LECTURE NOTE

ON

LAND SURVEY-I

FOR

DIPLOMA IN CIVIL ENGINEERING

(4TH SEMESTER STUDENTS)

AS PER SCTE&VT SYLLABUS

PREPARED BY:

Miss Pinky Sahu

PTGF in Civil Engineering

Department of Civil Engineering

Government Polytechnic, Sambalpur (Rengali)

www.gpsambalpur.com

CH-1: FUNDAMENTAL CONCEPT OF SURVEYING:-

* WHY SURVEYING:-

Eg 1. to built build a house

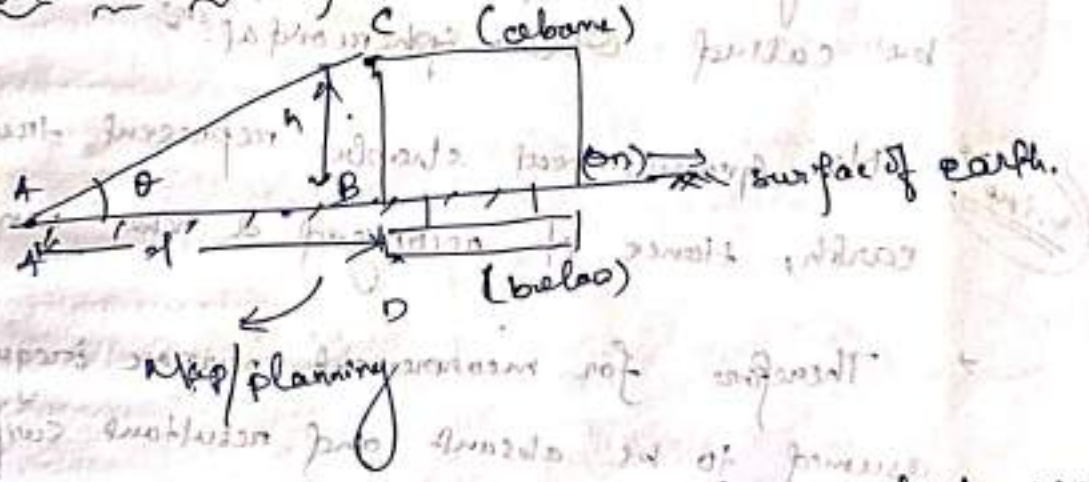
(1) Topography of the area → Site (named by)

(2) Map → planning → [ ] → Measurement.

(3) Site → Construct →

(4) after construction / design Construction.

INTRODUCTION OF SURVEY:-



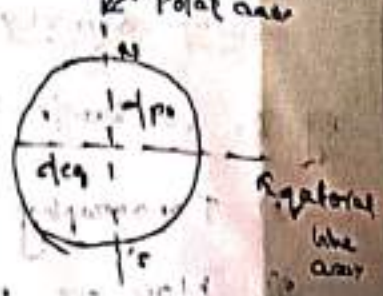
Definition

** → Surveying is defined as science or art in which we determine relative position of different points on, the above and beneath the surface of earth by taking horizontal, vertical and angular measurement and represent it on plan/map.

* Objective of surveying:-

→ To prepare a map or plan to represent an area on a horizontal plan. plain

Shape of Earth



→ Equatorial cross section is also slightly elliptical it should be called elliptical.

→ Southern hemisphere is larger than northern hemisphere - all polar sections are oval it may be called - Ovaloid.

→ Any section on earth parallel to equator is a circle & any section parallel to poles is ellipse - it may be called Oblate spheroidal.

→ No Geometrical shapes represent true shape of earth, Hence it recognized a new name - Geoid.

(V. imp)

→ Therefore for measurement purpose irregularities are assumed to be absent and resultant surface considered as spheroid.

Note

→ Earth Avg Radius = 6371 km

Deq > Dp

→ Difference in the length of equator (Deq) and polar axis (Dp) is 42.95 km.

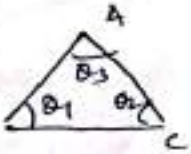
Deq - Dp = 42.95 km.

TYPE OF SURVEY

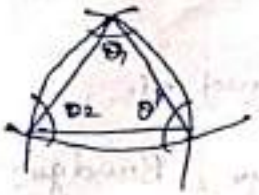
I. ON THE BASIS OF CORVETURE OF EARTH / ACCURACY :-

A. Plan Survey → (Small Area)

B. Geodatic Survey → (Large Area)

A. Plane Survey	B. Geodetic Survey
(i) Mean surface of earth considered as flat.	(i) Actual shape of earth (Curve is considered.
(ii) Distance between 2 line is straight line	(ii) Distance between two point is represented as arc.
(iii) In case of plane survey 2 plumbline apear to be parallal 	(iii) In this survey 2 plumb line meet at centre of earth. 
(iv) In case of plane survey tranglr formed as plane tringlr.  $\theta_1+\theta_2+\theta_3 = 180^\circ$	(iv) Trangle formed is Spherical trangle.   $\theta_1+\theta_2+\theta_3 > 180^\circ$ Excess sum of angle
(v) Area < 250 Km^2	(v) Area > 250 Km^2

(195.5 Km^2) — Bc. Punmia

Q. 

tringle Area → 195.5 m^2 [Bc Punmia.)

$\theta_1+\theta_2+\theta_3 > 180^\circ$

So, considered as Geo detic survey.

H.C. option

100
260 ✓ correct
300
70

250
195.5 ✓ Correct.
100
70

3. BASED ON OBJECTIVE of SURVEYING :-

A. ENGINEERING SURVEY :-

These survey are done to provide sufficient data for designing of engineering project like Highway, railway, water supply, sewage disposal.

B. MILITARY SURVEY :-

This survey is done for military purpose.

C. GEOGRAPHICAL SURVEY :-

→ This survey is done to study different layers/ Strata of earth surface & collecting details of different layers of earth.

→ This survey is required to determine the location extent of different minerals mineral and rock type

D. ~~AR~~ ARCHAEOLOGICAL SURVEY :-

To collect information about location, distribution and organization of past human culture across the large area.

