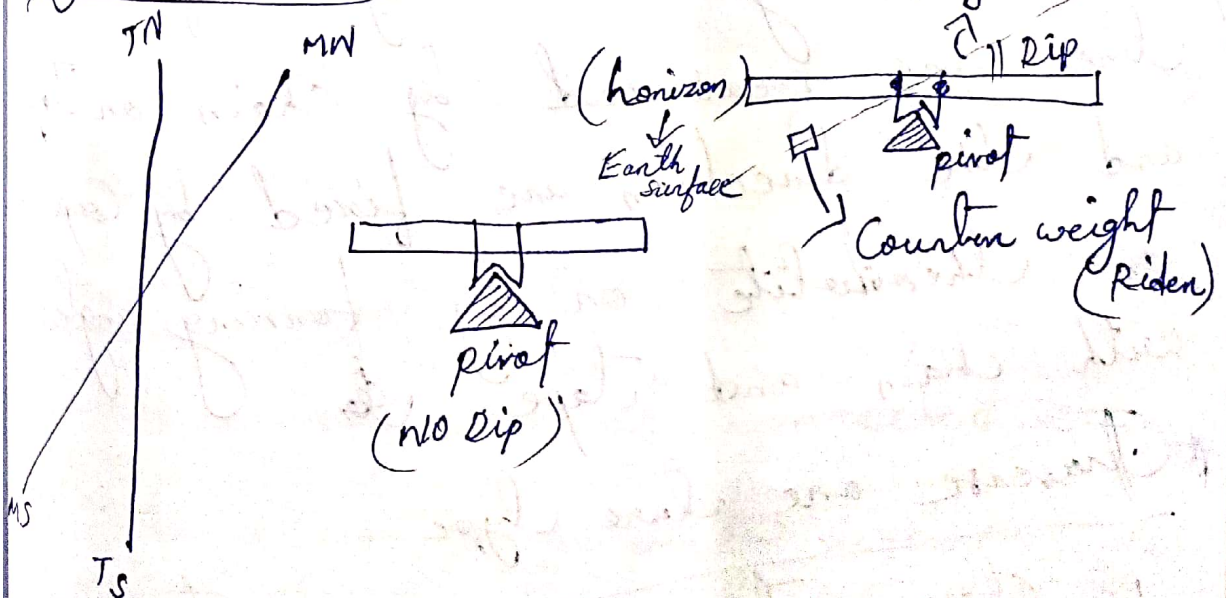
$$= \text{Required True bearing } = 220^{\circ} 30' - 180^{\circ} \\ S - 40^{\circ} 30' W$$

Problem of Inclined angle

The bearings of the line, OA, OB, OC, OD
 are $30^{\circ} 30'$, $140^{\circ} 15'$, $220^{\circ} 45'$ & $310^{\circ} 30'$ respectively
 find the angle $\angle OAB$ & $\angle COD$.

Magnetic dip

27-19.02.2020



magnetic dip angle between magnetic field line and the horizontal ~~line~~ plane at a particular location on the planet. This angle varies at different point on the earth surface.
At equator the dip is $0^\circ = \text{min}^\circ$,
At pole dip $= 90^\circ = \text{Max}^\circ$

Traversing

✓ In surveying, which involves a series of connected line is known as Traversing.

✓ The sides of the Traverse are known as Traverse legs.

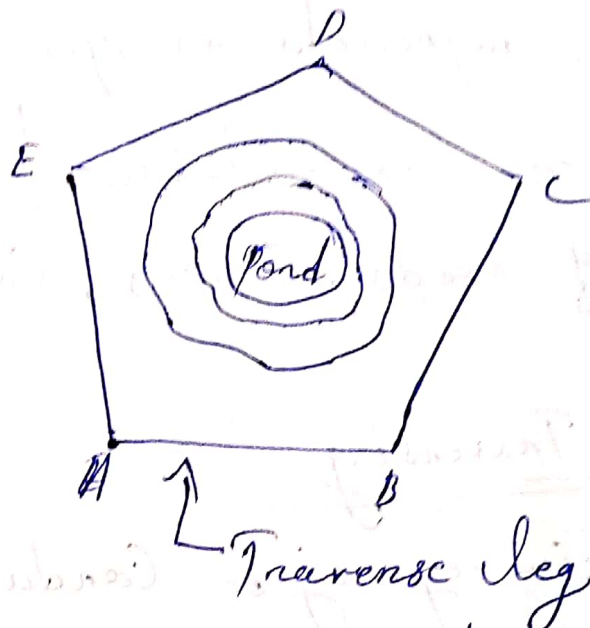
✓ In traversing the length of the lines are measured by chain or tape and the direction are fixed by compass or theodolite or by fore-sight angle with chain and tape.

Traverse are two types

1- Close Traverse 2- Open Traverse

Close Traverse

When a series of connected lines forms a closed circuit, i.e. when the finishing point coincides with the starting point of a survey, it is called a close traverse.



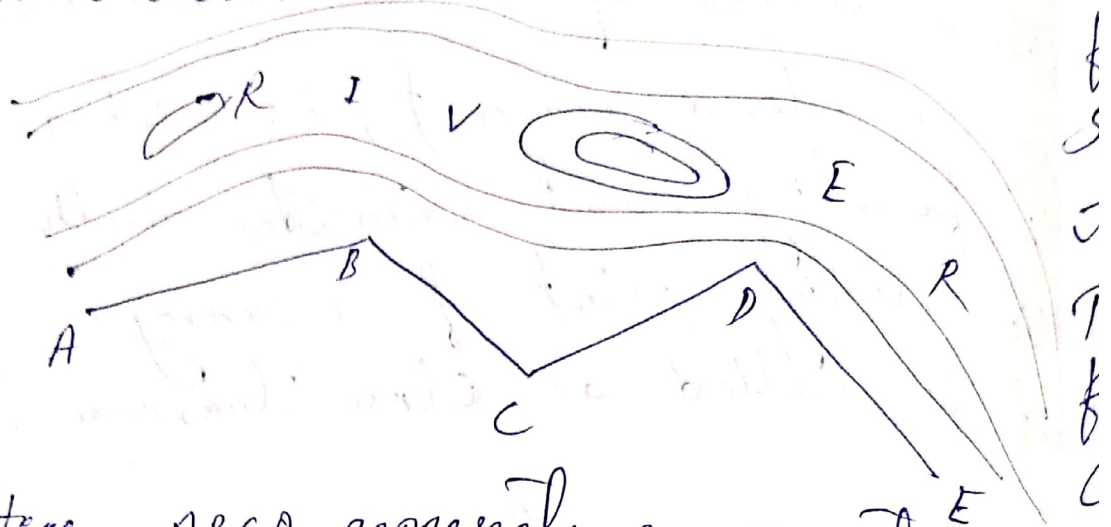
Here ABCDE is a closed traverse.

Close Traverse is suitable for the survey of boundaries of ponds, forests, estates etc.

Open Traverse

When a sequence of connected lines extends along a general direction and does not return to the starting

point, it is known as open traverse
on enclosed traverse.



Here, ABCD represents an open Traverse.
Open Traverse is suitable, for the
survey of roads, rivers, coast lines.

Method of Traversing

Dt-26.02.2021

1. Traversing Survey may be conducted by
the following method.

i) Chain Traversing

ii) Compass "

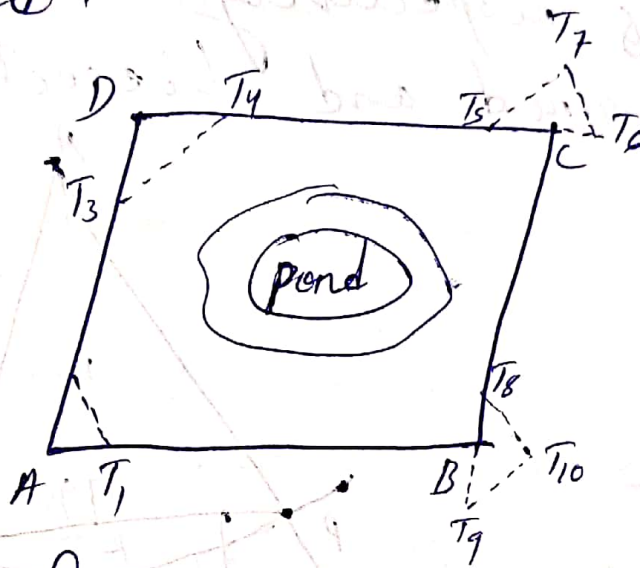
iii) Theodolite "

iv) plane table traversing

1. Chain Traversing

Chain Traversing is mainly conducted
when it is not possible the actual
triangulation method is this

method by chain angles. The adjacent side are fixed. The survey is conducted by chain and angles tape only and angles measurement are taken. When it is not possible to from triangular chain Traversing is conducted.



The perimeters chain angle is explained below.

Suppose a chain angle is to be found. To find the direction of side AB and AD. The station T_1, T_2 are fixed on lines AB and AD. The distances AT_1, AT_2 and T_1T_2 are measured. Then the angle T_1, T_2 is said to be chain angle. Show the chain angle is fixed by the line T_1, T_2 .

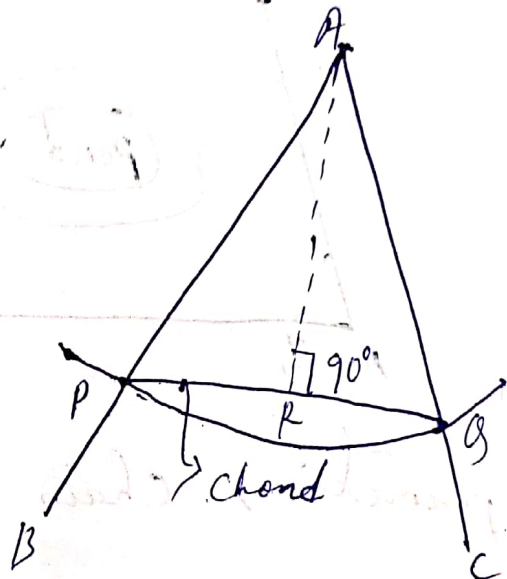
ii) Some times chain angle is fixed by a chord. Suppose The angle between the line AB and AC are to be fixed. A tape of length 15m and area intersecting the lines AB and AC at point P & Q respectively. The chord PQ is measured and bisected at R.

$$AP = PQ = 15m$$

$$\sin \theta = \frac{PR}{AP}$$

$$= \frac{2PR}{2AP} = \frac{PQ}{30}$$

$$\theta = \sin^{-1} \left(\frac{PQ}{30} \right)$$



2) Compass Traversing

In this method the fore bearing of back bearing of Travers are legs. The measured by a magnetic Compass and sides of Travers chain and of tape. Their object bearing are verified and necessity of action for local attraction are checked in this method.

Theodolite Traversing

In such traversing the horizontal angle betⁿ the travers legs are measured by a theodolite. The length of the legs measured by chain or by any other method. The magnetic bearing of each leg measured by theodolite then magnetic bearing of the sides are calculated.

Plane Table Traversing

In this method a plane table is setup at every travers station. In clockwise, anticlockwise direction. and the circle is finally closed.

problem on local attraction

DF-08.03

The following are the observe bearing of the line of a Travers ABCDE with a Compass in a place where local attraction was suspected.

<u>Line</u>	<u>FB</u>	<u>BB</u>
AB	$191^{\circ}45'$	$13^{\circ}0'$
BC	$37^{\circ}30'$	$222^{\circ}30'$
CD	$22^{\circ}15'$	$200^{\circ}30'$
DE	$242^{\circ}45'$	$62^{\circ}45'$
EA	$330^{\circ}15'$	$147^{\circ}45'$

The difference betⁿ FB and BB of line DE is exactly 180° . So, DE is free from local attraction.

Hence, FB of EA $330^{\circ}15'$ is also correct and BB of CD $200^{\circ}30'$ is also correct

The actual BB of EA should be,

$$330^{\circ}15' - 180^{\circ}00' = 150^{\circ}15'$$

but observed BB of EA is $147^{\circ}45'$

So, correction should be $150^{\circ}15' - 147^{\circ}45'$
(should be applied to $200^{\circ}30'$)

Correct FB of AB $191^{\circ}45' + 2^{\circ}30' = 194^{\circ}15'$

But the actual BB of AB should be,
 $194^{\circ}15' - 180^{\circ}00' = 14^{\circ}15'$

But the observed BB of AB is $13^{\circ}00'$

so, the 'connection' would be,

$$(14^{\circ}15' - 13^{\circ}00') = +1^{\circ}15' \text{ (should be applied at B)}$$

Correct FB of BC should be,

~~$$39^{\circ}30' + 180^{\circ}00' = 222^{\circ}30' - 180^{\circ}00' =$$~~

$$39^{\circ}30' + 1^{\circ}15' = 40^{\circ}45'$$

Correct BB should be, $40^{\circ}45' + 180^{\circ}00' = 220^{\circ}45'$

But observed BB of BC is $222^{\circ}30'$,

$$\text{so, connection would be } 220^{\circ}45' - 222^{\circ}30' = -1^{\circ}45'$$

Correct FB of CD should be,

$$22^{\circ}15' - 1^{\circ}45' = 20^{\circ}30'$$

Correct BB should be, $20^{\circ}30' + 180^{\circ}00' = 200^{\circ}30'$

~~But observed BB of CD is $200^{\circ}30'$~~

~~It is~~ (which tally is the observed BB of CD)

Connection

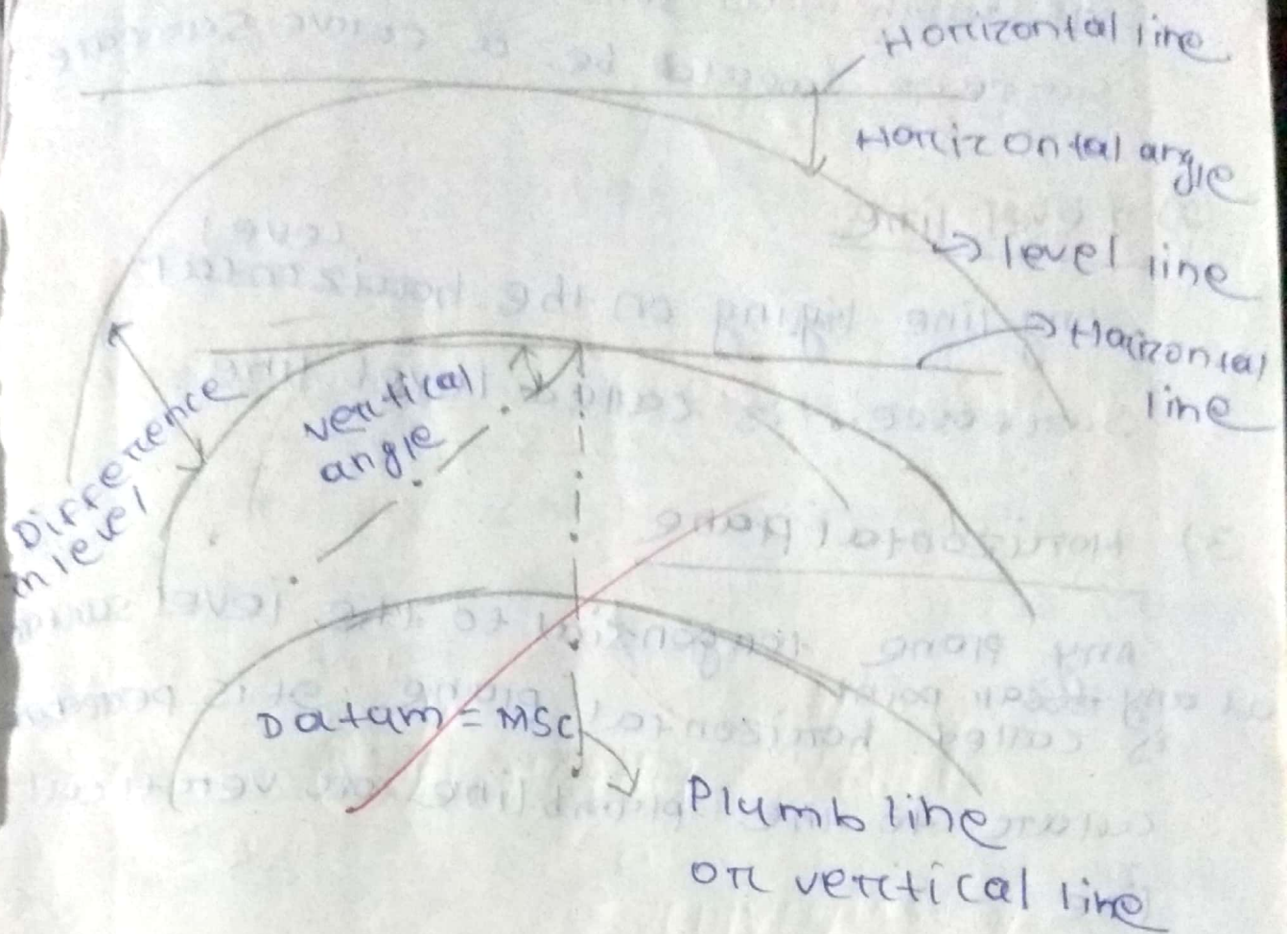
Connected

	<u>FB</u>	<u>BB</u>
AB + $2^{\circ}30'$ at A	$194^{\circ}15'$	$14^{\circ}15'$
BC + $1^{\circ}15'$ at B	$40^{\circ}45'$	$220^{\circ}45'$
$-1^{\circ}45'$ at applied at BB of CD is correct	$20^{\circ}30'$	$200^{\circ}30'$
DE + 0° at D	$242^{\circ}45'$	$62^{\circ}45'$
$2^{\circ}30'$ at at applied at BB of EA	$338^{\circ}15'$	$150^{\circ}15'$

H.C. Page-110 → Problem-9

20.7.19

Levelling



Levelling

It is the ~~act~~ ^{art} of determining the vertical distance of different point on or below the earth surface. This is mostly done on the vertical plane.

Different terms used in levelling

1) Level surface $\rightarrow$ ~~to~~

~~This is~~ Any surface parallel to

mean spheroidal surface of the earth is known as level surface. As earth is a sphere so the level surface would be a curve surface.

2) Level line

Any line lying on the ^{level} horizontal surface is called level line.

3) Horizontal plane

Any plane tangential to the level surface at any ~~isobaric~~ point is called horizontal plane. It is perpendicular to the plumb line or vertical line.

4) Horizontal line

Any line lying on the horizontal plane is called horizontal line.

5) Horizontal angle

An angle made ^{between the} horizontal line and level line is called horizontal angle.

6) Vertical line plane

This is a plane ^{as} where passing through ~~the~~ is
Any plane ~~any line~~ passing through the vertical ~~plane~~ ^{line} is called vertical plane.

7) Plumb line or vertical line

The line which indicate the direction ~~the~~ of gravity is called vertical line.

8) vertical angle

An ~~the~~ angle made bet^h the level line and vertical line is called vertical angle.