E. MINE SURVEY :-

It is being carried out for exploration of new mines (Eg coal mine, gold mine)

3. BASED ON OBJECTIVE of SURVEYING :-

1. ENGINEERING SURVEY :-

These survey are done to provide sufficient data for designing of engineering project like, Highway, railway, water supply, sewage disposal.

B. MILITARY SURVEY :-

This survey is done for military purpose.

C. GEOGRAPHICAL SURVEY :-

→ This survey is done to study different layers/ Strata of earth surface & collecting details of different layers of earth.

→ This survey is required to determine the location extent of different minerals and rock type.

D. ARCHAEOLOGICAL SURVEY :-

To collect information about location, their distribution and organization of past human culture across the large area.

E. MINE SURVEY :-

It is being carried out for exploration of new mines (Eg coal mine, gold mine)

4. BASED ON INSTRUMENT USED :-

A. CHAIN SURVEY :-

Here, only the linear measurements are made with a chain (or a tape) and no angular measurement are made.

B. COMPASS SURVEY :-

Here, Both the linear and angular measurement are made, the former being made with a tape/or chain and the lateral a compass.

C. LEVELING :-

Here, elevation of different point are determined. A graduated staff and a level are used for this purpose.

D. TECHEOMETRY :-

In this type of survey, both the horizontal and vertical distance are measured by sighting a graduled staff with a Tacheometer.

E. PLAIN TABLE SURVEY :-

In this survey, Observation and plotting are done simultaneously in the field through the accuracy of survey is Low.

F. THEODOLITE SURVEY :-

USED for Both Angular and horizontal measurements. More accurate than compass survey. Used to measure both horizontal and vertical angles.

6. PHOTOGRAMMETRIC SURVEY :-

→ Process of taking different measurment with the help of photograph.

→ Used to survey large are when Land is not accessiable

H. EDM Survey / Total station Survey :-

EDM → Electronic distance Measurement.

→ In this survey the distance is measure with the help of electromagnetic waves.

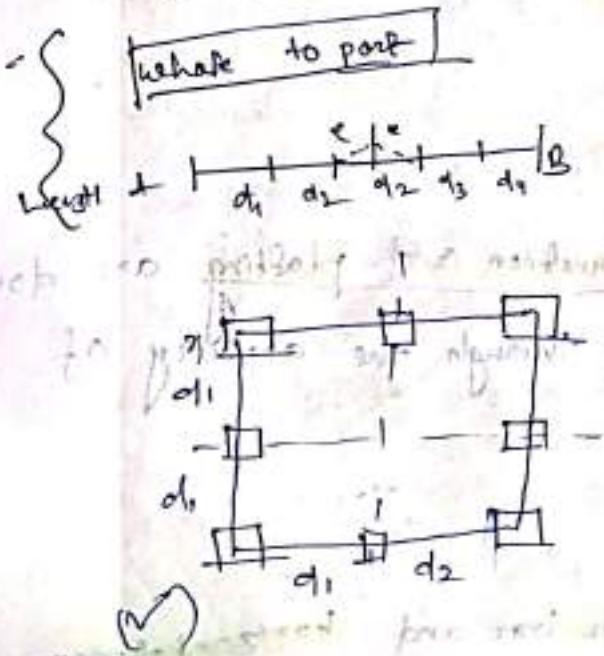
PRINCIPLES OF SURVEYING :-

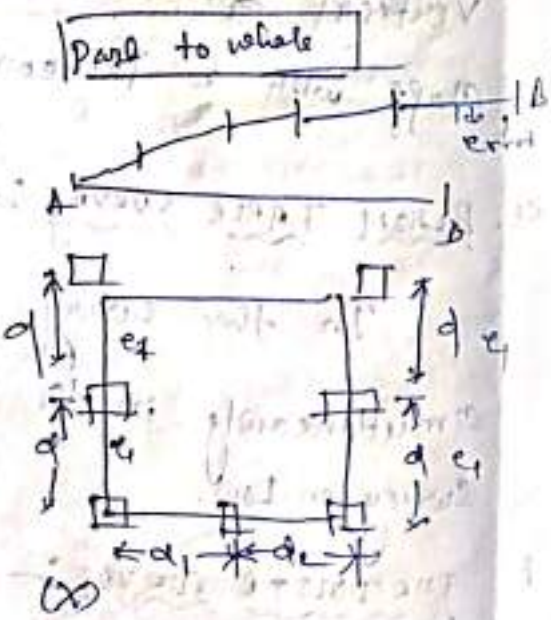
1st Work from whole to Part.

↓
first principle of surveying.

WHY-?

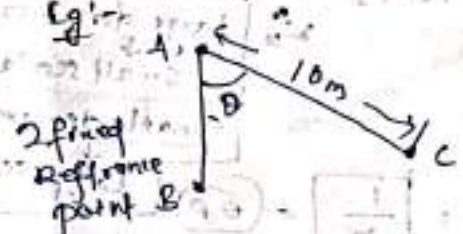
Ans (i) To Localise the errors
(ii) To control the Add/ accumulation of errors.



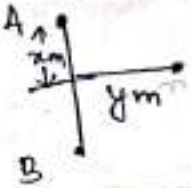


2nd: The relative position of points to be surveyed should be located by measurement from at least two point of fixed reference, the position of which is already fixed.

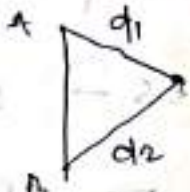
Eg:-



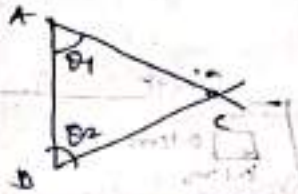
(a) distance and Angle



(b) distance & offset from reference line.



(c) By measuring only distance.



(d) By measuring 2 angle.

{ Locating third point
↳ At least 2 Reference measurement }

SCALE:-

REPRESENTATION OF SCALE:-

$$\text{SCALE} = \frac{\text{distance on map/sheet}}{\text{distance in Ground}}$$

$$\text{Scale} = \frac{1\text{cm}}{1\text{km}}$$

Scale:-
- Numerical scale
  - Engineering scale
  - Representative fraction (RF)
- Graphical scale.

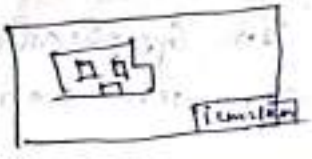
1. ENGINEER SCALE:-

- Here "1cm" on the plan represents some "whole number" of meter/km/etc". on the ground.

Eg:- 1cm = 10m

1cm = 1km.

[1mm = 1km (working)]



2. REPRESENTATIVE FRACTION (R.F) :-

Here one unit of length on the plane represents some whole number of same unit of length on the ground. [unit less; represented as 1:n]

Eg ES → 1cm = 10 m

$$RF = \frac{1\text{cm}}{10\text{ m}} = \frac{1}{10 \times 100\text{cm}} = \frac{1}{1000} = \frac{1}{n}$$

Large denominator → small scale

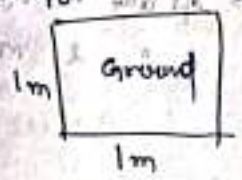
Small denominator → Large scale

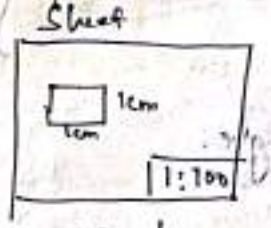
$RF_1 = \frac{1}{10}$, $RF_2 = \frac{1}{10000}$

$RF_1 > RF_2$

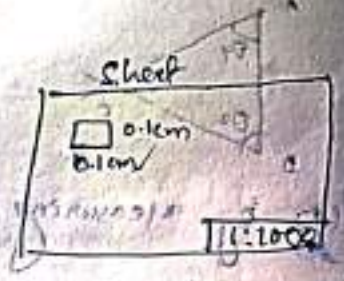
$R_2 \frac{1}{100}$) 1cm = 1m

RF = 1/1





$RF_1 = \frac{1}{1}$ (Large scale)

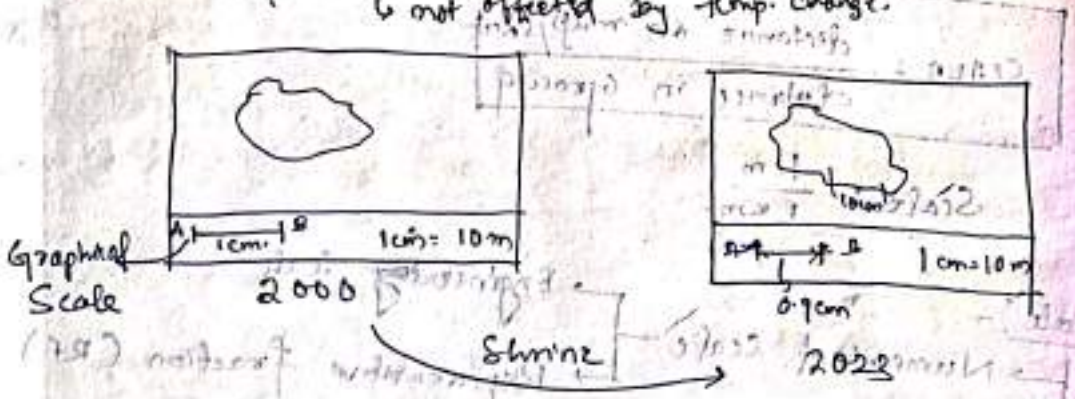


$RF_2 = \frac{1}{1000}$ (small scale)

$RF_1 > RF_2$

3. GRAPHICAL SCALE :-

↳ not affected by temp. change.



→ If the plan or map is to be used after a few year the numerical scale (ES & RF) may not give accurate result because of paper shrink or expand with the passage of time.

→ In Graphical scale error due to shrinkage/expansion can be eliminated.

ERROR DUE TO SHRINKAGE:

Shrinkage factor (Sf) = $\frac{\text{Shrunk length}}{\text{Original Length}} = \frac{\text{Shrinkage scale}}{\text{Original scale}}$

$= \frac{\text{Shrunk Value}}{\text{Original Value}}$

$Sf < 1$ (v.imp)

Ex: Data given previous value

$S.f = \frac{0.9}{1} = 0.9$

Corrected Length = $\frac{\text{Measured Length/shrinke value}}{Sf}$

$\{A.L = \frac{10cm}{0.9} = 11.11cm.\}$

Corrected Area = $\frac{\text{Measured Area}}{(Sf.)^2}$

Example:-

Data given $A = 250\ cm^2$ | 1cm = 50 cm

$sf = 0.9$

Soln

Correct Area = $\frac{\text{Measured Area}}{cf^2} = \frac{250\ cm^2}{0.9^2}$

$= 309\ cm^2$ (Approx)

1cm = 50 m

$1cm^2 = 50 \times 50\ m^2$

$= 2500\ cm.$

Area on ground $= 309 \times 50 \times 50$

$= 771450\ m^2$

ERROR DUE TO WRONG SCALE MEASUREMENT :-

Distance or area measured using wrong scale will not be corrected.

Correct Length = $\frac{\text{RF of wrong scale} \times \text{Measured Length}}{\text{RF of correct scale}}$

**

$$\text{Correct area} = \left[\frac{\text{RF of wrong scale}}{\text{RF of correct scale}}\right]^2 \times \text{measured area}$$

Example:-

- A surveyor measured the distance between two points on the plane drawn to a scale of 1:100 and the result was 60m. Later, he discover that he used a wrong scale of 1:50. Then the true distance between two points.

Sol^n Data given :-

RF wrong scale = 1:50

RF actual scale = 1:100

Measured length = 60m

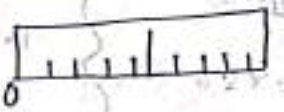
$$\text{Correct/true length} = \frac{\frac{1}{50}}{\frac{1}{100}} \times 60 = 2 \times 60$$

$$= 120 \text{ m}$$

TYPE OF SCALE :-

1. PLAIN SCALE :-

1cm. [2 dimension, 1 decimal]



→ In this it is possible to measured two dimensions Concurrent only. i.e. unit & tenth, Eg:- cm & mm, m & cm

→ Least coient = 1 mm

2. DIAGONAL SCALE :- Conjugate

→ In this it is possible to measure 3 dimension.