9) Datum line

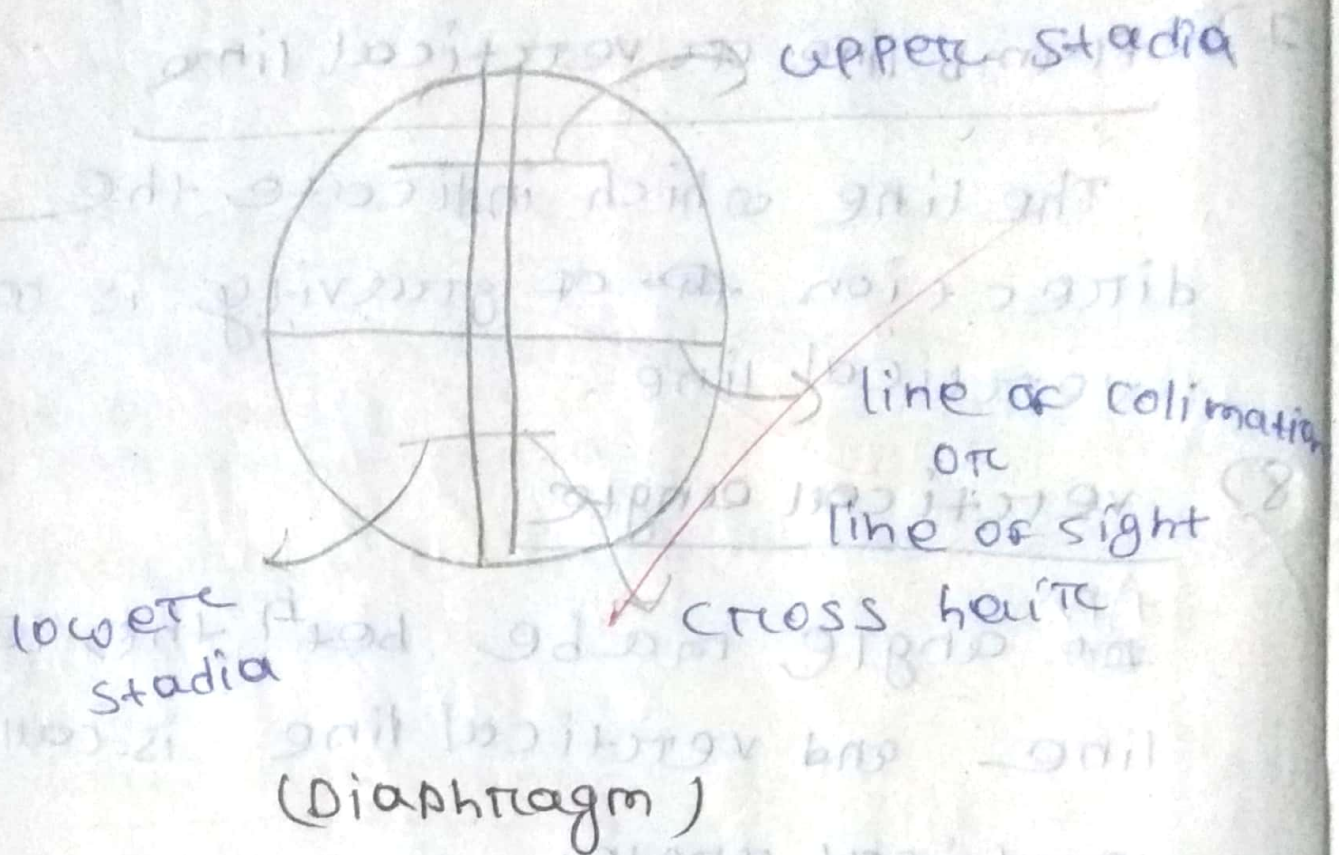
It is an imaginary line on the level surface from which the vertical distance is to be measured.

10) Reduced level (RL)

It is the ^{vertical} distance of a point on the level surface. It may be

2 marks
45

Line of collimation



It is an imaginary line ~~pass~~ ~~from~~ the eye piece to the centre of the object glass and its continuation.

line of collimation is also known as

~~known~~ line of sight

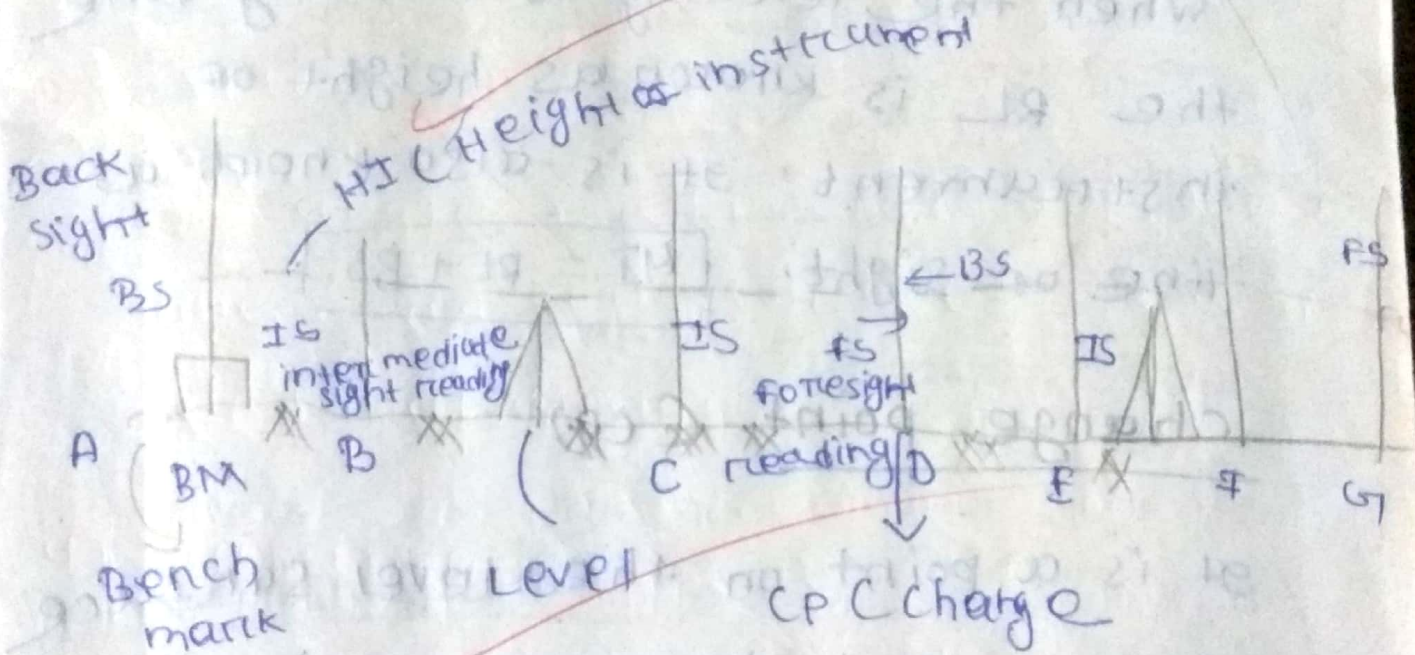
It is an imaginary line passing through the intersection or cross hairs at the diaphragm and the optical centre of the object glass and its continuation.

Bench mark (BM)

It is a point of known RL in the BM are four types

- i) GTS
- ii) permanent
- iii) temporarily
- iv) arbitrary

Back sight



Back sight reading

It is the first reading on the level surface after the levelling is properly done. It is always

Back sight (BS)

It is the reading 'back' BS and BS

Fore sight (FS)

It is the last reading taken on the level surface.

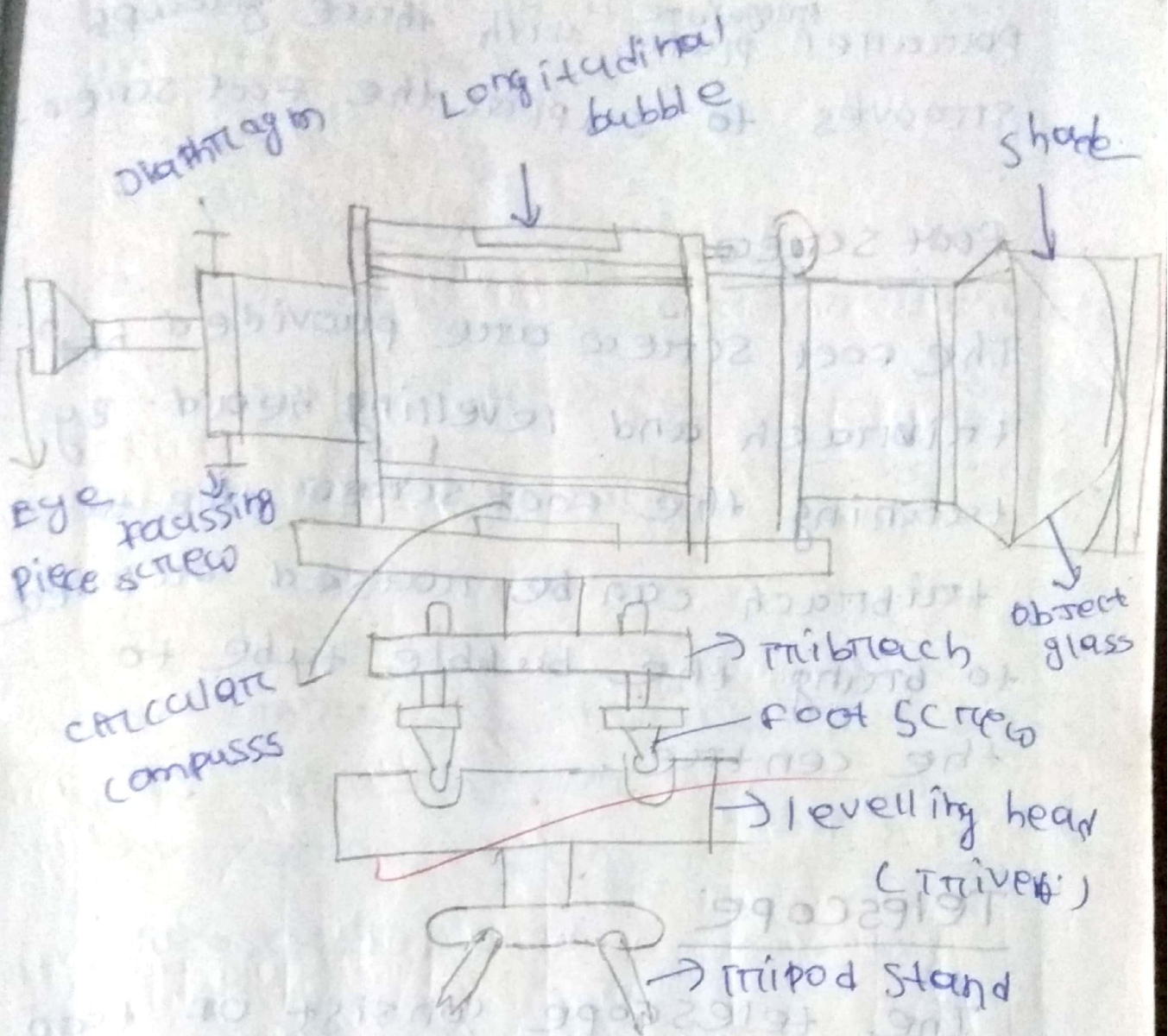
Height of instrument (HI)

When the levelling is properly done the RL is known as height of instrument. It is also known as line of sight.

$$HI = RL + BS$$

change point (CP)

It is a point on the level surface where the instrument is changed from this point FS is taken from one setting and BS is taken from other setting.

DUMPPY LEVELTripod stand

The tripod stand consist of three legs which may be solid or staked. The legs are made up light or hard wood. The lower part of the tripod stands legs are fitted with steel shoes.

Levelling head (trivet)

The levelling head consist of two parallel ^{triangular} plates with three groups of grooves to support the foot screw.

Foot screw

The foot screw are provided between tribrach and levelling head. By turning the foot screw the tribrach can be raised or lower to bring the bubble tube to the centre.

Telescope

The telescope consist of two metal tubes having one having moving with in the other. ~~is also~~ Each also consist of an eyepiece and object glass on opposite end.

A diaphragm is fixed with the telescope just in front of the eyepiece. The ~~dia~~ diaphragm consist of cross hairs. The

Telescope is focused by means of a focussing screw either inwards or outwards.

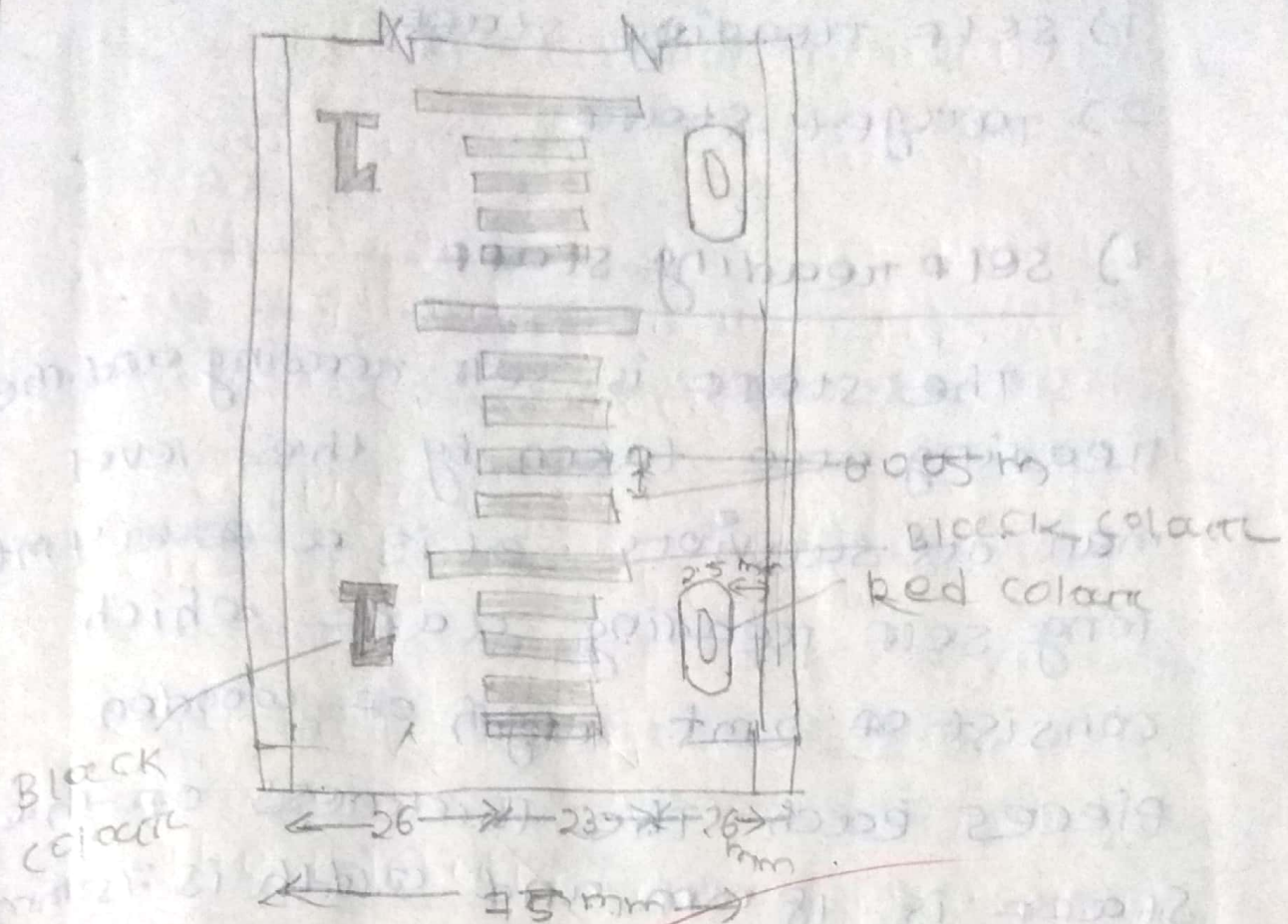
Bubble tubes

There are two bubble tubes one is longitudinal bubble tube and other one is cross hair bubble tube. The bubble tube is brought to the centre with the help of foot screw.

Compass

A compass is provided just below the telescope for taking the magnetic bearing reading when required.

Levelling staff



(Self reading staff)

A Levelling staff is a straight rectangular rod, made from timber of good quality and having graduation painted on its surface.

The purpose of using a levelling staff is to determine the elevation of a point on ground surface above or below the line of collimation.

The levelling staff are divided into two categorised

- 1) self reading staff
- 2) target staff

1) self reading staff

The staff is self reading and reading are taken by the level man or surveyor. It is a ~~four~~ 4m long self reading staff which consist of 2m length of wooden pieces each. The thickness of the staff is 18 mm and width is 75 mm respectively. It is provided a brass cap at the bottom and folding handles at the back. Each ~~width~~ metre is divided into 10 decimetres and each decimetre is divided into 20 equal spaces so that each spaces is equal to the 0.005m or 5 mm. On this staff the background is kept at white colour and all other spaces

decimetre numerical are marked in black colour. Each decimetre and the metre numerical are marked in red colour.

2) Target staff

On this staff a target is provided on the staff and ~~with~~ the instruction provided by the surveyor, the target is moved by the staffman.

A vernier scale is provided ~~with~~ the ~~target~~, which gives with the target staff which gives the ^{accurate} ~~accurate~~ reading.

7 mark Temporary adjustment of a Level

The adjustment made at every set up of the level before taking any ^{staff} ~~reading~~ are known as temporary adjustment.

The following are the steps to be followed in the temporary adjustment.

a) selection of suitable position

A suitable position is selected for setting the level. From this position it should be possible to take the greatest number of observations without any difficulty. The ground should be level.

b) fitting the level on the tripod stand

The tripod stand is placed at the require position ^{which} its legs ^{firmly} well apart and pressed ~~firmly~~ into the ground.

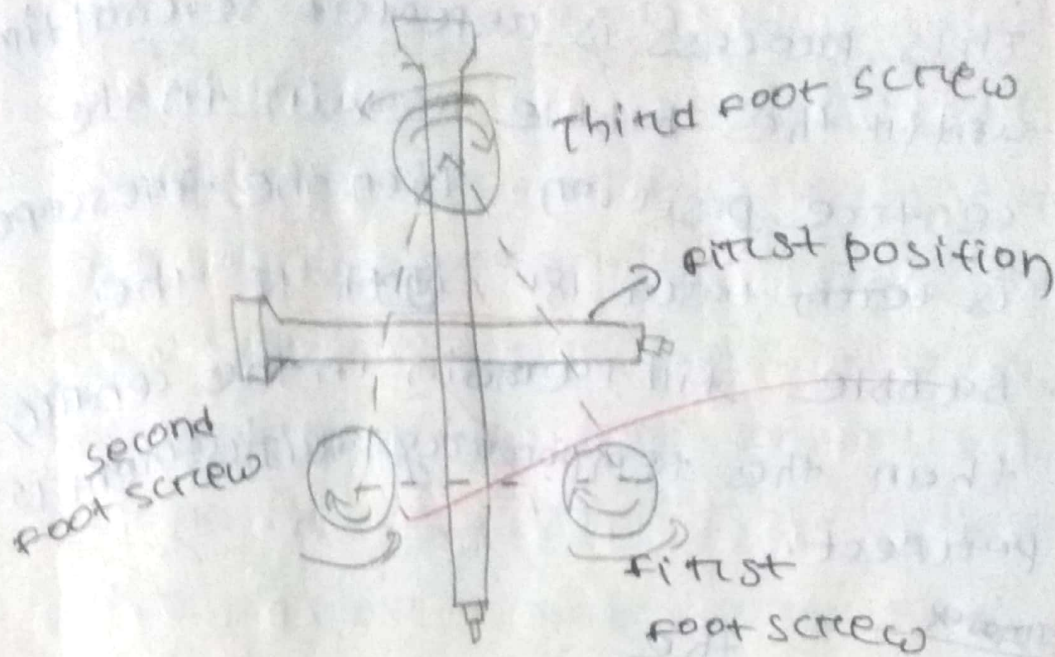
The level is fixed on the top of the tripod stand according to the fixing arrangement provided for that particular level.

c) Approximate levelling by ^{the} legs of tripod stand

The foot screws are brought to the centre of their run. ^{Two} legs of the tripod stand are ^{firmly} ~~firmly~~ fixed into the ground.

than the third leg is moved either in or out, left or right until the bubble is approximately at the centre.

d) perfect levelling by foot screws



As the longitudinal bubble is on the top of the telescope, the telescope is placed parallel to the ground (the first position) and the bubble is brought to the centre by equally turning both the foot screws either inwards or both outwards. Then the telescope is turned 90° (the 2nd position) and brought

over the third foot screw and the bubble is brought to the centre by turning the screw either clockwise or anti clockwise. Then the telescope is again brought to the original position. i.e. first position and the bubble is brought to the centre. This process is repeated several times until the bubble remain in the centre position. Then the telescope is ~~temp~~ turn 180° , ~~if~~ if the bubble still remain in the centre, then the temporary adjustment is perfect.

e) ~~Focus~~ focussing the eyepiece

A piece of white paper ~~these~~ is held in front of the object glass and the eyepiece is moved in or out by turning it ~~if~~ clockwise or anticlockwise until the cross hair can be seen properly.