Eg:- ~~Cm~~ m, dm, cm. [3 dimension, 2 decimal]

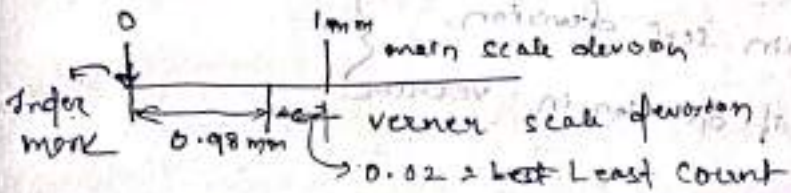
3. VERNIER SCALE :-

→ A vernier is a device for measuring accurately the fractional part of the smallest division on a graduated scale i.e. main scale.

Least Count :- the minimum division the scale can accurately measure.

→ The vernier scale has a index mark (arrow) which represents the zero of the vernier scale.

→ The Least count of the vernier scale is equal to the difference in length of one division of the main scale and one division of vernier scale.



$$LC = 1\,MSD - 1\,VSD$$

$$LC = 1mm - 0.98mm$$

$$LC = 0.02mm.$$

TYPE OF VERNIER :-

1. DIRECT VERNIER :-

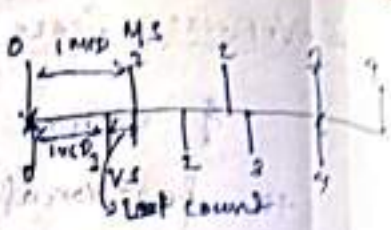
→ 1 main scale division > 1 vernier scale division.

$$1\,MSD > 1\,VSD$$

→ In both the scale reading increase in same direction
or/ Both scale calebarated in same direction.

~~Derivation of~~

$n(VS) = (n-1)(MS)$



$$\text{Least Count} = 1\,MSD - 1\,VSD$$

1 main scale division = S [least count of main scale]

Let n = number of division of vernier.

∴ Vernier scale = $n(VS) = (n-1)(MS)$

$1(VS) = \left(\frac{n-1}{n}\right) MS$

$= \left[\frac{n-1}{n}\right] S$

$$LC = S - \left(\frac{n-1}{n}\right) S$$

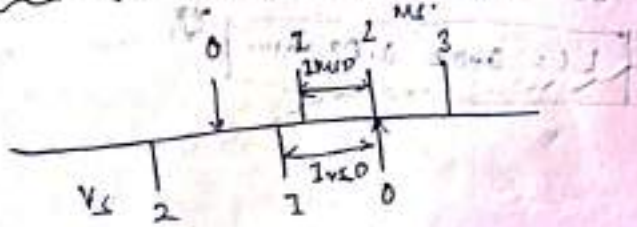
$$= \frac{nS - nS + S}{n}$$

V. imp $\quad \boxed{L.C. = \frac{S}{n}}$ or $\boxed{L.C. = |1\,MSD - 1\,VSD|}$

where { S = 1 main scale division. ; n = no. of division in vernier }

2. ~~Retrog~~

2. RETROGRADE VERNIER :-



→ 1 VSD > 1 MSD

→ Both the scale are calibrated are different direction.

Reading increase in opposite direction.

$$n(VS) = (n+1)MS$$

* $LC = 1VSD - 1MSD$

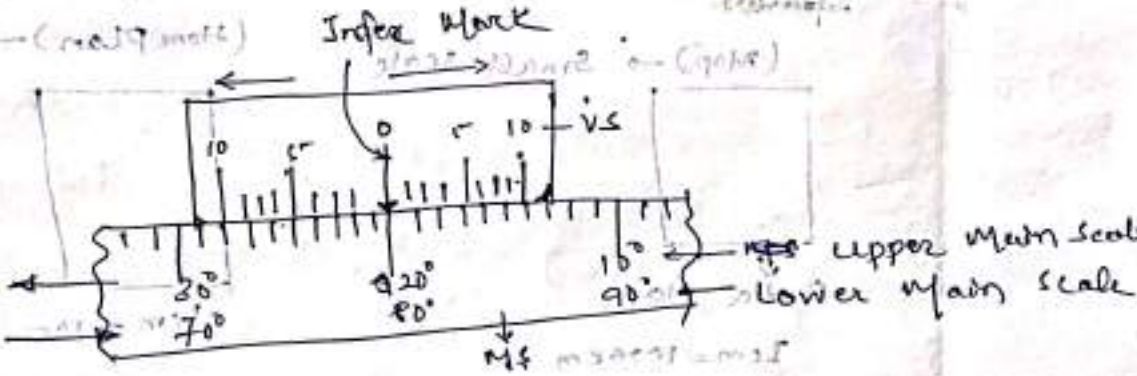
OR

$LC = |1MSD - 1VSD|$

or $LC = \frac{S}{n}$ S = 1 division of main scale
n = no. of division of vernier.

3. DOUBLE VERNIER:-

It is the vernier in which main scale is figured in both the direction and vernier also extends to both side of index mark.



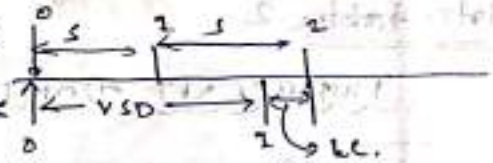
Example
↳ used in theodolite.

4. EXTENDED VERNIER:-

→ It may happen that the division on the main scale are very close and it would then be difficult, if the vernier were of normal length to judge the exact graduation where coincidence occur.

→ In this case extended vernier may used.

→ Here 2n-1 division on main scale, MS are equal to n division of vernier.



$nV = (2n-1)S$

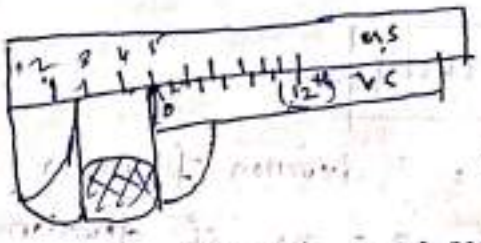
$LC = \frac{S}{n}$

$L.C. = 2S - V$

$LC = 2MSD - 1VSD$

→ Both are calculated in same direction.