Processing the object glass

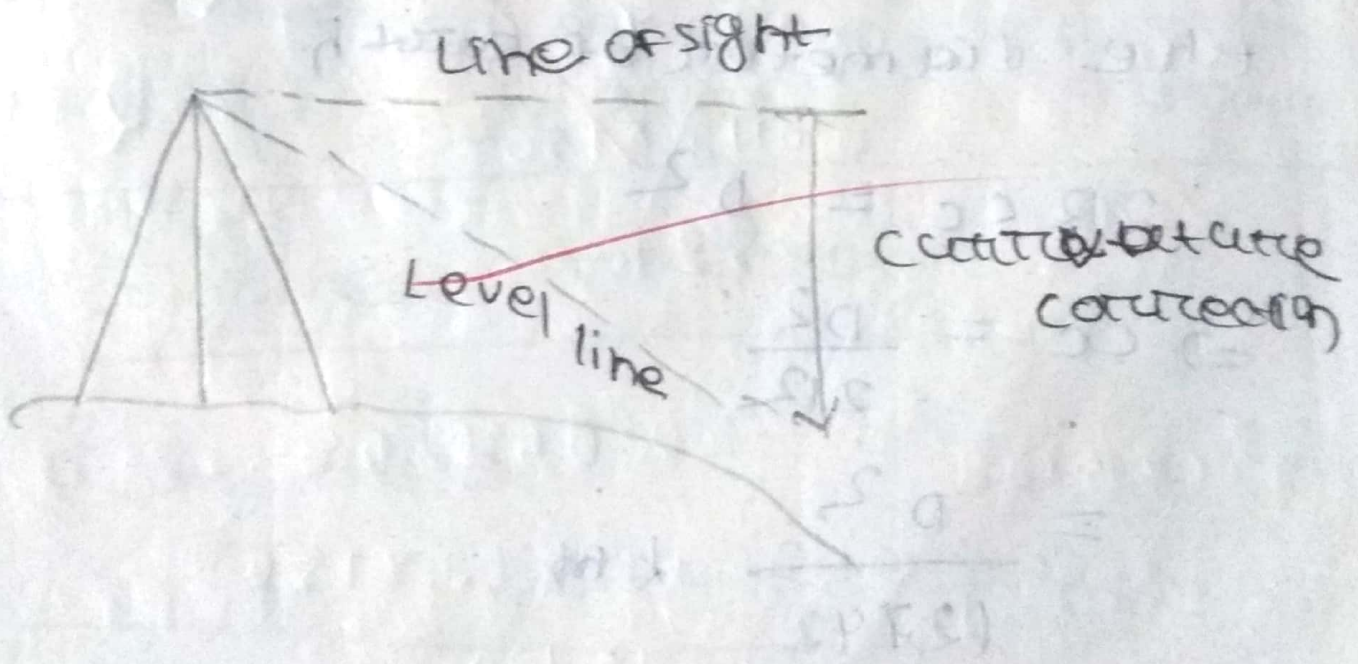
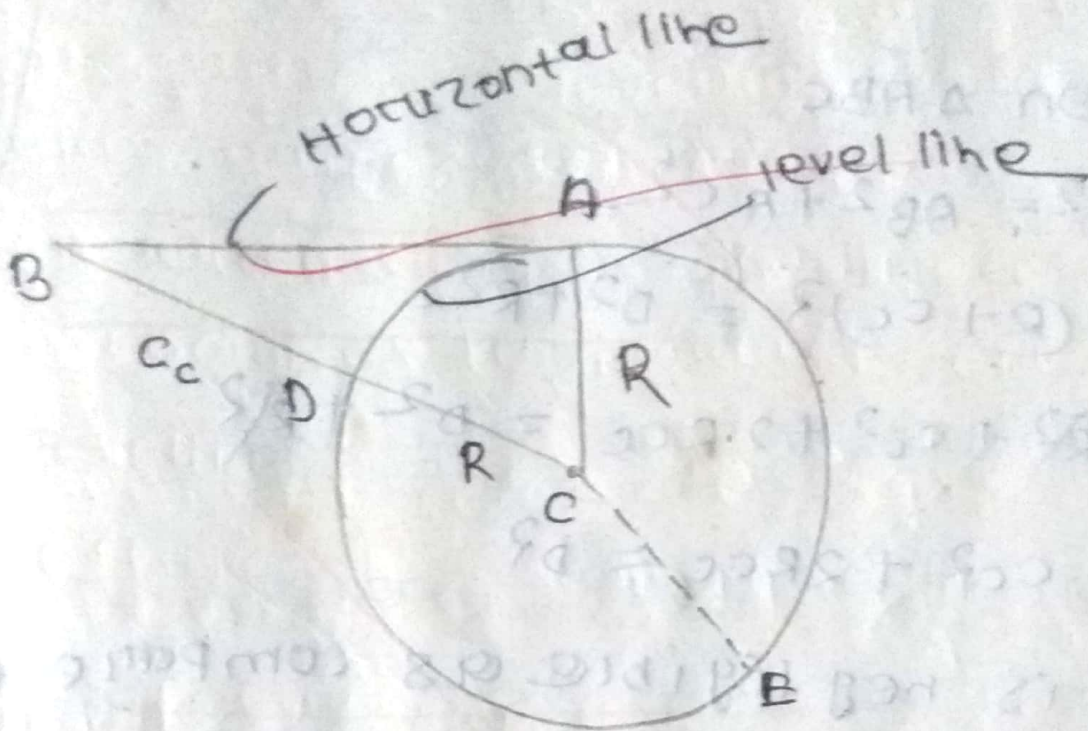
The telescope is directly ^{focused} towards the levelling staff. Looking through the eye piece the focusing screw is turned either clock wise or anticlockwise until the graduation of the staff is visible.

g) Taking the staff readings

Finally the levelling of the instrument is verified by turning the telescope in any direction, when the bubble remains in the central position on any direction of the telescope the staff reading are taken.

correction APPLIED

a) curvature correction



The vertical distance betⁿ the line of sight and the level line is known as curvature correction.

From the above diagram

$AB = D$ Horizontal distance in km

$AC = BC = R$ Radius of curvature

$BD = CC$ = curvature correction

DE = Diameter of earth

12742 km

on $\triangle ABC$

$$BC^2 = AB^2 + AC^2$$

$$\Rightarrow (R + CC)^2 = D^2 + R^2$$

$$\Rightarrow R^2 + CC^2 + 2RCC = D^2 + R^2$$

$$\Rightarrow CC^2 + 2RCC = D^2$$

CC^2 is negligible as compare to the diameter of earth

$$2RCC = D^2$$

$$\Rightarrow CC = \frac{D^2}{2R}$$

$$= \frac{D^2}{12742} \text{ km}$$

$$CC = \frac{D^2}{12742} \times 1000$$

$$C_c = -0.0784 D^2 m$$

C_c is always -ve.

so true staff reading

$$\text{True staff reading} = \text{observed staff reading} - \text{curvature correction}$$

b) Refraction correction

$$C_r = \frac{1}{7} \times C_c$$

$$= \frac{1}{7} \times -0.0784 D^2$$

$$C_r = -0.0112 D^2 m$$

It is the $\frac{1}{7}$ th part of C_c

C_r is always +ve

so

$$\text{True staff reading} = \text{observed staff reading} + \text{Refraction correction}$$

c) combined correction

$$C_{\text{combination}} = C_c + C_r$$

$$= -0.0784 D^2 + 0.0112 D^2$$

$$C_{\text{comb}} = -0.0672 D^2 m$$

$$\text{True Staff Reading} = \text{Observed Staff Reading} - \text{Combined Correction}$$

Combined correction is always -ve

Q) Find out the curvature correction, Refraction correction, Combined correction if the horizontal distance is 150m

Ans

$$C_c = 0.0784 \text{ m}^2$$

$$= 0.0784 \times 150^2$$

$$= -17.64 \text{ m}$$

$$C_r = \frac{1}{7} \times C_c$$

$$= \frac{1}{7} \times -17.64$$

$$C_r = 0.0112 \text{ m}^2$$

$$= 0.0112 \times 150^2$$

$$= +0.252 \text{ m}$$

$$\frac{1}{7} \times 17.64$$

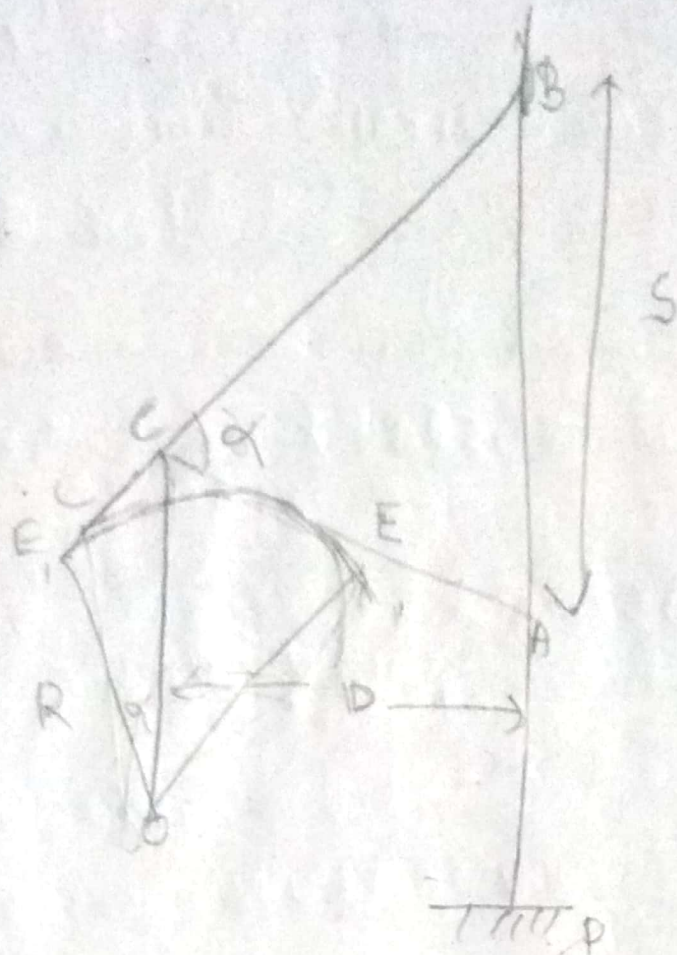
$$= +0.252 \text{ m (+ve)}$$

$$\text{Combined} = -0.0672 \text{ m}^2$$

$$= -0.0672 \times 150^2$$

$$= -15.12 \text{ m}$$

Sensitiveness of bubble tube



From the above diagram θ

D = Distance betⁿ level and staff

S = staff intercept betⁿ upper and lower side

n = num of division through which the bubble is ~~not~~ deflected

R = Radius of curvature of tube

α = angle subtended by REE'

d = Length of 1 division of the graduation

Expressed in the same unit of D/S

The sensitiveness in the bubble tube is the effect caused by the deviation of the bubble per division of the graduation of the bubble tube.

From the above diagram

$$R = \frac{nd \times D}{S}$$

where

R = Radius of curvature of tube

n = num of division through which

α' = sensitiveness

$$\alpha' = \frac{S}{nd} \times 206265$$

$$1 \text{ radian} = 206265$$

Q) A bubble tube of a level, has a sensitiveness of 20.5 per 2mm division. find the ~~error~~ in the reading on the staff held at a distance of 100m from the level when the bubble is deflected by 2 divisions from the centre.

Given

$$\alpha' = 20''$$

$$n = 2 \text{ mm} \text{ (division)} = 0.002$$

$$D = 100 \text{ m}$$

~~S~~

$$\alpha' = \frac{S}{nD} \times 206265 \text{ Second}$$

$$20 = \frac{S}{0.002 \times 100} \times 206265$$

$$\cancel{S} = \dots$$

$$20 = \frac{1031325}{S}$$

$$S = \frac{20}{1031325}$$

$$S = 0.019 \text{ m}$$

a) For a certain division observation the bubble was out of centre by 4 division. The error in staff reading held in the distance 60 m was found to be 0.08 m. If the length of 1 division of the bubble is 2 mm, find out the radius of curvature and sensitiveness of bubble tube.

Given data

$$n = 4$$

$$D = 60 \text{ m}$$

$$d = 2 \text{ mm} = 0.002 \text{ m}$$

$$S = 0.03 \text{ m}$$

$$R = \frac{nd \times D}{S}$$

$$= \frac{4 \times 0.002 \times 60}{0.03}$$

$$= 16 \text{ m}$$

$$\alpha' = \frac{S}{nd} \times 206265 \text{ sec}$$

$$\alpha' = \frac{0.03}{4 \times 60} \times 206265$$

$$\approx 25.78 \text{ sec}$$

Q) when the bubble is at the centre the reading on the staff, 100m from the level is 2.550m. The bubble is then deviated by 5 division and the staff reading is 2.500m. If the length of 1 division of the bubble is 2mm, calculate the radius

of curvature of the bubble tube
and the angular value of the
one division of the bubble.

Given data

$$S = 2.550 - 2.500$$

$$= 0.05$$

$$n = 2 \text{ mm} = 0.002 \text{ m} \quad 5 \text{ division}$$

$$d = 2 \text{ mm} = 0.002 \text{ m}$$

$$D = 100 \text{ m}$$

$$R = \frac{n \times D}{S}$$

$$= \frac{5 \times 0.002 \times 100}{0.05}$$

$$= 20 \text{ m}$$

$$= 20 \text{ m}$$

$$S = 0.05$$

$$\alpha = \frac{S}{n} \times 206265$$

$$= \frac{0.05}{5} \times 206265$$

$$= 2062.65 \text{ sec}$$

28.7.17

Method of calculation of Reduced Level (RL)

→ collimation system (HI method)

→ Rise & fall system

1) collimation system (HI method)

$$HI = RL + BS$$

on this method HI of the first point is calculated by addition of given RL to the BS.

$$HI = RL + BS$$

(The point where the first RL is already given in the question)

RL of the intermediate points and the change points are obtained by subtracting the respective staff reading from HI.

$$RL = \text{previous (HI)} - FS$$

$$HI = RL + BS$$

Arithmetic check

$$\sum BS - \sum FS = \text{First RL} - \text{Last RL}$$

Following consecutive readings were taken on point 1 to 7 along a line.

The readings are 0.785, 1.326, 2.538, 3.435, 1.367, 2.328, 1.234

At 1.657 the instrument was shifted after 4th reading and the first reading was taken on a

Bm with RL = 100

Station	Readings			HI	RL	Remark
	BS	IS	FS	(RL + BS)		
1	0.785	-	-	0.785 + 100 = 100.785	100	
2	-	1.326	-	100.785 - 1.326 = 99.459	99.459	
3	-	2.538	-	100.785 - 2.538 = 98.247	98.247	
4	1.367	-	3.435	98.247 + 1.367 = 99.614	99.614	Change point
5	-	2.328	-	99.614 - 2.328 = 97.286	97.286	
6	-	1.234	-	97.286 - 1.234 = 96.052	96.052	
7	-	1.657	-	96.052 - 1.657 = 94.395	94.395	
$\sum BS = 2.152$			$\sum FS = 5.992$			

$$865 - 285$$

$$285 - 285$$

$$= 5092 - 2152$$

$$= 294$$

First RL - Last RL

$$= 100 - 97.06$$

$$= 2.94$$

Q) Following are the readings were taken on a dumpy level along the a chain line at a common interval 15m. The first reading was at a change of 165m where the RL is 98.085. The instrument was shifted before 4th and 9th reading.

BS IS FS BS
 3.150, 2.245, 2.125, 0.860, 3.125
 2.460, 1.835, 1.470, 1.965, 1.225,
 2.390, 3.035

Station	Chainage	Reading			HI	RL	Remarks
		BS	IS	FS			
1	165	3.150	-	-	$ \begin{array}{r} 3.150 + 98.085 \\ = 101.235 \\ 2.150 + 98.085 \\ = 101.235 \end{array} $	98.085	
2	180	-	2.245	-	101.235	$ 101.235 - 2.245 = 98.99 $	
3	195	-	1.125	-	101.235	$ 101.235 - 1.125 = 100.11 $	
4	210	3.125	-	0.860	$ 100.11 + 3.125 \\ = 103.235 $	$ 103.235 - 0.860 = 102.375 $	changed point
5	225	-	2.760	-	103.235	$ 103.235 - 2.760 = 100.475 $	
6	240	-	1.835	-	103.235	$ 103.235 - 1.835 = 101.400 $	
7	225	-	1.470	1.470	103.235	$ 103.235 - 1.470 = 101.765 $	
8	270	1.225	-	1.965	$ 101.765 + 1.225 \\ = 102.990 $	$ 102.990 - 1.965 = 101.025 $	change point
9	285	-	2.390	-	102.76	$ 102.76 - 2.390 = 100.37 $	
10	300	-	-	3.035	102.76	$ 102.76 - 3.035 = 99.725 $	

$$BS = 7.5$$

$$FS = 5.86$$

$$\sum BS - \sum FS = 7.5 - 5.86 = 1.6$$

$$1st RL - Last RL = 98.99 - 98.085 = 1.6$$

1.8.17

RISE & FALL METHOD

~~The first reading~~ The first reading,
at a chainage of 165 m, where the
RL is 98.085. The instrument is
shifted 4th & 9th reading.

BS IS IS BS IS BS IS
3.150 / 2.245 / 1.125 / 3.125 / 0.0860
3.125 / 2.760 / 1.835 / 1.470 / 1.965 / 1.225
2.390 / 3.035. APPLY RISE & FALL
method and find out the gradient
of AB

Station	chainage	BS	IS	FS	Rise (+)	Fall (-)	RL	Remark
1	165	3.150	-	-			98.085	
2	180	-	2.245	-	0.905		98.99	
3	195	-	1.13	-	1.12		100.11	
4	210	3.125	-	0.0860	0.265		100.375	change point
5	225	-	2.760	-	0.365		100.74	
6	240	-	1.835	-	0.925		101.665	
7	255	-	1.440	-	0.365	0.495	102.03	
8	270	1.225	-	1.965		1.105 0.495	101.535	change point
9	285	-	2.390	-		0.695 1.165	100.32	
	300	-	-	3.035		0.645	99.725	

$$\sum BS = 7.5 \quad \sum FS = 5.86 \quad \{\text{Rise} = 3.945\}$$

$$\sum Fall = 2.305$$

Arithmetic check

$$\sum BS - \sum FS$$

$$= 7.5 - 5.86$$

$$= 1.64$$

$$\text{First RL} - \text{Last RL} \neq \text{First RL}$$

$$= 98.99725 - 98.085$$

$$= +1.64$$

$$\sum \text{Rise} - \sum \text{Fall}$$

$$= 3.945 - 2.305$$

$$= +1.64$$

Gradient of AB

$$= \frac{\text{Difference of Level}}{\text{Horizontal distance}}$$

$$= \frac{1.64}{300}$$

$$= 5.46 \times 10^{-3}$$

$$= 5.46 \times 10^{-3}$$

First - Last

$$= 208.125 - 8.61/199.96$$
$$= 8.16$$

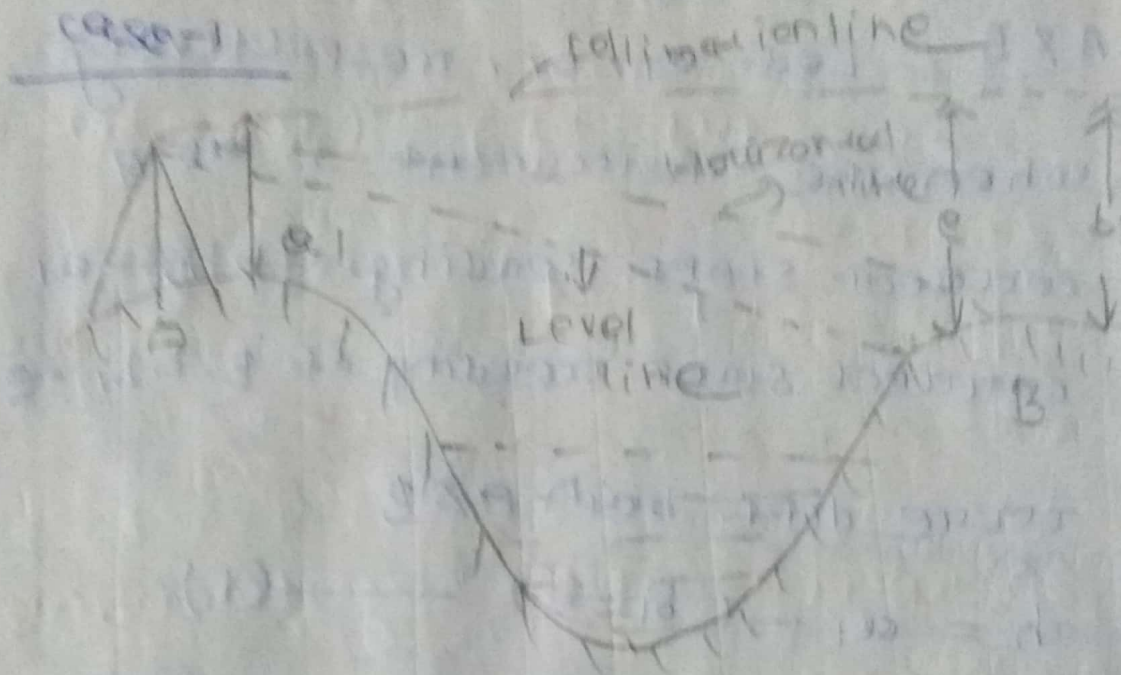
$$\text{gradient line} = \frac{8.16}{160} = 0.051$$

Reciprocal Levelling

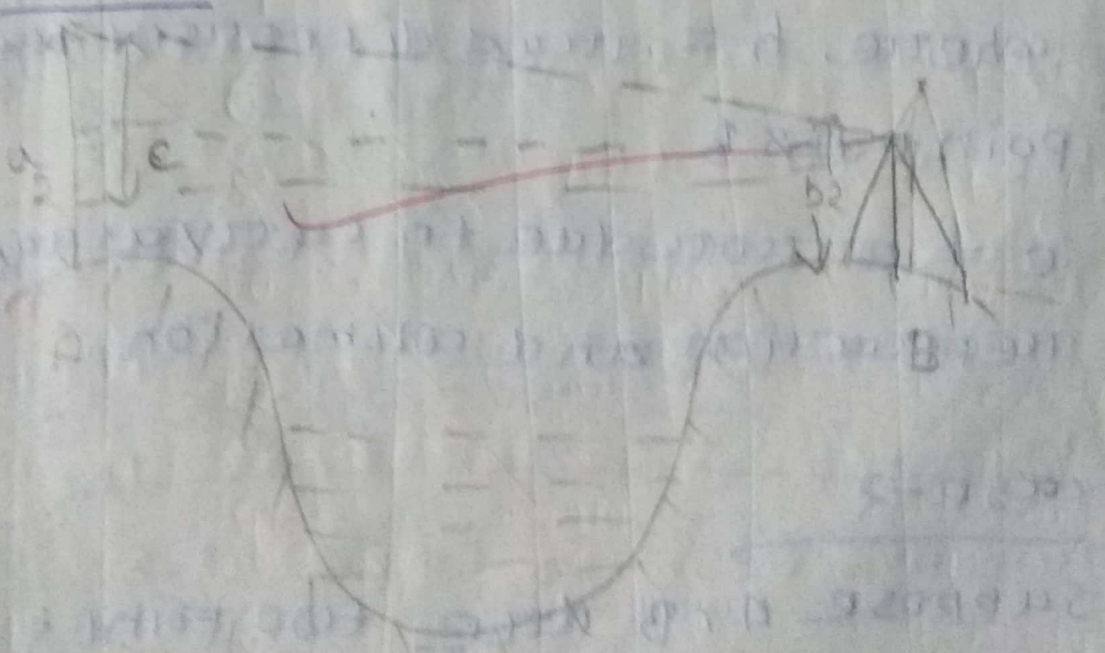
If the level is placed exactly mid way betⁿ two points and staff reading was taken to determine the difference of level then the errors (due to curvature, refraction, collimation) are automatically disappear. But in case of rivers or a valley, it is not possible to set the level mid way betⁿ the two banks

So in this case reciprocal levelling is adopted

on reciprocal levelling the level is set up on both the bank of the river and two sets of staff readings are taken by holding the staff on opposite bank.



Case-2



case-1

Suppose A & B are two points on the opposite bank of a river. The level is set up very near to point A, and after proper adjustment staff readings are taken at point A & B. Let a_1 , b_1 , respectively when the instrument is at A

correct staff reading at A = a_1
correct staff reading at B = $b_1 - e$
true diff betn A & B

$$h = a_1 - (b_1 - e) \quad \text{--- (1)}$$

where h = true different betn point A & B

e = error due to curvature, refraction and collimation.

case-2

Suppose A & B are two points on the opposite bank of a river. The level is set up very near

to B and staff reading are taken at point A & B. ~~Let~~ let it be a_1 & b_2 respectively

when the instrument is at B correct staff reading

$$at A = (a_2 - e)$$

correct staff reading at B = b_2

(so, true diffn betn point A & B is

$$h = (a_2 - e) - b_2 \quad \text{--- (1)}$$

By adding eqn (1) & (2)

$$h = a_1 - (b_1 - e)$$

B point reading ~~there~~
 is the local level

$$h = (a_2 - e) - b_2$$

$$h = a_1 - b_1 + e$$

$$h = a_2 - e - b_2$$

$$2h = (a_1 - b_1) + (a_2 - b_2)$$

$$h = \frac{(a_1 - b_1) + (a_2 - b_2)}{2}$$

By adding eq

By subtraction eq (1) & (2)

$$h = a_1 - b_1 + e$$

$$h = a_2 - e - b_2$$

$$(1) \quad (2) \quad (+) \quad (+)$$

$$a_1 - b_1 + e - a_2 + e + b_2 = 0$$

$$\Rightarrow 2e = (a_2 - b_2) - (a_1 - b_1)$$

$$\Rightarrow e = \frac{(a_2 - b_2) - (a_1 - b_1)}{2}$$

- Q) In reciprocal leveling two point P & Q are situated on the opposite banks of a river when the instrument was near P the reading observe when P & Q are 1.365 / 2.550 when the instrument was near Q the reading observe P & Q are 1.005 / 1.960. Find out the true diffⁿ betⁿ P, Q

ii) Total error due to ~~refraction~~ curvature
refraction (collimation)

iii) find out the ^{true} ~~apparent~~ RL of A if the
RL of B is 112.695.

at A

$$1.365 + 2.550$$

Apparent diffⁿ betⁿ P & A

$$2.550 - 1.365 = 1.185$$

at B

$$1.005 + 1.960$$

Apparent diffⁿ betⁿ P & B

$$1.960 - 1.005 = 0.955$$

$$\text{True diff} = \frac{1.185 + 0.955}{2}$$

$$= 1.07$$

$$e = \frac{1.185 - 0.955}{2}$$

$$= 0.115$$

True RL of P

True RL of P - b

$$= 112.895 - 1.27$$

$$= 111.625$$

- 2) In reciprocal levelling two points A & B are taken on opposite banks of river, when the level was setup near A, the staff reading on A & B are 2.245, 3.375. When the level was at B the staff readings were 1.955 & 3.055. Find the true difference betⁿ A & B and find the RL of B, if the RL of A is 125.550.

A + P

$$2.245 + 3.375$$

Apparent diffⁿ betⁿ P & Q

$$3.375 - 2.245$$

$$= 1.13$$

Q

$$1.955 / 3.055$$

apparent diffⁿ betⁿ p & q

$$3.055 - 1.955$$

$$\begin{aligned} \text{true diffⁿ betⁿ p \& q} &= \frac{1.13 + 1.1}{2} \\ &= 1.115 \end{aligned}$$

$$e = \frac{1.13 - 1.1}{2} = 0.015$$

~~True RL of Q~~

True RL of P - h

$$= 125.550 - 1.115$$

$$= 124.43$$

Difficulties in levelling

- 1) When the staff is too near to the instrument or the levelling staff is held very near to the levelling in

→ instrument errors

→ ~~personal errors~~

→ ~~Natural errors~~

1) Instrumental errors

- a) The permanent adjustment of the instrument may not be perfect. That is, the line of collimation may not be parallel to the axis of the bubble tube.
- b) The internal arrangement of the focussing tube is not perfect.
- c) The graduation of the levelling staff may not be perfect.

2) Personal errors

- a) The instrument may not be levelled perfectly.
- b) The focussing of the eyepiece and object glass may not be perfect and the parallax may not be eliminated entirely.
- c) The position of the staff may be displaced at the change point at the time of taking FS and BS readings.
- d) The staff may appear inverted when viewed through the telescope. By mistake, the staff readings may be taken upwards instead of downwards.
- e) The reading of the staff may be taken rather than the central collimation hair may be taken by mistake.
- f) A wrong entry may be made in the level book.
- g) The staff may not be properly and fully extended.

3) Errors due to natural causes.

- a) When the distance of sight is long, the curvature of the earth may affect the staff reading.
- b) The effect of refraction may cause a wrong staff reading to be taken.
- c) The effect of high winds and a shining sun may result in a wrong staff reading.

THEODOLITE TRAVERSING

Theod

The theodolite is an instrument used mainly for accurate measurement of horizontal and vertical angle.

The following are the diffⁿ purposes for which the theodolite can be used

- 1) Measurement of horizontal angle
- 2) Measuring vertical angle
- 3) Measuring of deflection angle
- 4) Measuring of magnetic bearing
- 5) Measuring the horizontal distance betⁿ two points
- 6) Finding the vertical height of an object
- 7) Finding the difference of elevation between various points.
- 8) Ranging a line

Theodolite may be of two types

- i) Transit theodolite
- ii) Non-Transit theodolite

Transit theodolite
On the transit theodolite, the telescope can be revolved to a complete revolution about its horizontal axis, in a vertical plane.

Non - Transit theodolite

On the non-transit theodolite, the telescope cannot be revolved to a complete revolution in the vertical plane. But it can be revolved to a

certain extent in the vertical plane, in order to measure the angle of elevation or depression.

Theodolite may also be classified as

1) vernier theodolite

2) micrometer theodolite

* In vernier theodolite, vernier scale is fitted. But in micrometer theodolite it is fitted with a micrometer.

DEFINITIONS

1) centring

The setting of theodolite exactly over a station mark by means of a plumb-bob is known as centring. The plumb bob is suspended from a hook fixed below the vertical axis.

2) Transiting

The method of turning the telescope about its horizontal axis in a vertical plane to 180° is known as transiting. In other words, transiting other ~~results~~ ~~could~~ change in ~~the~~ ~~cc.~~

3) Face Left

Face Left means that the vertical circle of the theodolite is on the left of the observer at the time of taking reading. The observation taken in the face left position is called as face left observation.

4) Face Right

It is the situation when the vertical circle is on the right side of the observer at the time of taking reading. The observation taken in

Face Right position is called as Face Right Observation.

5) Telescope Normal

The face left position is known as telescope normal or telescope direct. It is also referred to as bubble up.

6) Telescope inverted

The face right position is called as telescope inverted or telescope reversed. It is also referred to as bubble down.

7) changing face

The operation of bringing the vertical circle from one side of the observer to the other side is known as changing face.

8) Swinging the telescope

This indicates turning of the telescope in a horizontal plane. It is called right swing, when the telescope is ~~turned~~^{turned} clockwise. It is called left swing when the telescope is turned anticlockwise.

9) Line of collimation

It is an imaginary line passing through the intersection of cross hairs at the diaphragm and the optical centre of the object glass and its continuation.

10) Axis of the Telescope

This axis is an imaginary line passing through optical centre of the object glass and the

optical centre of eyepiece.

11) Axis of bubble tube

It is an imaginary line tangential to the longitudinal curve of the bubble tube at its mid point.

12) Vertical axis

It is the axis of rotation of the telescope in the horizontal plane.

13) Horizontal axis

It is the axis of rotation of the telescope in the vertical plane. It is also known as trunnion axis.

14) Temporary adjustment

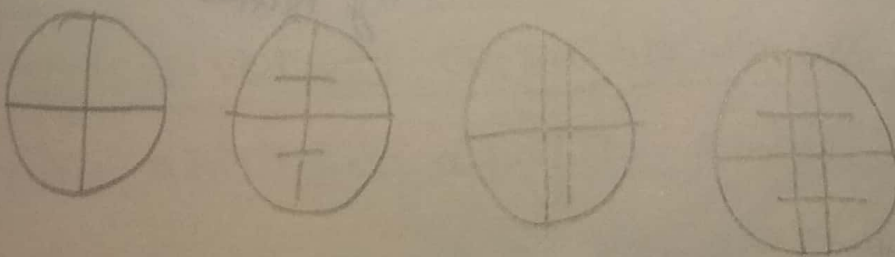
The setting of the theodolite over a station at the time of taking any observation is called temporary adjustment. This adjustment is necessary for every set up of the instrument.

15) Permanent adjustment

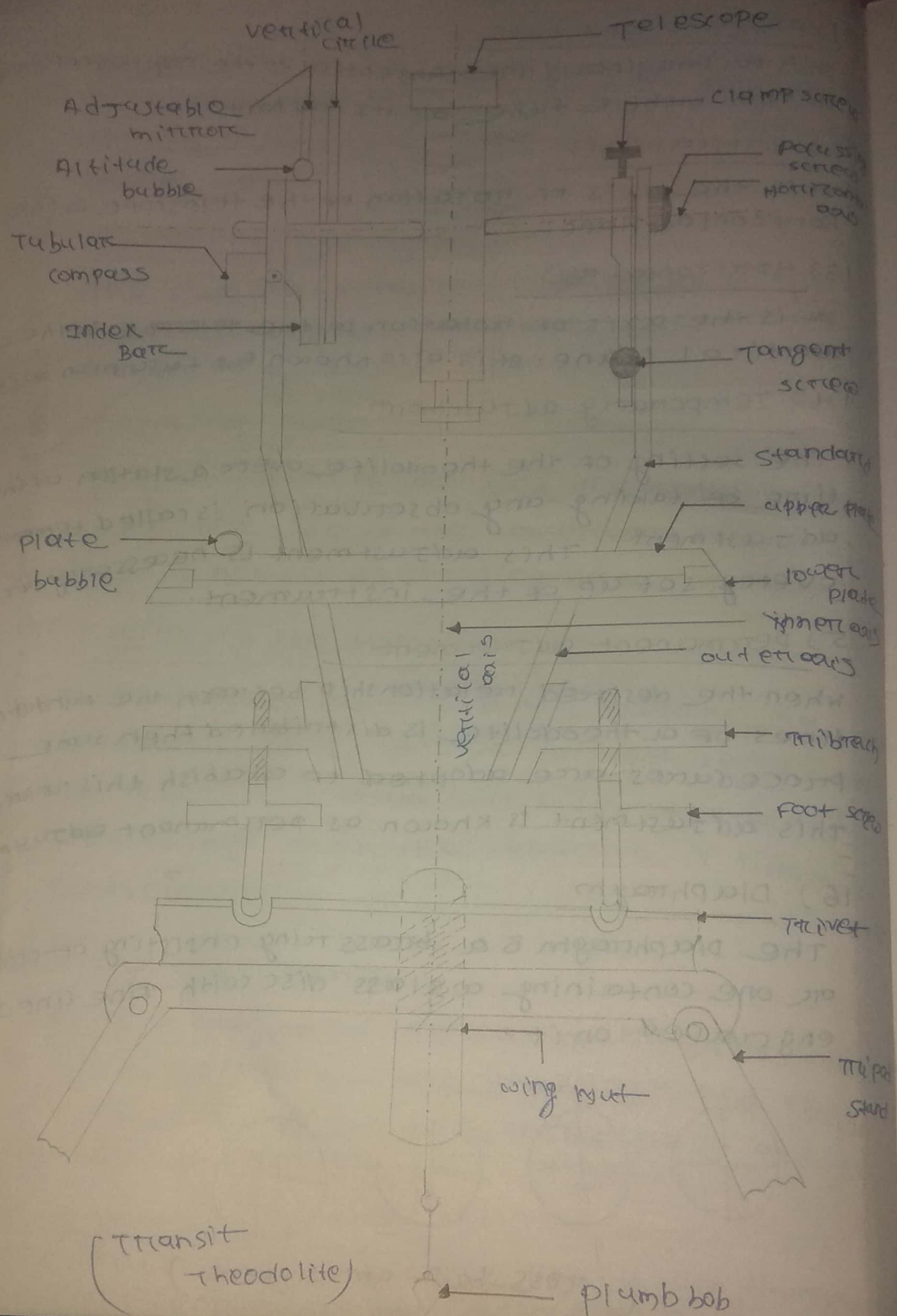
When the desired relationship between the fundamental lines of a theodolite is distributed then some procedures are adopted to establish this relationship. This adjustment is known as permanent adjustment.

16) Diaphragm

The Diaphragm is a brass ring consisting of cross-hair or one containing a glass disc with fine lines engraved on it.



(cross-hair arrangement)



24/10/17

Least count of the ~~main~~ ^{vernier} scale

This is the difference betⁿ the value of smallest division of the main scale and that of smallest division of the vernier scale. It is the smallest value that can be measured by the theodolite.

Let ~~M~~ ^{$n-1$} be the smallest division of the main scale and n be smallest division of the vernier ~~scale~~ scale.

Let V = value of smallest division of vernier scale.

d = value of smallest division of main scale

$$n \times V = (n-1) \times d$$

$$\Rightarrow V = \frac{(n-1) \times d}{n}$$

$$L.C = d - V$$

$$L.C = d - \frac{(n-1) \times d}{n}$$

$$L.C = \cancel{d - \frac{(n-1) \times d}{n}} = \frac{d - nd + d}{n}$$

$$L.C = \cancel{\frac{d}{n}} = \frac{2d - nd}{n} = \frac{d(2-n)}{n}$$

sensitiveness of bubble tube

The ability of a bubble tube to show a very small deviation of a bubble from its horizontal position is termed as sensitiveness of bubble tube.

Sensitiveness of bubble tube = $\frac{S}{dn} \times 206265''$

Transit theodolite

1) Trivet

It is a circular plate having a central threaded hole for fixing the theodolite on the tripod stand by a wing nut. It is also called base plate. The foot screws are secured to this plate by means of ~~ball~~ ball and socket arrangement.