MEASUREMENT OF DERIVED VARIABLE



LC : 1 mm − 0.98 mm : 0.02 mm

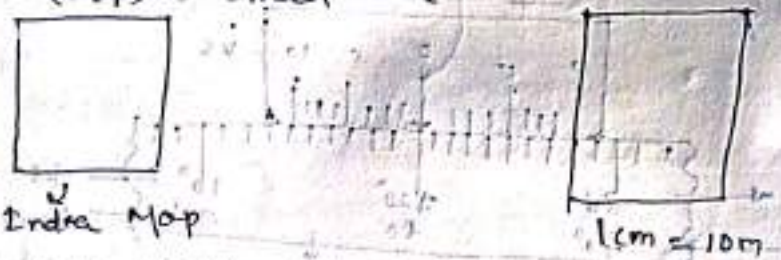
∴ 5 mm + 12 (0.02) mm

Value = vernier index mark + LC × graduation extended matched

Note Points − 1

(Map) → Small scale

(Home Plan) → Large scale



Index Map

1 cm = 1000 km

1 cm = 10 m

default → observe → Map

Map A → Scale small

Map B → Scale Large

Area is given (Find) = ?

$$Rf = \sqrt{\frac{\text{area on map}}{\text{Area on ground}}}$$

Note − 2

IMPORTANT UNITS :-

10 mm = 1 cm	1 foot = 12 inch
100 cm = 1 m	1 yard = 3 ft
1000 m = 1 km	1 feet = 0.3048 m.

mm	cm	dm	m	dm	hm.	km

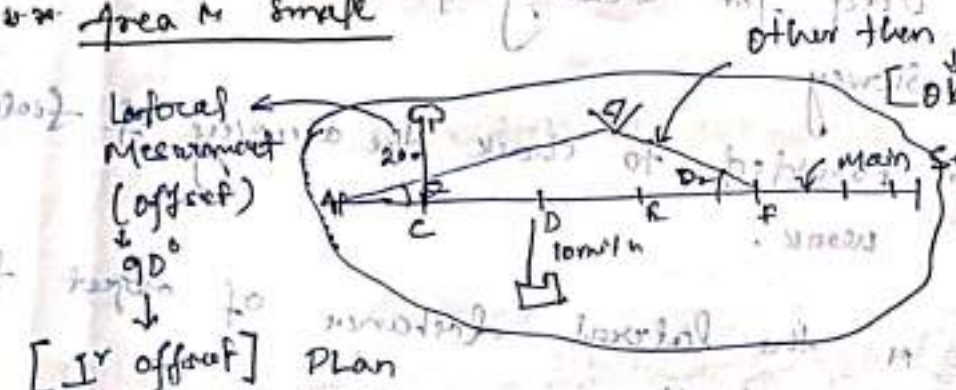
milli → Centi → deci → m → deca → hecto → kilo

CH-2 :- LINEAR MEASUREMENT

INTRO

→ Distance is measured using chain or tape. The survey is suitable for a small extend on open ground and to take simple detail.

Area is small



Area is Large

Station → A, B, C, D, E, F, G, H, I, (Main survey station)

Main survey line → Line joining the main survey station

Eg :- AB, BC, CD etc.

DH → Main survey line.

Base line :- Main survey line passing through centres of survey area & Longest main survey line is called base line

→ which divide survey area into 2 parts.

* Tie station (subsidiary station) :- Station located on main survey line.

* Tie line :- The line joining 2 tie station are known as tie line / auxiliary line.

→ Used for locating interior detail of survey

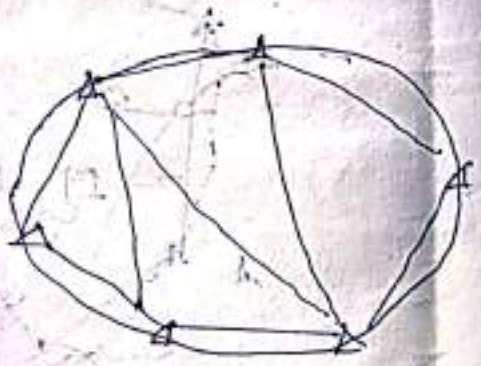
* Check line :- Provided to check the accuracy of field work.

* Offset :- It is the lateral distance of object from survey line.

→ It may be ⊥ perpendicular (90°) or any angle (other than 90°) / Oblique offset.

Triangle

→ In chain/tape survey whole area is devided into no. of triangle the triangle must be well conditional.



→ The triangle will angle b/w 30° & 120°

** $30° \leq \text{angle} \leq 120°$

↓

well conditional angle.

→ If any angle of triangle → ** $< 30°$ or $> 120°$

↓

Ill conditional triangle

Example:-

Considered $\triangle ABC$ in which angle are Given. Which of the following triangle are well conditional & ideal angle.

(a) $80°, 90°, 60°$ $(\checkmark)$ → well conditional triangle

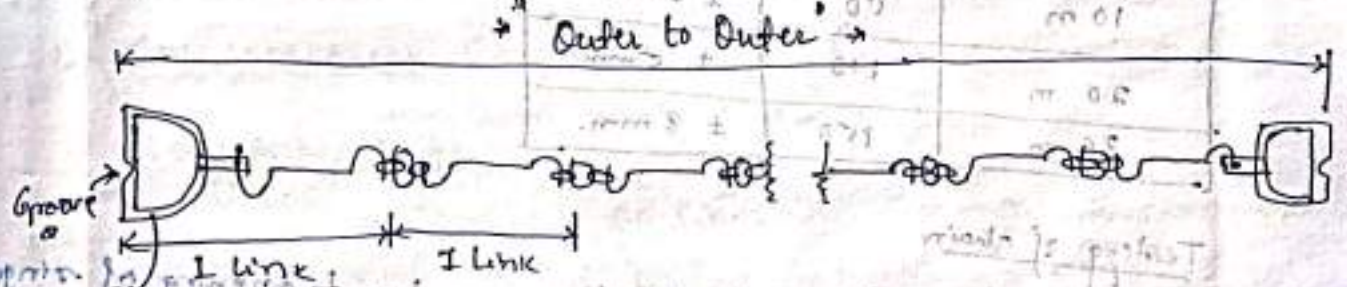
(b) $20°, 80°, 80°$ → a I angle $\neq < 30°$ → III conditional triangle