2) Foot screws

These are meant for levelling of the instrument. The lower part of the foot screws are secured in the trivet by means of a ball and socket arrangement and the upper threaded part passes through the threaded hole in the tribrach plate.

3) Tribrach

It is a triangular plate carrying three foot screws at its ends.

4) Levelling Head

The trivet, foot screws and the tribrach constitute a body which is known as the levelling head.

5) Lower plate

The lower plate is attached to the outer end and is also known as the scale plate. It is

levelled and it is graduated from 0 to 360° in clockwise direction. Each degree is again subdivided into two, three or four divisions. Thus the value of one small division may be 30', 20', 15'. The lower plate is provided with a clamp screw and a tangent screw when control its movements. When the clamp screw is tightened, this plate is fixed with the outer axis. The size of the theodolite is designated w/o. to the diameter of the lower plate.

6) Upper plate

The upper plate contains the vernier scale A and B. It is attached to the inner axis. Its motion is control by the upper clamp screw and the upper tangent screw. When the clamp screw is tightened the vernier scale are fixed with the inner axis and for the fine adjustment the scales or the tangent screw is rotated.

7) Plate bubble

~~Two~~ Two plate bubbles are mounted at right angles to each other on the upper surface of the vernier scale. One bubble is kept parallel to the horizontal axis of the theodolite. Some time one plate bubble is provided on the vernier plate. The bubble are meant for levelling the instrument at the time of measuring the horizontal angle.

8) Standard or A-frame

Two frame (shaped like A) are provided on the upper plate to support the telescope, the vertical circle and the vernier scale.

9) Telescope

The telescope is provided betⁿ the standard at right angles to horizontal axis. It can be rotated about its horizontal axis in vertical plane. The telescope is provided with a focussing screw, clamping screw and tangent screw.

10) Vertical circle

The vertical circle is rigidly fixed with the telescope and moves with it. It is divided into four quadrant. Each quadrant is graduated from 0-90 in opposite directions, with the zero mark at the ends of the horizontal diameter of the vertical circle.

The line joining the zero mark corresponds to the line of collimation.

11) Index bar or T-frame

The index bar is provided on the standard in front of the vertical circle. It carries two verniers (C & D) at the two ends of the horizontal arm.

12) Altitude bubble

This bubble tube is provided on the top of the index bar. This bubble is brought to the centre by ~~clip~~^{clip} screw at the time of measuring vertical angle. A mirror is provided on the top of the bubble ~~to~~^{to} help observe it when the instrument is set up above normal height.

13) Compass

Some times a circular box compass is mounted on the vernier scale between the standards.

14) Temporary adjustment of Theodolite

1) Setting the theodolite over the station

The tripod stand is placed over the required station. The theodolite is then lifted from the box and fixed on top of the stand by means of a wing nut according to the fixing arrangement provided along with the instrument.

2) Approximate Levelling by Tripod stand

The legs of the tripod stand are placed well apart and firmly fixed on the ground. Then, approximate levelling is done using this stand. To do this, two legs are kept firmly fixed on the ground and the third is moved in or out clockwise or anticlockwise so that the bubble is approximately at the centre of its run.

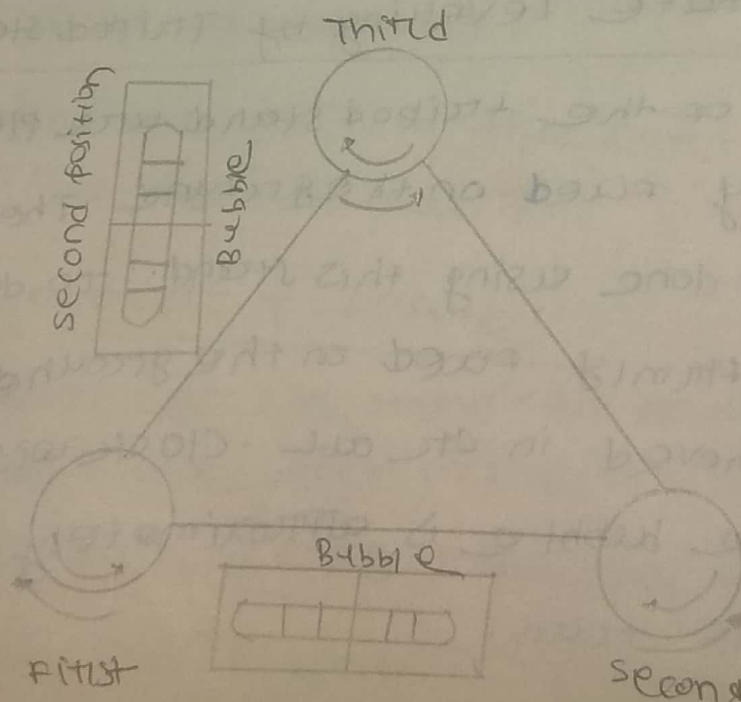
3) Centring

centring is the process of setting the instrument exactly over a station. At the time of approximate levelling means on the tripod stand, it should be ensured that the plumb bob suspended from the hook under the vertical axis lies approximately over the station peg. Then, with the help of the shifting head (movable capstan nut) the centring is done accurately so that the plumb bob is exactly over the nail of the station peg.

4) Levelling

Before starting the levelling operation, all the foot screws are brought to the centre of their turn. Then the following procedure is adopted.

a) The plate bubble is placed parallel to any pair of foot screws (say the first and second foot screws). By turning both these screws equally inwards or outwards, the bubble is brought to the centre.



b) The plate bubble is turned through 90° so that it is perpendicular to the line joining the first and second foot screws. Then by turning the third foot screw either clock-wise or anticlockwise the bubble is brought to the centre.

Some instruments may have two plate bubbles perpendicular to each other. In such a case, one bubble is kept parallel to any pair of foot screws, the other plate bubble will automatically be perpendicular to the position of the first bubble. Hence, the instrument need not be turned. The first bubble can be brought to the centre by turning the first and second foot screws, and the second bubble can be brought to the centre by turning the third foot screw.

c) The process is repeated several times, so that the bubble remains in the central position of the plate bubble, both directions perpendicular to each other.

d) The instrument is rotated through 360° about its vertical axis. If the bubble still remains in the central position, the adjustment of the bubble is perfect and the vertical axis is truly vertical.

5) Focussing the eye piece

The eyepiece is focussed so that the cross-hairs can be seen clearly. To do this, the telescope is directed towards the sky or a piece of

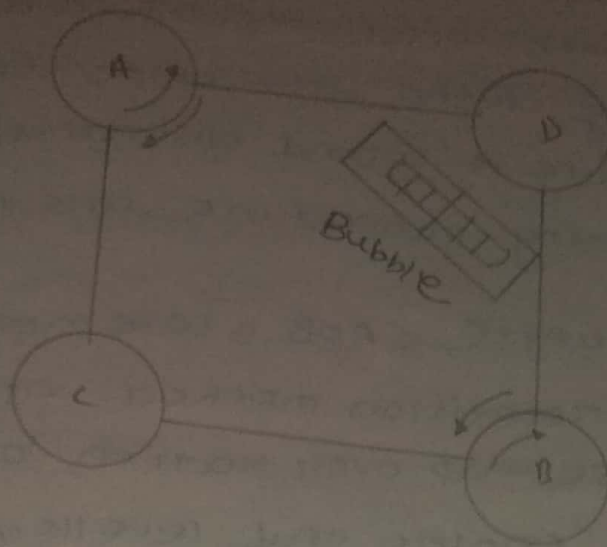
white paper is held in front of the object glass and the eyepiece is moved in or out by turning it clockwise or anticlockwise until the cross-hairs appear distinct and sharp.

6) Focussing the object glass

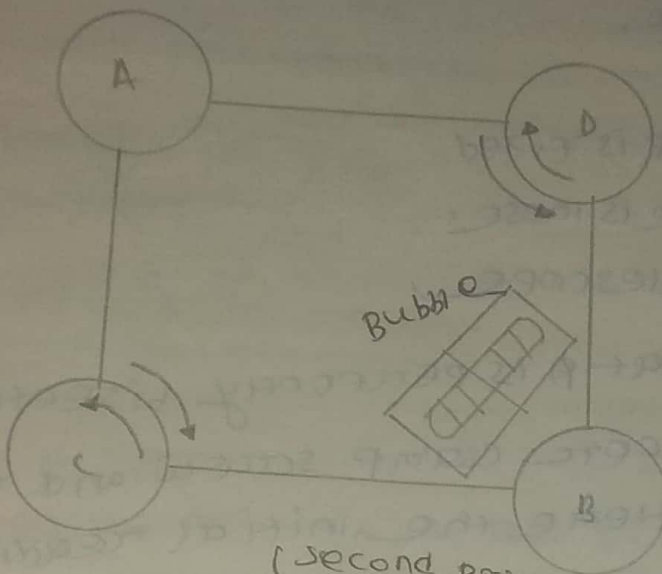
This is done to bring a sharp image of the object or target in the plane of cross-hairs and to eliminate parallax. To do this, the telescope is directed towards the object or target and focussing screw is turned clockwise or anticlockwise until the image appears clear and sharp and there is no relative movement between the image and cross-hairs. The absence of relative movement can be verified by moving the eye up and down.

7) Setting the vernier

The vernier A is set to 0° and vernier B to 180° . To do this, the lower clamp is fixed. The upper clamp is loosened and the upper plate turned until the arrow of vernier A approximately coincides with zero (i.e. the 0° mark) and that of vernier B approximately coincides with 180° mark. Then the upper clamp is tightened and by turning the upper tangent screw, the arrows are brought to a position of exact coincidence.



First position



(Second position)

26.10.17

Direct method of measuring horizontal angle

There are two methods of measuring horizontal angle
i.e. repetition method

Repetition method

on this method, the angle is added a number of times. The total is divided by the number of readings to get the angle. The angle should

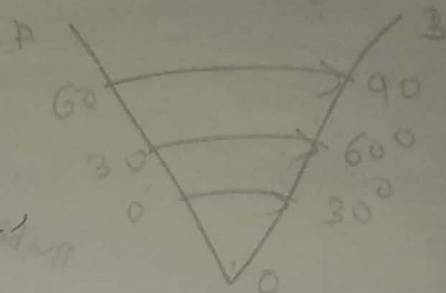
be measured clock wise in the face left and right position, with three repetition at each end. The final reading of the first observation will be the initial reading of second observation on station on and the following procedure are to be adopted.

1) Suppose the angle $\angle AOB$ is to be measured by the method of repetition method. First the theodolite is set up over station 'O', the instrument is centred and levelled properly. The vernier A is set as ~~zero~~ 0° and vernier B is set as 180° .

2) The upper clamp is fixed and the lower one is loose.

By turning the telescope,

the ranging rod at A is perfectly bisected with the help of the lower clamp screw and the lower tangent screw. Here the initial reading of vernier A is 0° .



3) The upper clamp is loosed and the telescope is turned clock wise perfectly bisect the ranging rod at point B. The upper clamp is clamped. Suppose the reading on vernier A is 30° .

4) The lower clamp is loosed and anticlock the telescope is turn anticlock wise to exactly bisect the ranging rod at point A. Hence the initial reading is 30° for the second observation.

5) The power clamp is tightened, the upper one is loosened and the telescope is turned clockwise to exactly bisect the ranging rod at B. Let the reading on vernier A is 60° .

6) The initial reading for the third observation is 60° . $\angle AOB$ is again measured. Let the final reading on the vernier A is 90° , which is the accumulated angle.

$$\angle AOB = \frac{\text{accumulated angle}}{\text{no. of readings}}$$

$$= \frac{90^\circ}{3} = 30^\circ$$

7) The face of the instrument is changed and the previous procedure is followed.

8) The mean of the two observations gives the actual angle $\angle AOB$.

2) Reiteration method

The method is suitable when several angles are measured from a single station. In this method, all the angles are measured successively and finally the horizon is closed, i.e. the angle betⁿ the last station and first station. So the final reading of the leading vernier should be same as its initial reading. If the discrepancy is small, the error is equally distributed among all the observed readings. If it is large, the readings should be cancelled and new readings can be taken as.

Following procedure are adopted for this method.

1) The theodolite is perfectly centred over O and levelled properly in the usual manner.

2) Vernier A is set at 0 and vernier B is set at 180° .

3) The upper clamp is fixed and the lower one loose. The ranging rod at A is perfectly bisected. The lower clamp is tight.

4) The upper clamp is loose and the ranging rod should be bisected at point B, by turning the telescope in clock wise direction. The readings on both the verniers are taken. $\angle AOB$ is noted.

5) Similarly, the object C is bisected properly and the readings on the verniers are noted. $\angle BOC$ is noted.

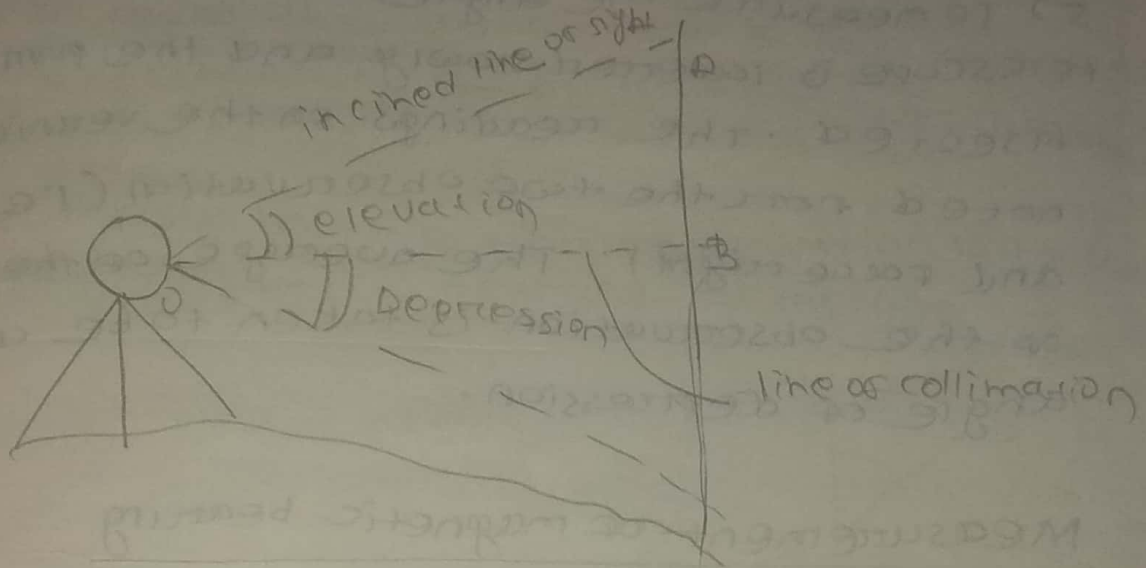
6) Now the horizon is closed, i.e. the last angle $\angle COA$ is measured. The position of the reading vernier is noted. The leading vernier should show the initial reading on which it was set. If it does not, the amount of discrepancy is noted. If it is small, the error is distributed among the angles. If the discrepancy is large, the observation should be taken again.

7) ~~The face right~~ The instrument is changed to the face right position and previous procedure are adopted for taking the horizontal angles in the reiteration method. The mean of the two observations should give ~~keep~~ the actual angle under this method.

Measurement of vertical angle

27.10.17

The vertical angle is the angle between the horizontal line i.e. line of collimation and the inclined line of sight. When it is above the horizontal line, it is known as angle of elevation, when it is below the horizontal line it is known as angle of depression.



Following procedure are adopted while measuring the vertical angle.

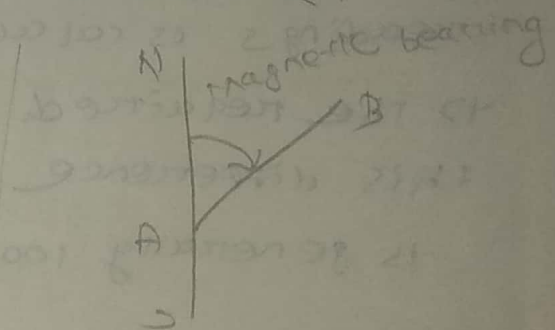
- 1) The theodolite is set up over station 'O' and centred and levelled properly. The vernier and arc are set at $0^\circ-0'$ respectively. The telescope is then clamped.
- 2) The plate bubble is brought to the ~~and~~ centre with the help of foot screw. Then the altitude bubble is brought to the centre by means of clip screw. At this position the line of

- collimation is exactly horizontal.
- 3) To measure the angle of elevation, the telescope is raised slowly to bisect the point A accurately. The readings on both the verniers are noted and the angle of elevation is recorded.
 - 4) The ~~face~~ face of the instrument is changed, the point A is again bisected, the readings on verniers are noted. The mean of the angles of the observed is assumed to be correct angle of elevation.
 - 5) To measure the angle of depression, the telescope is lowered slowly and the point B is bisected. The readings on the verniers are noted for the two observation (i.e. face left and face right). The average of the angles of the observation is taken to be correct angle of depression.

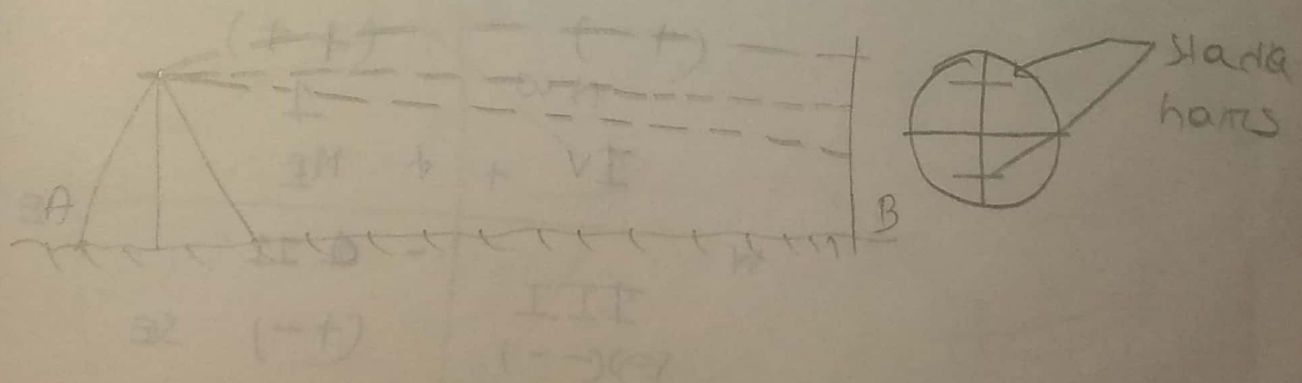
Measurement of magnetic bearing

- 1) The theodolite is set up at point A, and centered and levelled properly. Vernier A is set at 0° and vernier B is set at 180° . The upper clamp is fixed.
- 2) Now ~~a~~ through a compass, fixed on the left hand of ~~a~~ ~~the~~ A frame. On some theodolite a circular compass is provided over the vernier scale both the standards. However the ~~a~~ needle of the compass is released.

- 3) By loosening the lower clamp, the telescope is rotated until it points to the north. At this time the position of the telescope is set to be perfectly oriented along the magnetic meridian.
- 4) The lower clamp is fixed and the upper clamp is loosened. Then by turning telescope in a clockwise direction, the ranging rod at B is bisected with the help of the upper tangent screw.
- 5) The readings on both the verniers are taken. The mean of the two observations is the magnetic meridian bearing of AB.
- 6) The face of the instrument is changed and the magnetic bearing of AB is measured in a similar manner.
- 7) The mean of the two observations will give the correct magnetic bearing of the line.



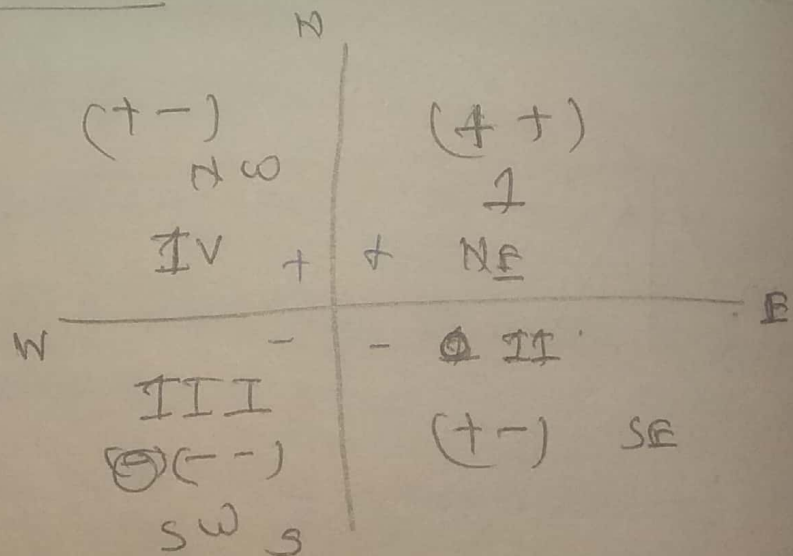
Measuring horizontal distance by stadia method



- 1) The bubble is set up at A. It is then centred properly. The vertical verniers (generally one) are set at 'zero' of the vertical circle by the clamp screw and the tangent screw of the telescope (since the vertical circle is fixed to the telescope).
- 2) The plate bubble is brought to the centre by turning the foot screws and the altitude bubble is centred by means of the clip screw (which is just below the altitude bubble). The line of collimation is made exactly horizontal in this manner.
- 3) The levelling staff is held at B, and the telescope is directed towards this point. By focussing the staff, the readings of the upper and lower stadia are noted. The difference between the two readings is calculated.
- 4) The required distance AB is obtained by multiplying this difference by the stadia constant (which is generally 100).

31.10.17

Convert WCB to RB



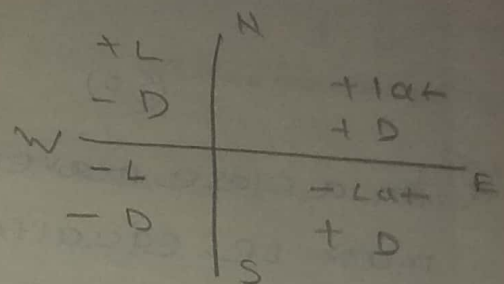
WCB	Corresponding RB	Quadrant
0-90°	WCB	NE
90-180°	180-WCB	SE
180-270°	WCB-180°	SW
270-360°	360-WCB	NW

convert the following WCB to RB and

- i) 45° 30'
- ii) 125° 45'

iii) 222° 15'

iv) 320° 30'



~~WCB~~ ~~WCB~~ RB RB

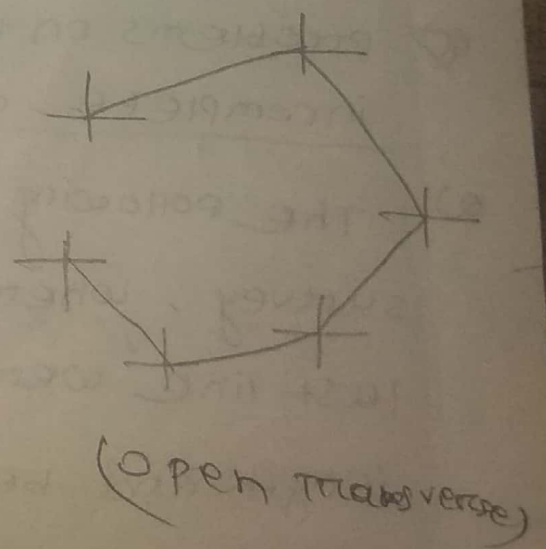
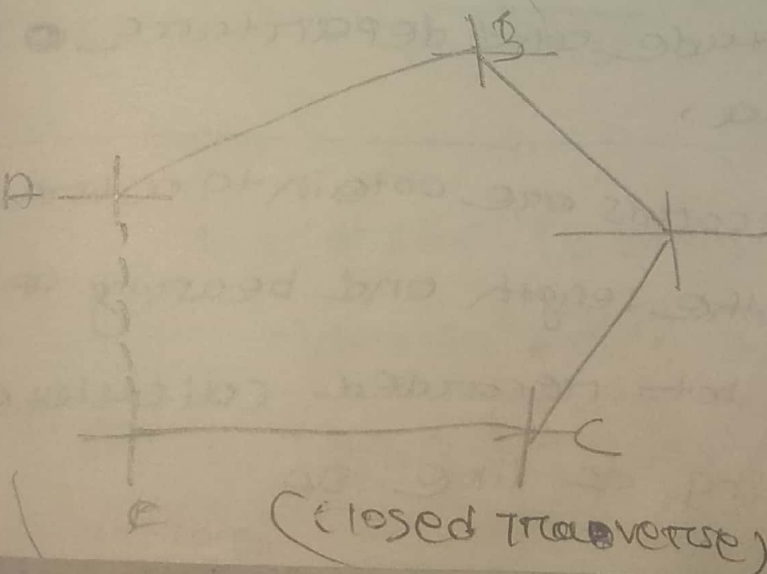
i) N 45° 30' E

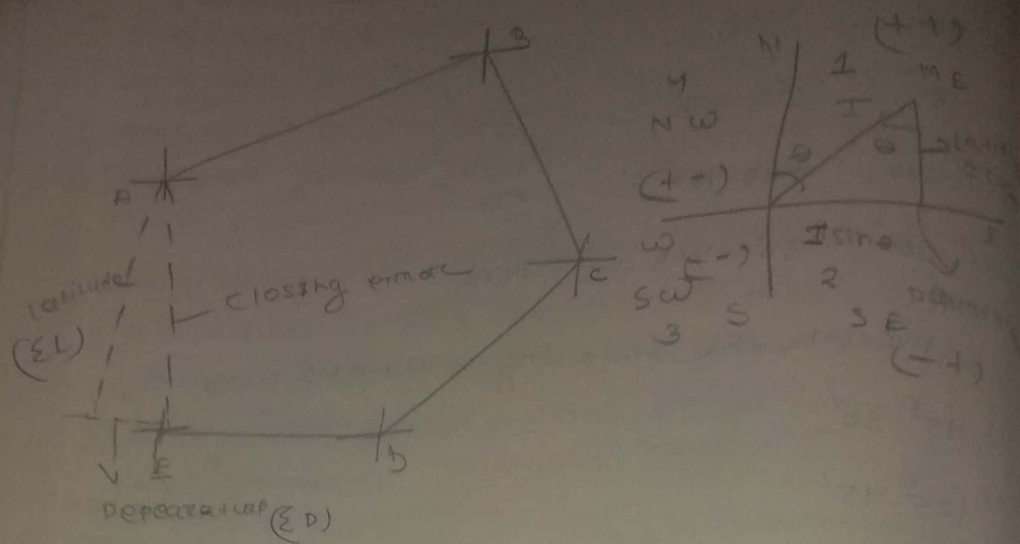
ii) ~~S 59° 25' E~~

iii) S 42° 15' W

iv) ~~N 40° 30' W~~

v) N 39° 30' W





* On a close traverse the algebraic sum of latitude must be equal to zero and so the algebraic sum of departure will also be equal to zero.

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

* Latitude is the distance measured parallel to the north-south line and departure of a line is measured parallel to the east-to-west line.

⊗ problems on latitude and departure with incomplete data.

- Q) The following records are obtained in a traverse survey, where the length and bearing of a last line were not recorded. Calculate the length and bearing of line DA.

Line	Length (cm)	Bearing
AB	75.50	$30^{\circ}24'$
BC	180.50	$110^{\circ}36'$
CD	60.25	$210^{\circ}30'$
DA	?	?

Ans)

Line	Length (cm)	Bearing	RD	Latitude $L \cos \theta$	Departure $L \sin \theta$
AB	75.50	$30^{\circ}24'$	N $30^{\circ}24'$ E	$75.50 \cos 30^{\circ}24'$ $= 65.12$	38.21
BC	180.50	$110^{\circ}36'$	S $69^{\circ}24'$ E	-63.51	+168.95
CD	60.25	$210^{\circ}30'$	S $30^{\circ}30'$ W	-51.91	-30.60
DA	L	θ		$L \cos \theta$	$L \sin \theta$

$$\Sigma L = 65.12 - 63.51 - 51.91 + L \cos \theta = 0$$

$$-50.3 + L \cos \theta$$

$$L \cos \theta = 50.3$$

$$\Sigma \Delta = 38.21 + 168.95 - 30.60 + L \sin \theta = 0$$

$$176.56 + L \sin \theta$$

$$L \sin \theta = -176.56$$

$$\frac{L \sin \theta}{L \cos \theta} = \frac{-176.56}{50.3}$$

$$\tan \theta = 3.5101$$

$$\theta = \tan^{-1}(3.5101)$$

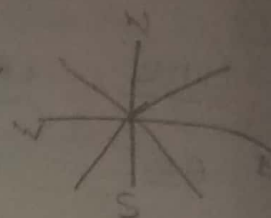
$$\theta = 74^{\circ}05' \quad \text{N } 74^{\circ}05' \text{ W}$$

$$AE = \sqrt{(50.3)^2 + (176.56)^2}$$

Distance DA = 183.58 m

Q) The record of a closed traverse is given below with two distance missing

Line	Length m	Bearing
AB	100.5	N 30° 30' E
BC	?	S 45° 0' E
CD	75.0	S 40° 30' W
DE	50.5	S 60° 0' W
EA	?	N 40° 15' W



calculate the lengths of BC and EA.

Line	Length m	Bearing	Latitude $L \cos \theta$	Departure $L \sin \theta$
AB	100.5	N 30° 30' E	86.59	51.00
BC	?	S 45° 0' E	-0.70	
CD	75.0	S 40° 30' W	-57.03	-48.71
DE	50.5	S 60° 0' W	-25.25	-43.73
EA	?	N 40° 15' W		

Line	Length m	Bearing	Angle	Latitude $(L \cos \theta)$	Departure $(L \sin \theta)$
AB	100.5	N 30° 30' E	30° 30'	86.59	51.00
BC	L_1	S 45° 0' E	45° 0'	-0.7071 L_1	-0.7071 L_1
CD	75.0	S 40° 30' W	40° 30'	-57.03	-48.71
DE	50.5	S 60° 0' W	60° 0'	-25.25	-43.73
EA	L_2	N 40° 15' W	40° 15'	0.76312 L_2	-0.6462 L_2

$$\Sigma L = 86.79 - 0.707L_1 - 57.93 - 25.27 + 0.763L_2$$

$$= -0.707L_1 - 0.763L_2 = -4.31 \quad (1)$$

$$= 0.703L_2 - 0.703L_1 = -4.31 \quad (2)$$

$$SD = 51.00 + 0.707L_1 - 48.71 - 43.73 - 0.646L_2 = 0$$

$$0.707L_1 - 0.646L_2 = 41.44 \quad (3)$$

Adding eqn (1) & (2)

$$= -0.707L_1 - 0.763L_2 = -4.31$$

$$0.707L_1 - 0.646L_2 = 41.44$$

$$0.763L_2 = -4.31$$

$$0.646L_2 = 41.44$$

$$0.117_{L_2} = 0.37.13$$

$$L_2 = \frac{37.13}{0.117} = 317.35 \text{ m}$$

putting the value of L_2 in eqn (1)

$$0.707L_1 = 0.763 \times 317.35 + 4.31$$

$$L_1 = 348.58 \text{ m}$$

Balancing of traverse

2.11.17

Remark

1) Bowditch's Rule

a) correction to latitude of any side

$$= \frac{\text{Length of that side}}{\text{perimeter of traverse}} \times \text{total error in latitude}$$

b) correction to departure of any side

$$= \frac{\text{Length of that side}}{\text{perimeter of traverse}} \times \text{total error in departure}$$

2) Transit Rule

a) correction to latitude of any side

$$= \frac{\text{latitude of that side}}{\text{Arithmetical sum of all latitudes}} \times \text{total error in latitude}$$

b) correction to departure of any side

$$= \frac{\text{departure of that side}}{\text{Arithmetical sum of all departures}} \times \text{total error in departure}$$

3) Third Rule

a) correction to northing of any side

$$= \frac{\text{northing of that side}}{\text{sum of northings}} \times \frac{1}{2} (\text{total error in latitude})$$

b) correction to southing of any side

$$= \frac{\text{southing of that side}}{\text{sum of southings}} \times \frac{1}{2} (\text{total error in latitude})$$

c) correction to easting of any side

$$= \frac{\text{easting of that side}}{\text{sum of eastings}} \times \frac{1}{2} (\text{total error in departure})$$

d) correction to westing of any side

$$= \frac{\text{westing of that side}}{\text{sum of westing}} \times \frac{1}{2} (\text{total error in departure})$$

CONTOURCONTOURING

To find the

contouring is a levelling operation.

The main objective of contouring is to determine the point on the ground having same reduced level.

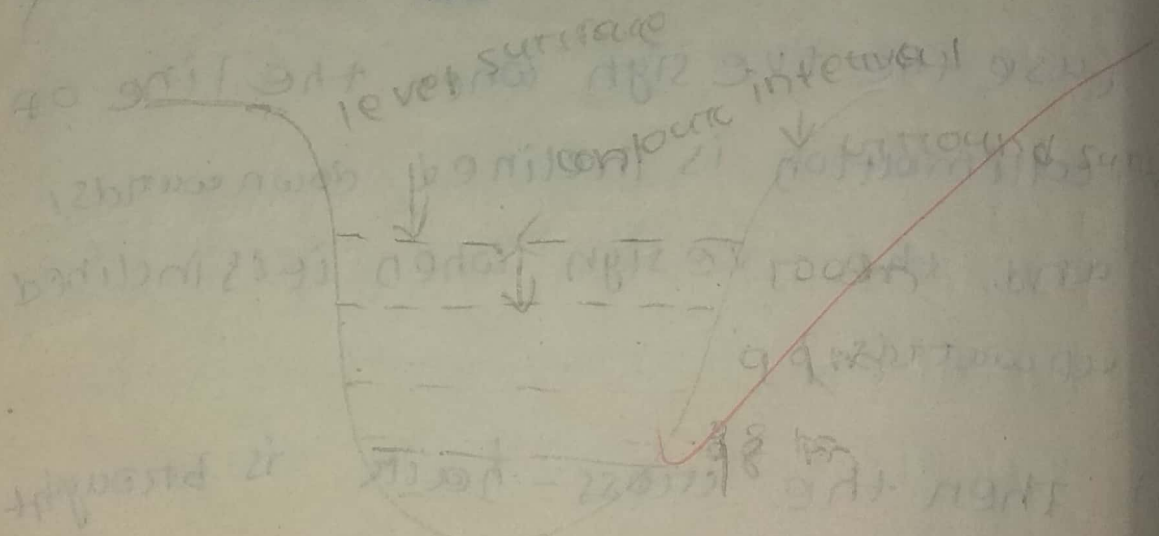
contour line joint the point of

same elevation directly etc by

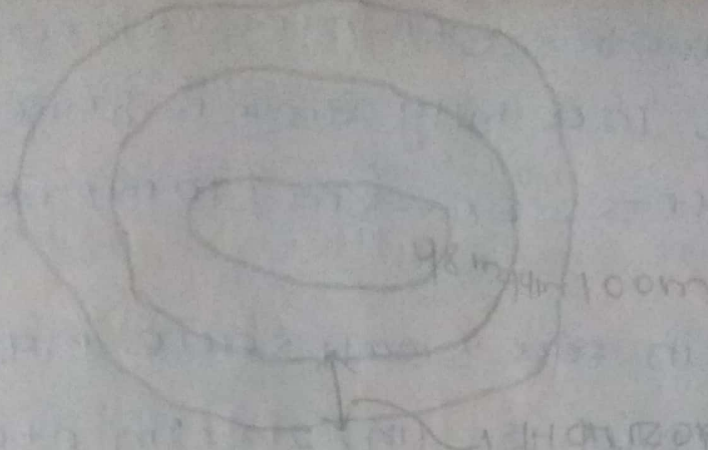
interpolation technique.

contour line

A line passing through points of equal RL.



Ex - Suppose a contour of 100m indicates all the points on this line having the RL of 100m. Similarly a contour of 99m indicates all the points on this line having the RL of 99m.



Contour interval

It is the vertical distance between two consecutive contour lines.
 Suppose a map includes a contour line of 100m, 98m, 96m and so on, then here the contour interval is 2m. The contour interval:

- The contour interval depends on
 - Nature of the ground surface (whether flat or ^{slope} slope)
 - The scale of the map.
 - The purpose of the survey.
- The contour interval for flat country are generally small
 Ex - 0.25m, 0.50m, 0.75m etc.

The contour interval for steep slope in a hilly area is generally greater ex - 5m / 10m / 15m etc.

Again for small scale map, the interval is 1m, 2m, 3m etc and for large scale map the interval is 0.25 / 0.50 / 0.75 etc.

It is remembered that the contour interval for a particular map is constant.

Horizontal equivalent

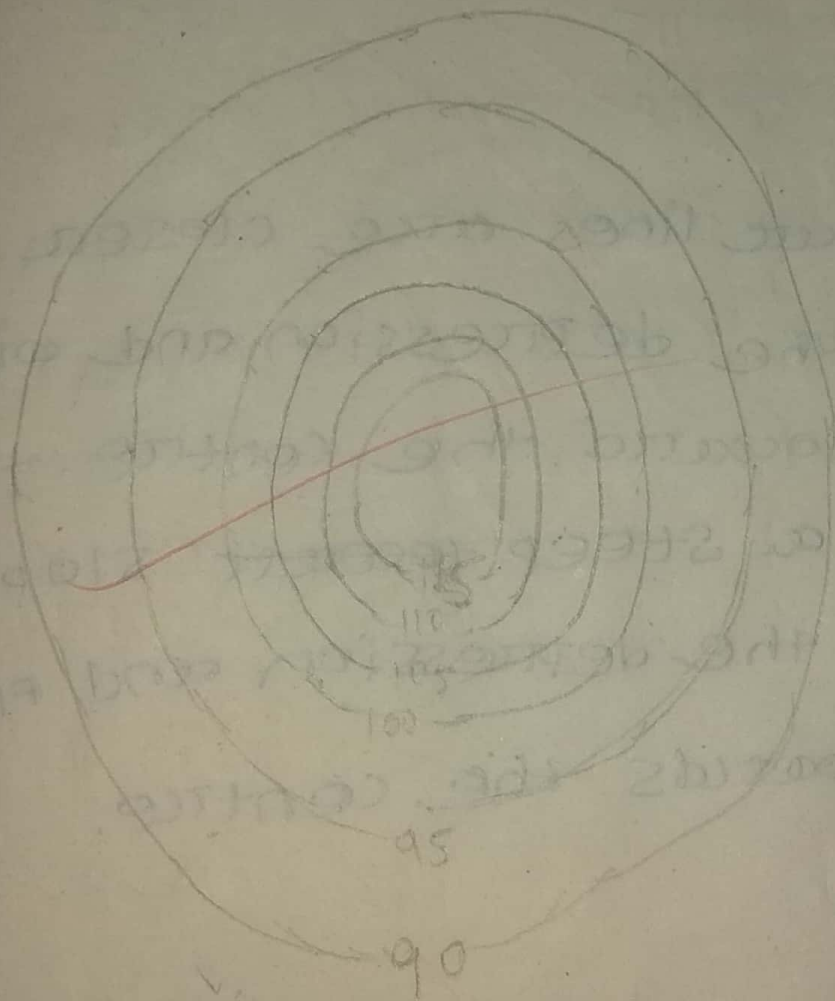
It is the horizontal distance between two consecutive contour lines.