(c) $130°, 10°, 40°$ → $< 20°, > 120°$ → III conditional triangle

→ Ideal well conditional triangle :- "Equilateral triangle"

EQUIPMENTS USED IN CHAIN SURVEY :-

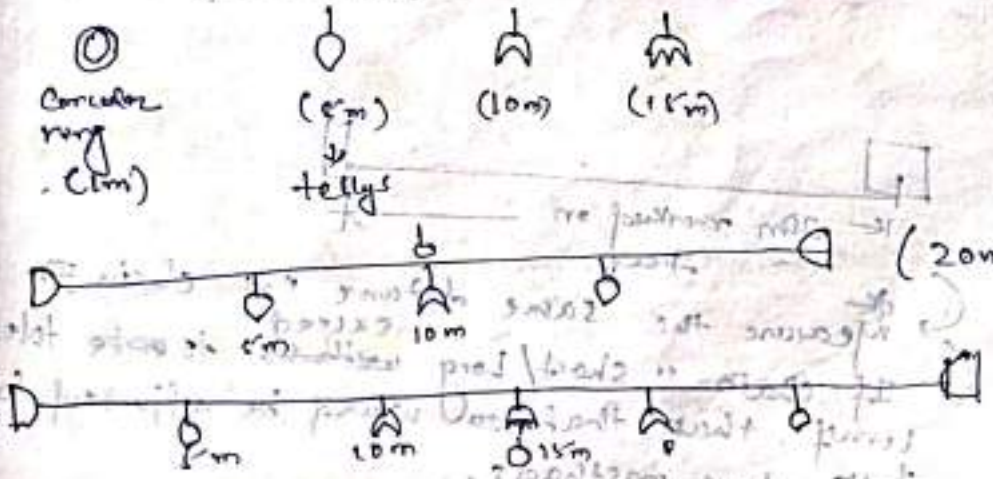
(i) CHAIN :-



→ Material used → Galvenised steel / Mild steel.

→ After every Im Length → Brass Ring ◎ [Except 0m, 10m, 15m]

→ tallies / tags → after every 5m length.



TYPE OF CHAIN

(A) METRIC CHAIN :-

* 1 link length = 200 mm

* Available → (5m, 10m, 20m, 30m) chain

$\frac{1}{200}$ link ← 1mm

$\frac{1000}{200}$ link ← 1000 mm

* 1 m length → 5 links

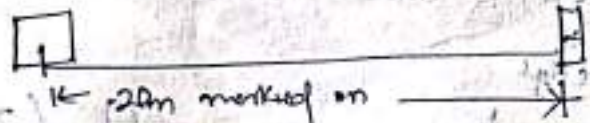
Imp for Exam

Metric Chain Length	Links	Tolerence ** mm
5 m	25	± 2 mm
10 m	50	± 3 mm
20 m	100	± 5 mm
30 m	150	± 8 mm.

Testing of chain

* If chain is found to be long → due to opening of rings
↓
Adjusted by closering the opening of joint.

* If chain is found to be short → due to Link band
↓
Adjusted by stretching Link bands.

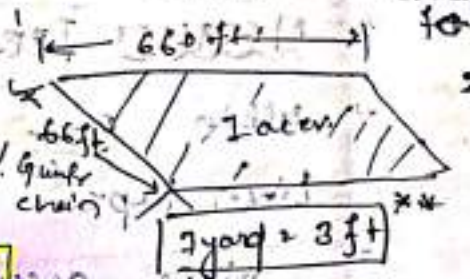


↳ * Measure the same distance by chain ⇒ If chain is short/Long exceed tolerance limit. then that should be adjusted by the above methods.

B. GUNTER CHAIN :- (Scrivener Chain) → Edmund Gunter

- Length → 66 ft
- No. of Link → 100
- 1 Link Length → 0.66 ft
- Use for land measurement.

10 chain



design 4 ft to crrected for pitch → 22 yard

1 yard = 3 ft

22 yard = 22×3 = 66 ft

(1 × 10) Gunter chain = 1 acre

1 mile = 80 Gunter chain

1 acre = 10 × 66 × 66

= 43560 ft²

C. REVENUE CHAIN :-

- Length : 33 ft
- no. of link → 16
- 1 Link = $\frac{33}{16}$ ft

D. ENGINEERING CHAIN :-

- Length = 100 ft
- Total no. of Link = 100 Links
- 1 Link = $\frac{100}{100}$ = 1 ft

II. TAPE :-

There are used for more accurate measurement & are classified according to material from which they are constructed.

TYPE OF TAPE :-

A. CLOTH / LINEN TAPE :-

- Made from cloth / linen
- It is available in length 10 m, 20 m, 30 m.
- width = 12 - 15 mm
- due to streeching its length get effected
- Tape get effected due to wind and temperature get twist.

→ It get affected due to temperature.

B. METALLIC TAPES :-

→ When Brass and Copper are reinforced in cloth/ linen tape.

→ More accurate than cloth & linen tape.

→ Generally avilable in Length of 20 - 20 m

C. STEEL TAPE :-

→ It more accurate than Metallic tape.

→ Affected due to temperture.

→ width = 6mm — 10mm [Gen → 1m to 50m] → SK. dugu / Boric

D. INVAR TAPE :-

→ It is modify steel tape made up of alloy ~~Steel~~ Nickel (36%) & Steel (64%)

→ It is used for more precise work.