It is not constant. It varies according to the steepness of the ground.

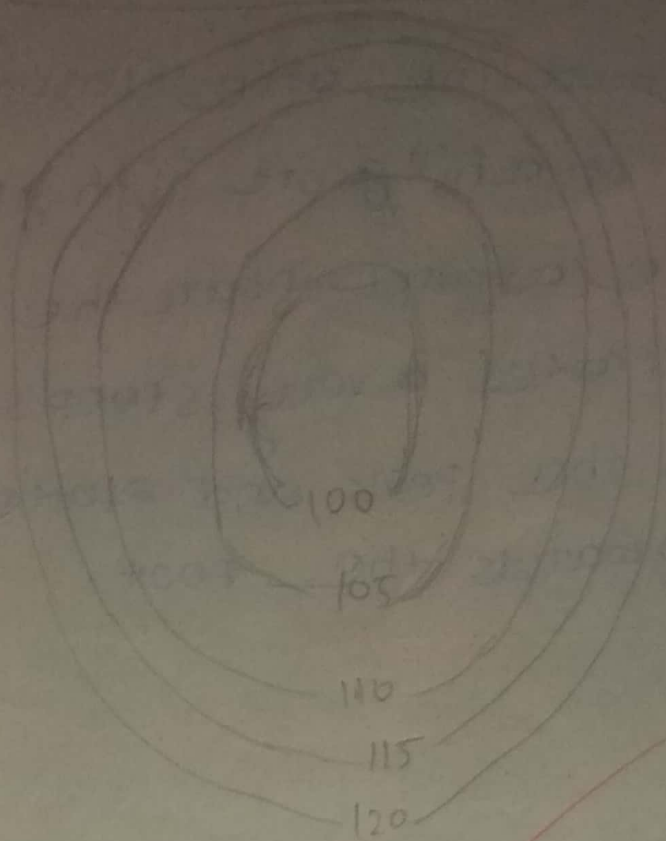
The contour line close together and the flatter slope they are widely spaced.

Important characteristics of contouring

- 1) The contour line are closer near the top, of a hill or high ground, and wide apart near the foot. This indicates a very steep slope towards the peak and flatter slope towards the foot.



2)



The contour lines are closer towards the depression and wider apart towards the centre. This indicates a steep ~~slope~~ slope towards the depression and flatter slope towards the centre.

3)

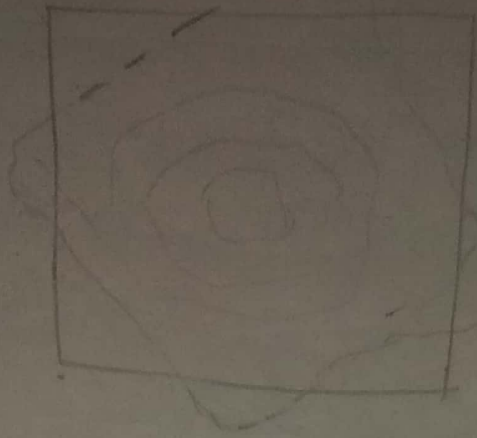
100.0

99.0

98.0m

uniformly spaced contour line indicates a uniform slope.

4)

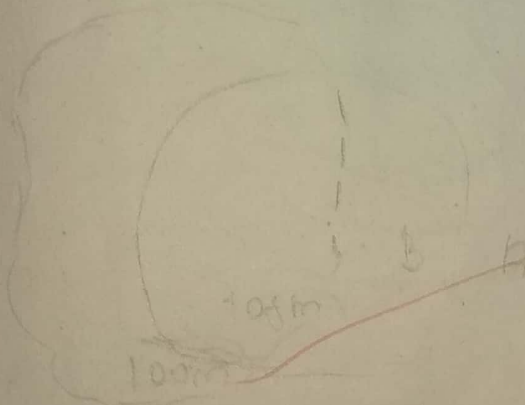


Contour line always form a closed circuit. But the lines may be within or outside the limits of the map.

~~5) over~~

5)

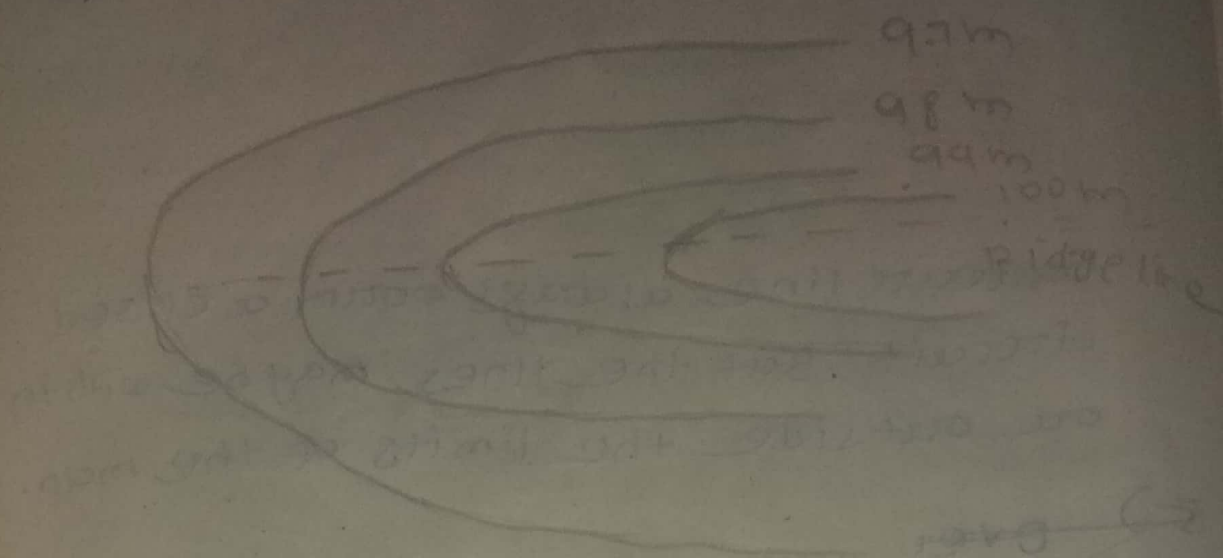
5)



Contour line cannot cross one another except in the case of the overhanging cliff. The cliff must be

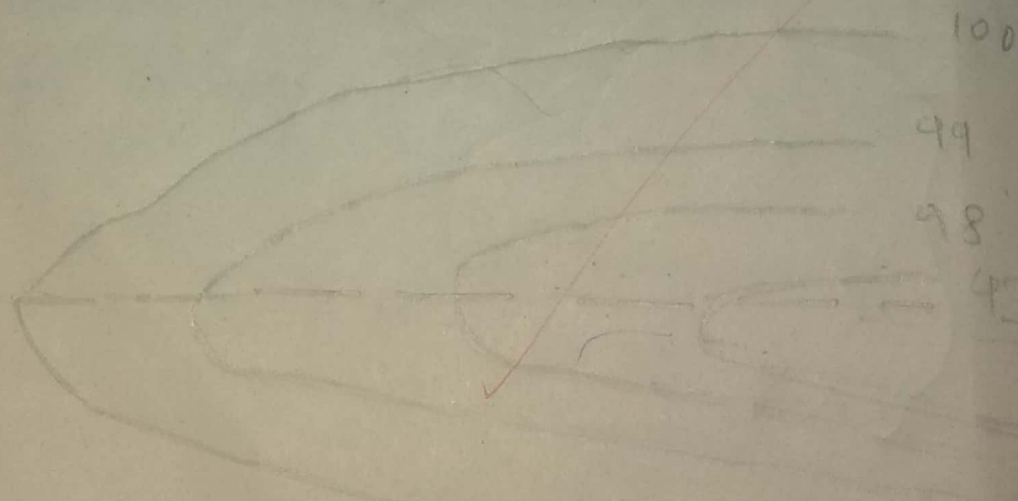
shown with a dotted line.

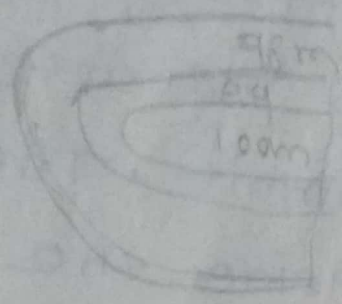
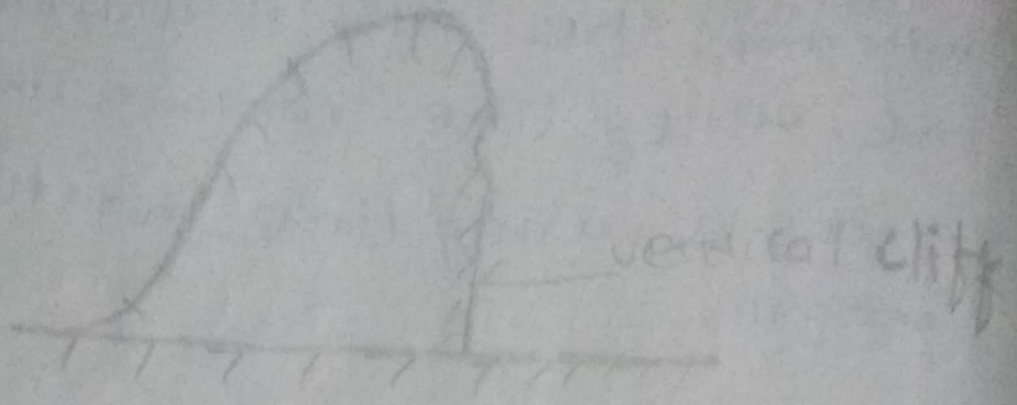
6)



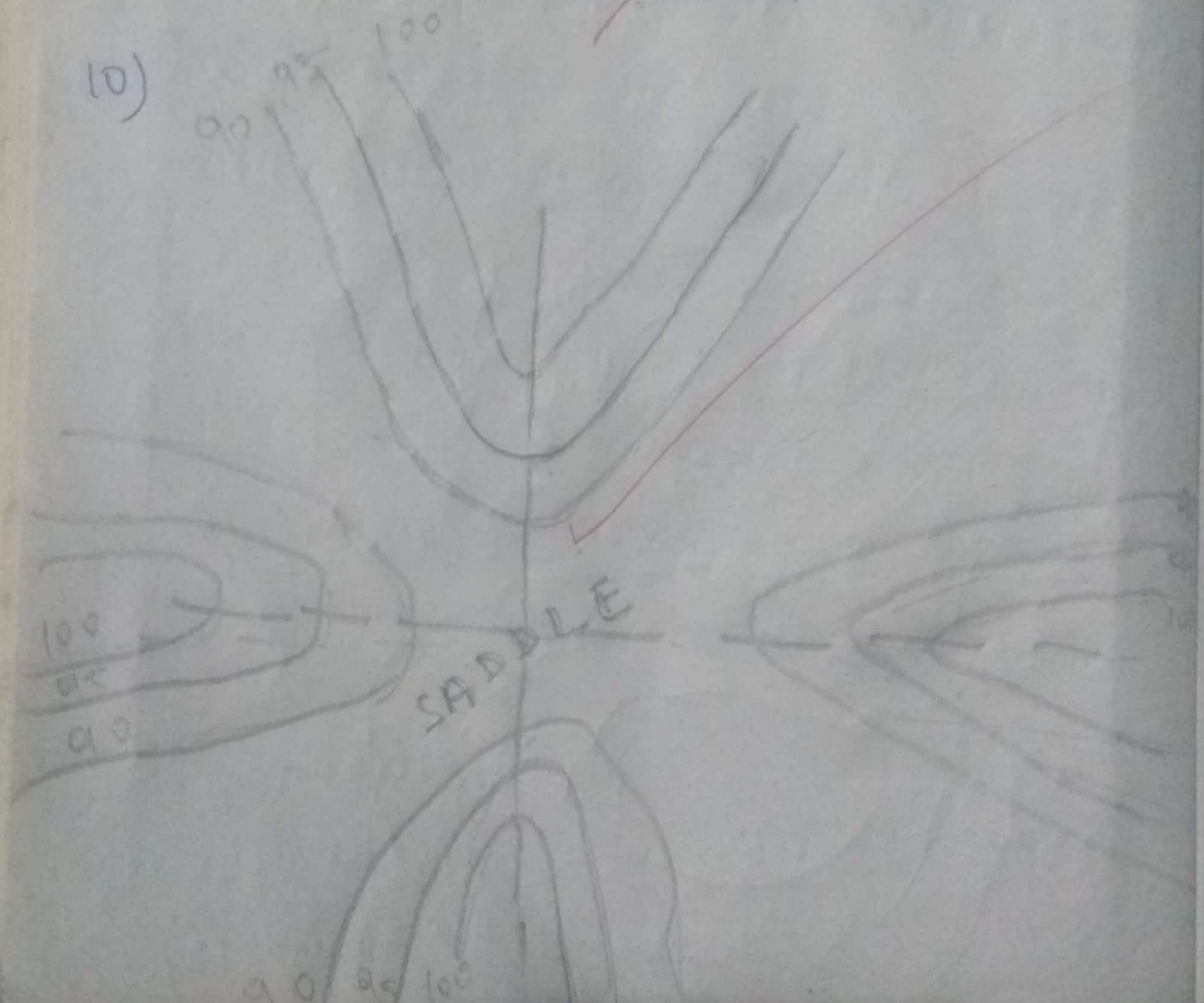
when the higher values are inside the loop, it indicates the ridge line. contour line cross a ridge line at right angle.

7)





contour line meeting at a point
indicate a vertical cliff.



depression betⁿ summit are called saddle.

Methods of contouring

There are two methods of contouring.

i) Direct

ii) Indirect

1) Direct method

case-I →

when the area is oblong and cannot be contour^{ed} by single station.

on this method, the various points are any contour line located on the ground by taking level. Then these points are marked by pegs. After this the points are plotted on the map to any suitable scale by plane table. This method is very slow but it gives accurate contour line.

Procedure

1) Suppose a contour map is to be prepared for an oblong area, a temporary bench mark is set up

near the site by taking fly level readings from a permanent BM.

2) The level is then set up at a suitable position 'L' from where maximum area can be covered.

3) The plane table is set up at a suitable station 'P' from where the above area can be plotted.

4) A Back sight reading is taken on a temporary BM. Suppose the RL of the temporary BM is 249.50m and the BS reading is 2.250 . Then the RL of the HI is 251.750 . If a contour of 250.00m is required the staff reading should be 1.750m . If a contour of 249.00m is required then the staff reading should be 2.75m and so on.

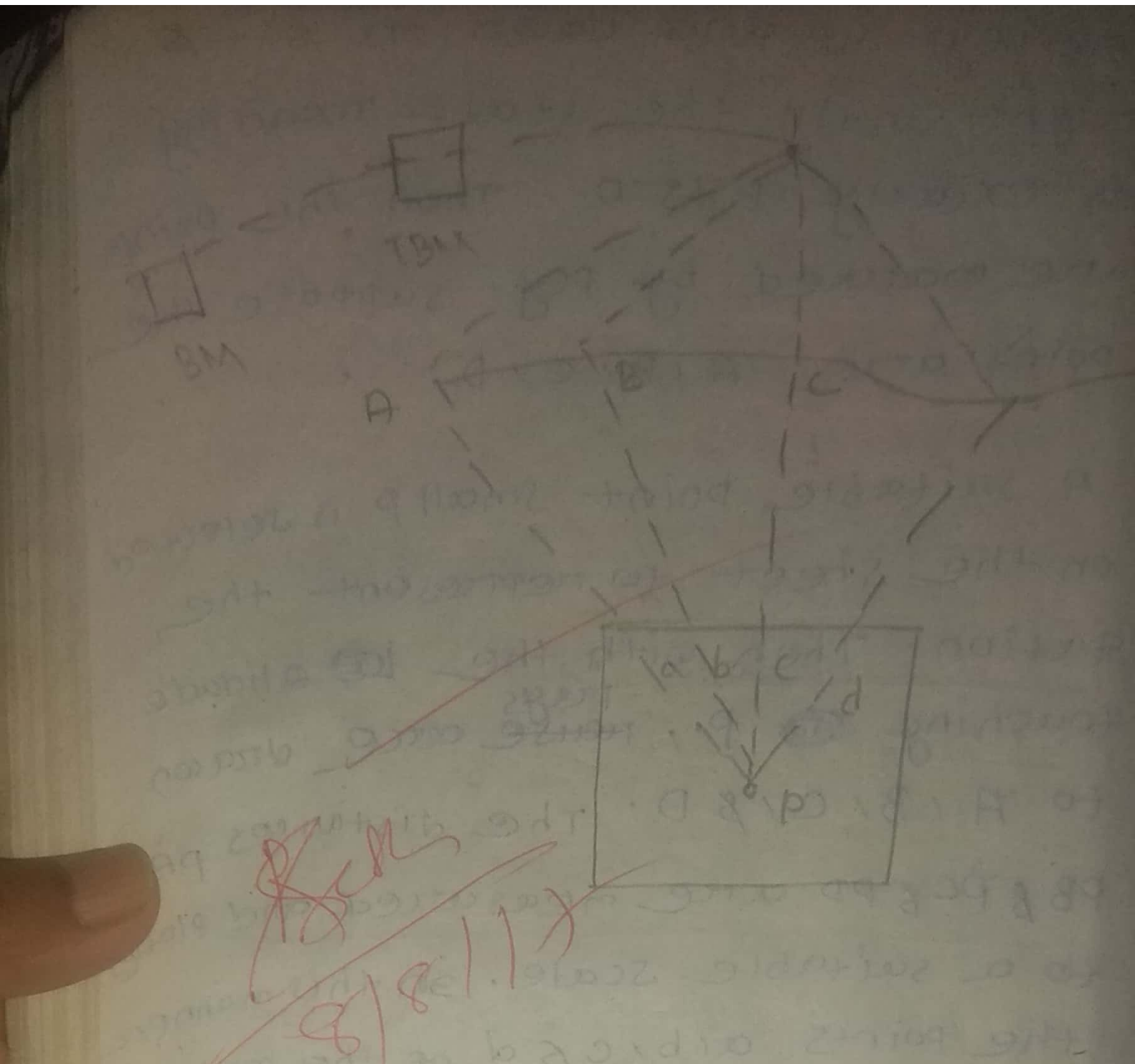
5) The staff man hold the staff at diffⁿ points of the area by

moving up and down or left & right until the staff reading is exactly 1.750. Then the points are marked by peg. Suppose the points are A / B / C / D

6) A suitable point small p is selected on the sheet to represent the station. Then with the ~~level~~ alidade touching ~~the~~ p, ^{rays} ~~are~~ drawn to A / B / C / & D. The distances pA, pB & pC & pD are measured and plotted to a suitable scale. In this manner the points a, b, c & d of the contour line of 250.00m are obtained. These points are joined to obtain the contour of ~~250~~ 250.00m.

7) Similarly the points of other contour are located.