→ Its co-effient of thermal expantion → $\alpha = 0.122 \times 10^{-6}$

→ Width = 6mm

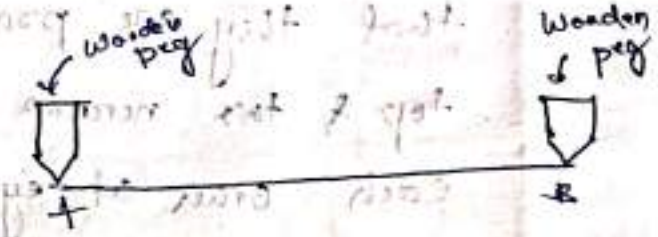
→ It is so soft so that it can deform easily (through to handle)

→ Length avilabe → 20m, 30m. [

ACCESSORIES FOR CHAINING :-

1. PEGS :-

→ These are used to mark definite points on ground from which measurement are to be taken

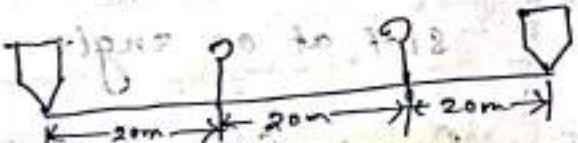


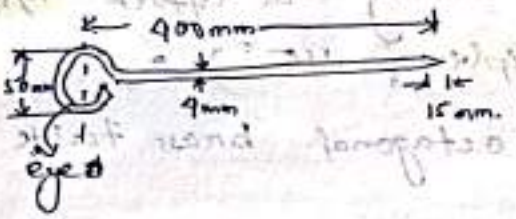
→ Size → 2.5 – 5 cm²

→ Length → 15 – 90 cm

2. ARROWS :-

→ Arrows are placed after every chain/tape length.





3. RANGING ROD :-

→ The process of locating a number of intermediate points on long survey line is called ranging.

→ Ranging Rod is made up of well seasoned timber i.e. teak, deodar etc. or steel.

→ These are use to locate intermediate point such that these point lie on straight line joining the two station.

→ Dia of Ranging Rod → 30 mm.

Length → 2m, 3m

→ Alternate black and white / Red and white painted in ranging rod. size "200 mm".

4# Off set Rod :-

→ The rod is similar to ranging rod with only difference that they are provided with hook and opening at top & two narrow vertical slot at right angle to each other at eye level.

5# OFFSET MEASUREMENT EQUIPMENT :-

Cross Staff

(i) Open Cross Staff :- (Most Accurate) ** We can set the offset at angle 90°.

(ii) → It consist of two narrow pair of narrow vertical slot at an angle of 90°.

(ii) French Cross staff :-

→ It is used for setting the offset 45°, 90°, 135° or (multiple of 45°).

→ It consist of octagonal brass tube slit on each side.

(iii) → It is less accurate then Open cross staff.

(iv) Adjustable Cross staff :-

→ Use to set any angle from survey line.

→ Consist of 2 cylinder.

→ Lower cylinder → main scale

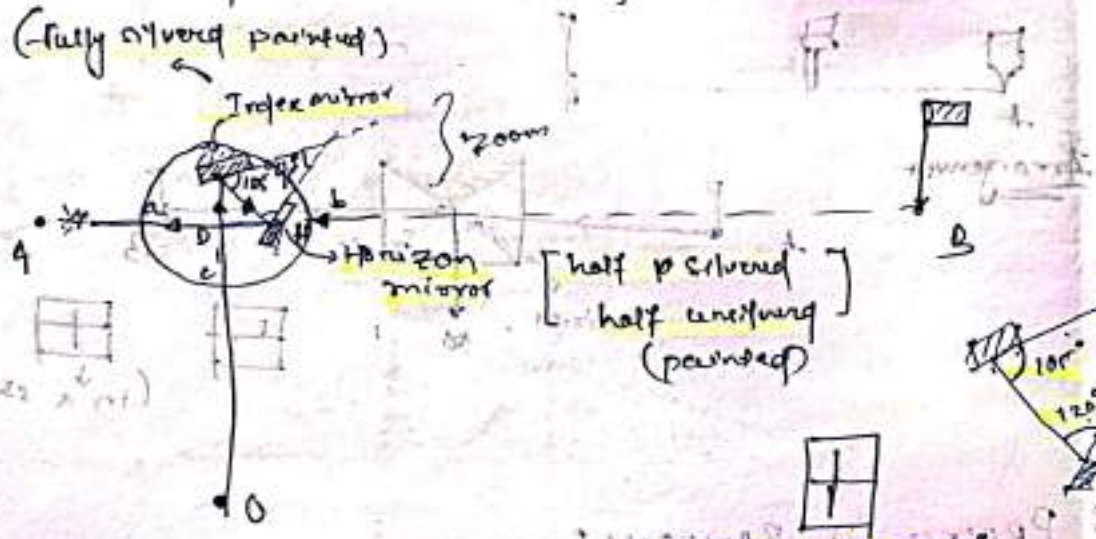
→ Upper cylinder → Vernier scale

→ Slit → to provide line of sight.

Note :- from all the above the most accurate cross staff is "Open Cross staff".

(iv) Optical Square :-

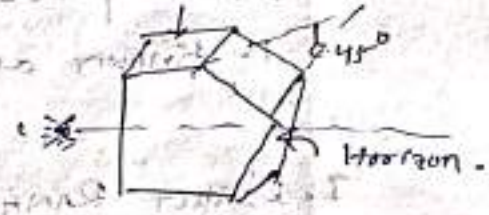
→ It is used to set the offset at 90°.



→ Principle of optical Square →

Note :-

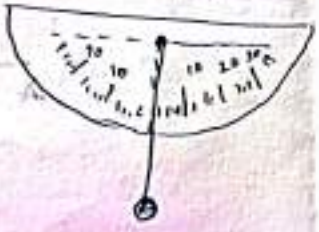
→ Instead of using two mirror, a prism can also be used having two reflecting sides at an angle of 45° ring is termed as "Prism Square"



6. SIMPLE CLINOMETER :-

→ It is used to measure angle of slope of ground.

→ A light plumb bob is suspended from centre of semicircle



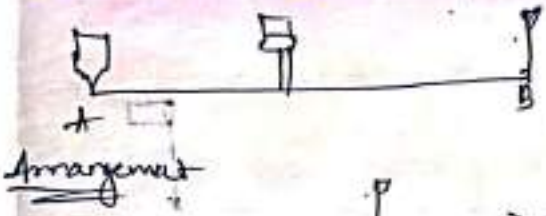
7. LINE RANGER :-

→ It is used to set intermediate point on main survey line.