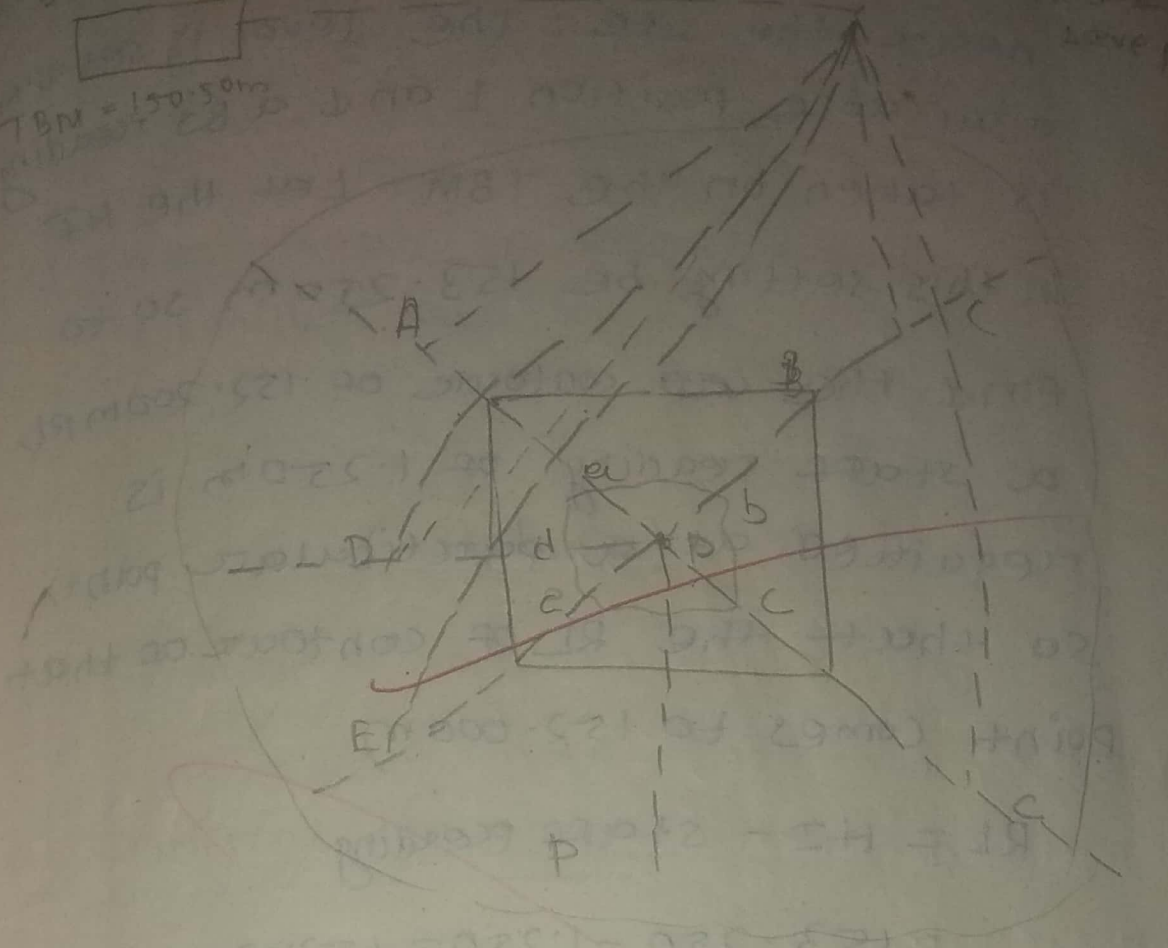
8) When required the levelling instrument and the plane table are shifted and set up in a new position in order to continue the operation along the oblong area.



$$BS = 2.74m$$

$$RLOF HT = 153.25m$$

$$TBM = 150.50m$$



RLOF HT

$$= TBM + BS$$

$$= 153.25$$

Direct method



- 1) The plane table is set up at a suitable station p from where the whole area can be commanded.
- 2) A point p is suitably selected on the sheet to represent the station p. Radial lines are then drawn in different directions.

3) A temporary bench-mark is established near the site. The level is set up at a suitable position L and a BS reading is taken on the TBM. Let the HI in this setting be 153.250 m. So to find the ~~contour~~ contour of 152.000 m, a staff reading of 1.250 m is required at a particular point, so that the RL of contour of that point comes to 152.000 m.

$$RL = HI - \text{staff reading}$$

$$= 153.250 - 1.250 = 152.000 \text{ m}$$

4) The staffman holds the staff along the rays drawn from the plane table station in such a way that staff reading on that point is exactly 1.250. In this manner, points A, B, C and E are located on the ground where the staff readings are exactly 1.250.

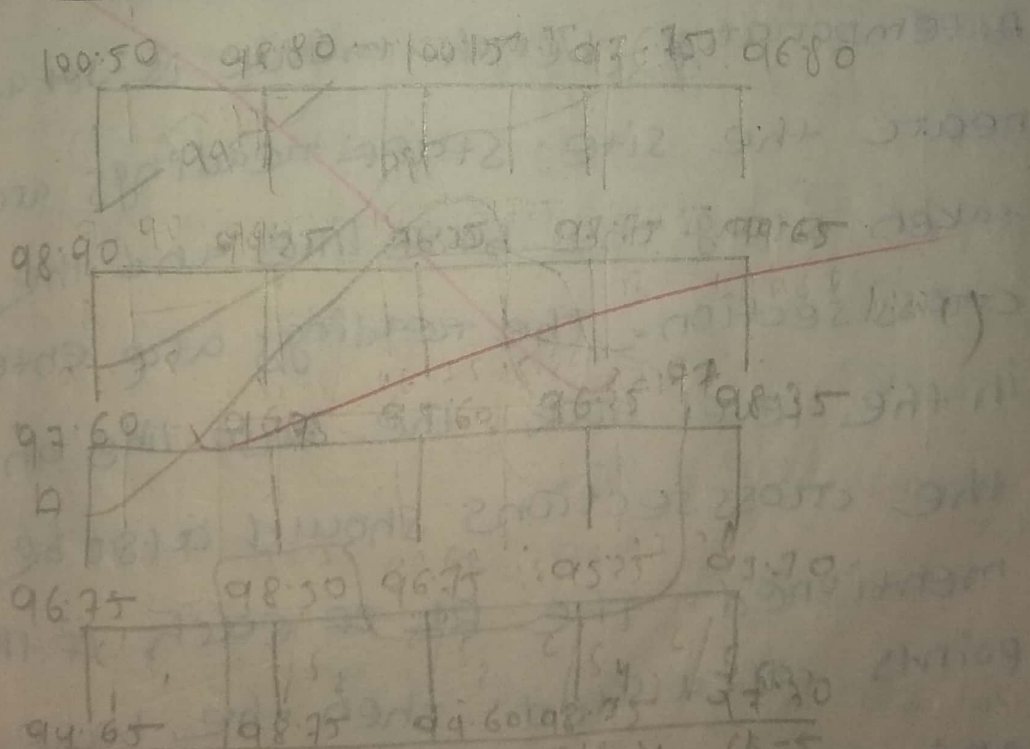
5) The distance PA, PB, PC, PD, PE are measured and plotted to

any suitable scale. Thus the points a, b, c, d and e are obtained which are joined in order to obtain a contour of 152.000.

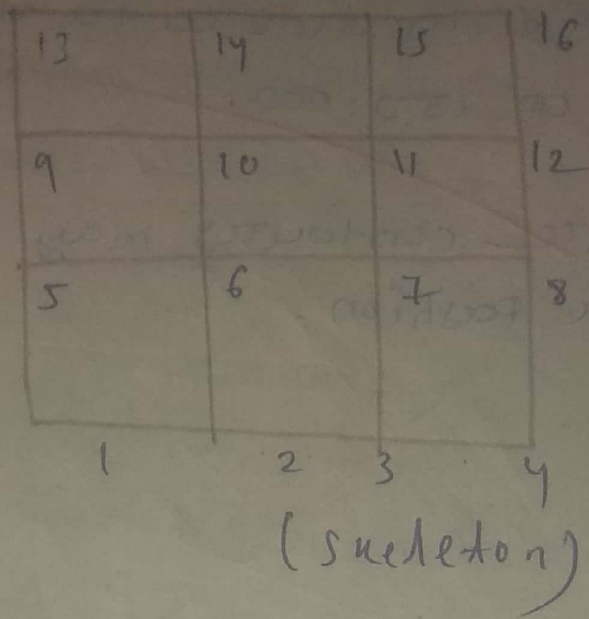
b) The other contours may be located in similar fashion.

b) Indirect method

→ cross section



On this method, a base line, centre line or profile line is considered. Cross sections are taken perpendicular



to this line at regular intervals (say 50m, 100m etc). After this, points are marked along the cross-sections at a regular intervals (say 2.5m, 1m etc). A temporary bench-mark is set up near the site. Staff readings are taken along the base line and the cross section. The readings are entered in the level book. The base line and the cross sections should also be mentioned. The RL of each of the points calculated. Then the base line and cross-sections are plotted to a suitable scale. Subsequently, the RLs of the respective points are

noted on the map, after which the required contour line is drawn by interpolation.

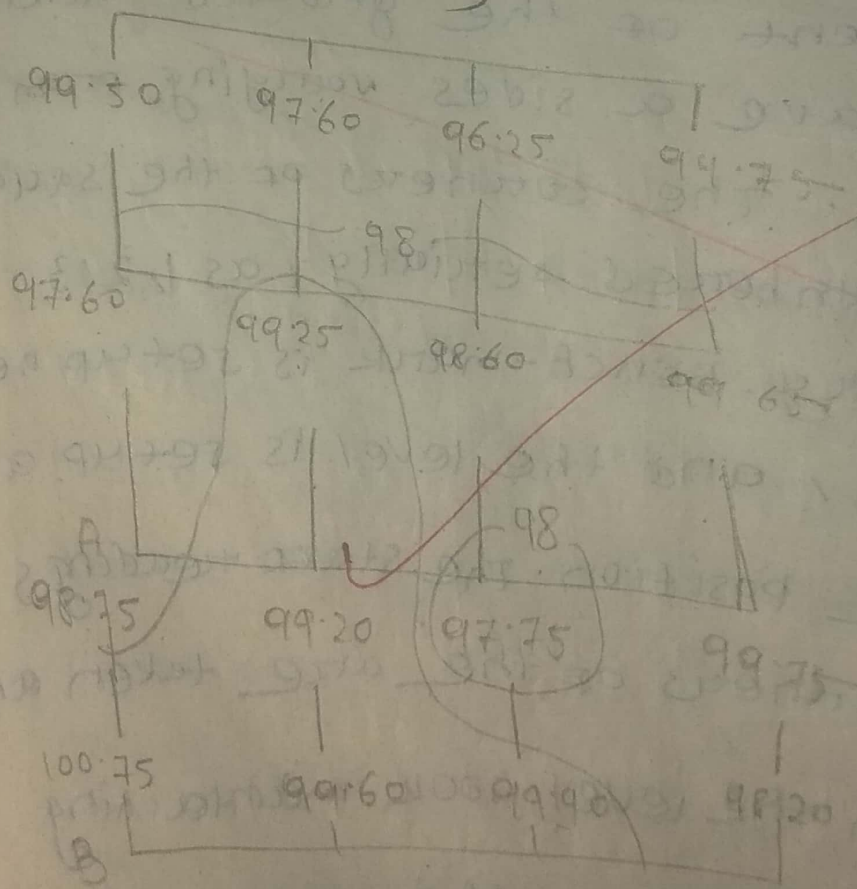
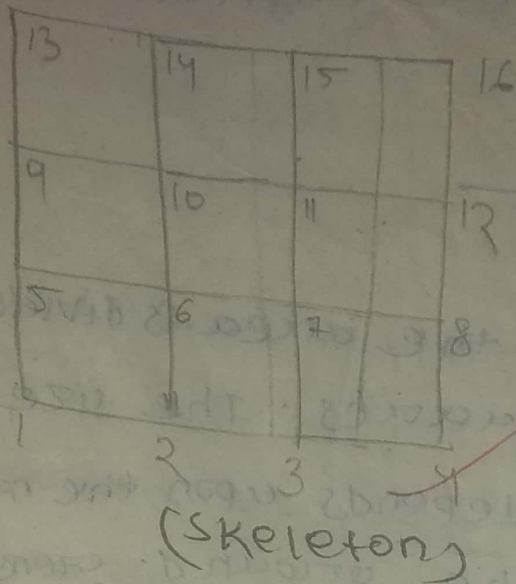
This method is suitable for cross section survey, when cross sections are taken transverse to the longitudinal section.

b) using squares

~~on this method~~

on this method the area is divided into a number of squares. The size of these squares depends upon the nature and extent of the ground. Generally they have a sides varying from 1 to 2m. The corners of the squares are numbered serially, as 1, 2, 3... A temporary bench-mark is set up near the site, and the level is set up at a suitable position. The staff readings of the corners of the area are taken and noted in the level book maintaining the sequence of the serial numbers of the corners. The RLs of all the corners are calculated. The

skeletons of the surfaces are plotted to a suitable scale. The two principal axes are noted on the corners, and which the contour lines are drawn by interpolation.



(PLS noted as per sketch)

METHOD OF INTERPOLATION

a) Arithmetical method

A & B are two corners of a square
and RL of point A ~~is~~ 98.75m
RL of point B is 100.75m

~~cont~~

So, the vertical distance betⁿ point

$$A \& B \text{ is } 100.75 - 98.75 = 2\text{m}$$

Let, Horizontal distance betⁿ point

$$A \& B = 10\text{m}$$

Let, a 99m contour be required

So, diffⁿ of level betⁿ point A & 99m

Contour is

$$99.00 - 98.75 = 0.25\text{m}$$

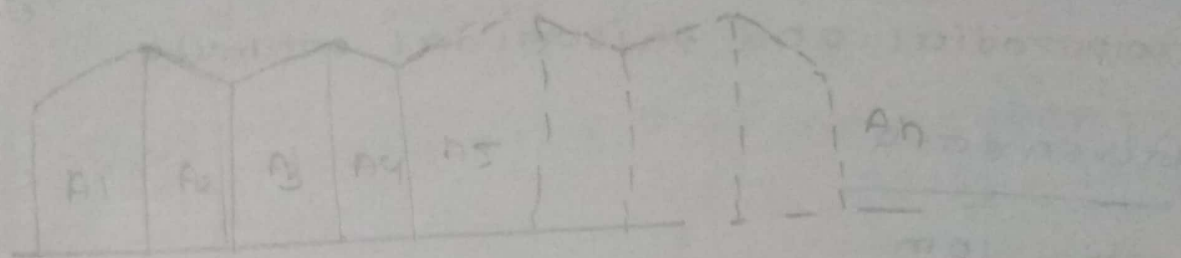
Distance of 99m contour line from

$$A = \frac{\text{Horizontal distance} \times \text{diffⁿ of level}}{\text{vertical distance}}$$

$$= \frac{10}{2} \times 0.25$$

$$= 1.25\text{m}$$

Formula for calculation of volume



A) Trapezoidal Formula

[Average - End - Area - rule]

Volume (cutting or filling)

$$V = \frac{D}{2} \left\{ \text{area of first section} + \text{area of last section} + 2 \left[\text{sum of area of other sections} \right] \right\}$$

where D = common distance between two sections

B) Prismoidal Formula

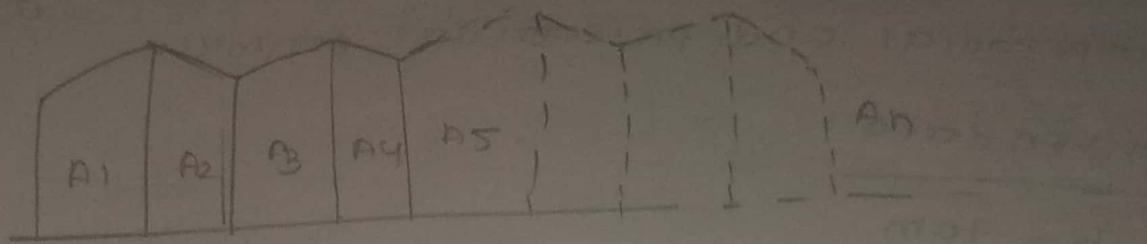
Volume (cutting or filling)

$$V = \frac{D}{3} \left\{ \text{area of first section} + \text{area of last section} + 4 \left(\text{area of sum of even sections} \right) + 2 \left(\text{area of sum of odd sections} \right) \right\}$$

where D = common distance

- 1) An embankment of 10m width and side slope 1.5:1 is required to be made on a ground which is level in a direction transverse to the centre line. The central height at 40m intervals are as follows.

Formula for calculation of volume



A) Trapezoidal Formula

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where D = common distance

- 2) An embankment of 10m width and side slope 1.5 is required to be made on a ground which is level in a direction transverse to the centre line. The central height at 40m intervals are as follows.

0.90, 1.25, 2.15, 2.50, 1.85, 1.35, 0.85

calculate the volume of the earth work by trapezoidal and prismoidal formula.

Given data

$$b = 10\text{m}$$

$$s = 1.5$$

$$D = 40\text{m}$$

Q. calculate area for the diffⁿ section

~~Computed area =~~

As this is a level section,
so $A_1 = [b + sb] \times h$

$$= [10 + 1.5 \times 0.90] \times 0.90$$

$$= ~~12.15 \times 0.90~~ 10.215 \text{ m}^2$$

$$A_2 = [10 + 1.5 \times 1.25] \times 1.25$$

$$= ~~23.43~~ 14.84 \text{ m}^2$$

$$A_3 = [10 + 1.5 \times 2.15] \times 2.15 = 28.43 \text{ m}^2$$

$$A_4 = [10 + 1.5 \times 2.50] \times 2.50 = 34.375 \text{ m}^2$$

$$A_5 = [10 + 1.5 \times 1.85] \times 1.85 = 23.63 \text{ m}^2$$

$$A_6 = [10 + 1.5 \times 1.35] \times 1.35 = 16.23 \text{ m}^2$$

$$A_7 = [10 + 1.5 \times 0.85] \times 0.85 = ~~10.83~~ 9.58 \text{ m}^2$$

Volume

$$\begin{aligned}
 V &= \frac{D}{2} \left[\text{area of first section} + \text{area of last section} + 2 \left[\frac{1}{4} \text{th of area of other section} \right] \right] \\
 &= \frac{40}{2} \left[10.21 + 9.58 + 2 \left[14.84 + 28.43 + 23.63 + 16.23 + 34.37 \right] \right] \\
 &= \frac{40}{2} \left[10.21 + 9.58 + 234.28 \right] \\
 &= 5096.4 \text{ m}^3
 \end{aligned}$$

Prismoidal formula

$$\begin{aligned}
 V &= \frac{40}{3} \left\{ 10.21 + 9.58 + 4(14.84 + 34.37 + 16.23) + 2(28.43 + 23.63) \right\} \\
 &= \frac{40}{3} \left\{ 19.79 + 678.24 \right\} \\
 &= \cancel{5143 \text{ m}^3} \quad 5142.26 \text{ m}^3
 \end{aligned}$$

12.10.17

Q) The areas enclosed by the contours in a lake are as follows.

<u>Contour</u>	<u>Area</u>
270	2050
275	8400
280	16300
285	24600
290	31500

Calculate the volume of water betⁿ the contour 270m and 290m by the trapezoidal formula and prismoidal formula.

Trapezoidal

$$V = \frac{D}{2} \left[\begin{array}{c} \text{Area of} \\ \text{first} \\ \text{section} \end{array} + \begin{array}{c} \text{Area of} \\ \text{last section} \end{array} + 2 \left[\begin{array}{c} \text{sum of area} \\ \text{of other} \\ \text{section} \end{array} \right] \right]$$

$$= \frac{20}{2} \left[2050 + 31500 + 2 [8400 + 16300 + 24600] \right]$$

$$= 330375 \text{ m}^3$$

prismoidal

$$V = \frac{D}{3} \left[2050 + 31500 + 4 \left(\frac{8400 + 24600}{2} \right) + 2 (16300) \right]$$

$$= 814250 \text{ m}^3 \quad 330250 \text{ m}^3$$