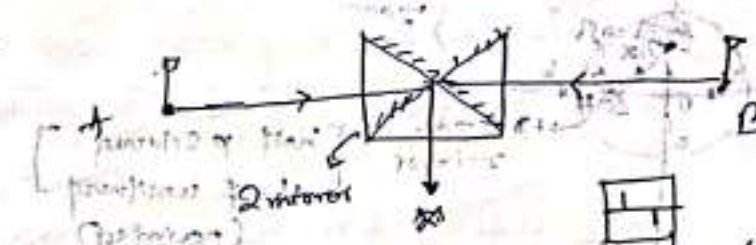
→ In this case diagonal side of prism is fully silvered / painted.

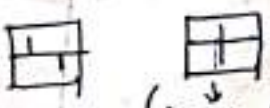
→ It consist of 2 triangle → Isoscale triangle

→ Principle → "Reflection"



Arrangement





(in a straight line)

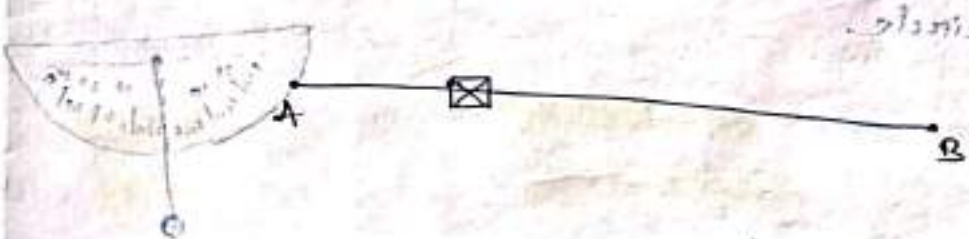
PROCESS OF RANGING :—

→ If line to be surveyed is longer than the length of chain/tape, some intermediate points have to be established along the length of line.

→ The process of establishing the intermediate point is known as ranging.

I. DIRECT RANGING :— Minimum no of ranging rod → 3

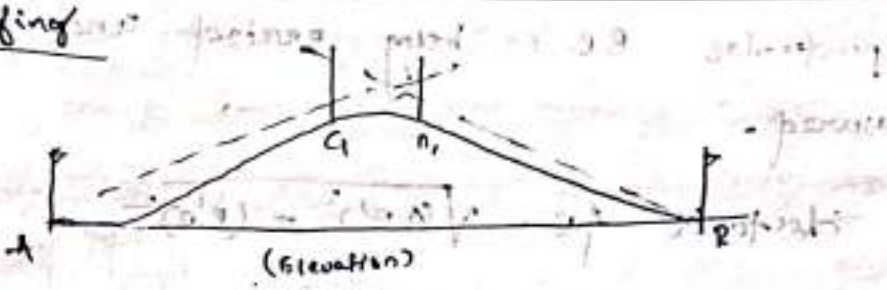
→ It is done when 2 end of the survey line clearly visible. It can be done by line ranger or Ranging Rod.



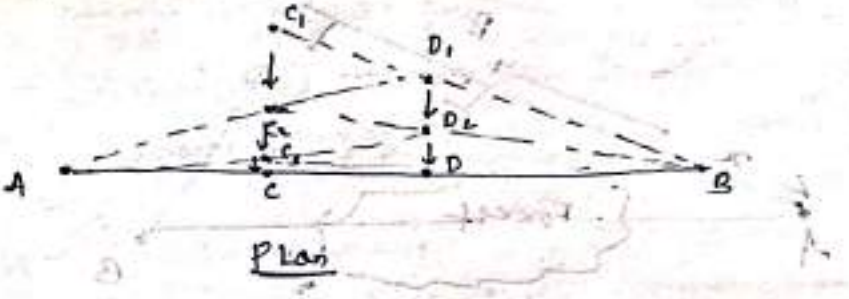
2. INDIRECT RANGING :— Minimum no of Ranging Rod - 4

→ It is done when both of survey line are not visible due to high intervening ground or existing ground level between two points or when distance between two points is very long.

Indirect Ranging



* C_1 → point D_1 & B (visible)
* D_1 → point C_1 & A (visible)



→ Let A and B the two end station of a Line to its ranging ground between them, and C and D are two intermediate points to be establish on chain line.

→ Two chainmen stand at C_2 and D_1 such that chainman at C_1 can see both ranging rod D_1 and B and chainman at D_2 can see both C_1 and A.

→ Now chainman at D_1 direct chainmain at C_1 ~~both up and A~~ to move to C_2 as in line with A.

→ Similarly chainmen at C_2 direct D_2 to move D_2 as in Line with B.

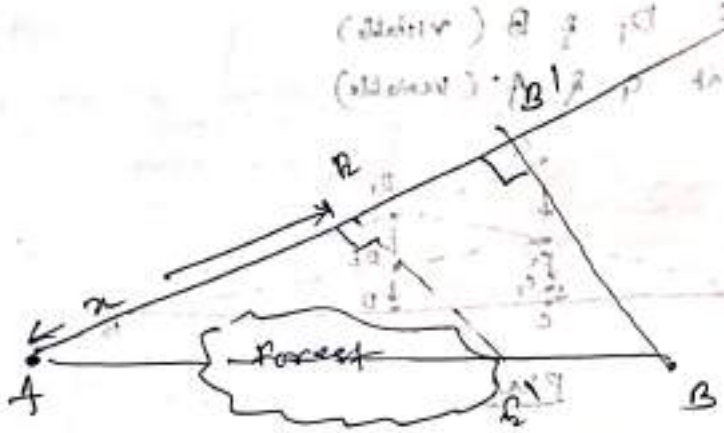
→ By Directing each other two chainman proceed to line this AB and finally come to C and D.

3. RANDOM LINE METHOD :—

* The method is also used when ends of survey line are not visible.
* In this method random line such as AB' is being laid such that the point is visible from B'.

→ Perpendicular B'E is being erected and distance is measured.

distance AB = $\sqrt{(AB')^2 + (B'E)^2}$



we found all sides of triangle AEB' by using similarity of triangle : ΔAB'E ~ ΔAE'E

PROCESS OF CHAINING :-

If linear measurement is done with chain by term as chaining.

It can be done by 2 methods :-

(1) Direct Method

(2) Indirect Method.

1. DIRECT METHODS :-

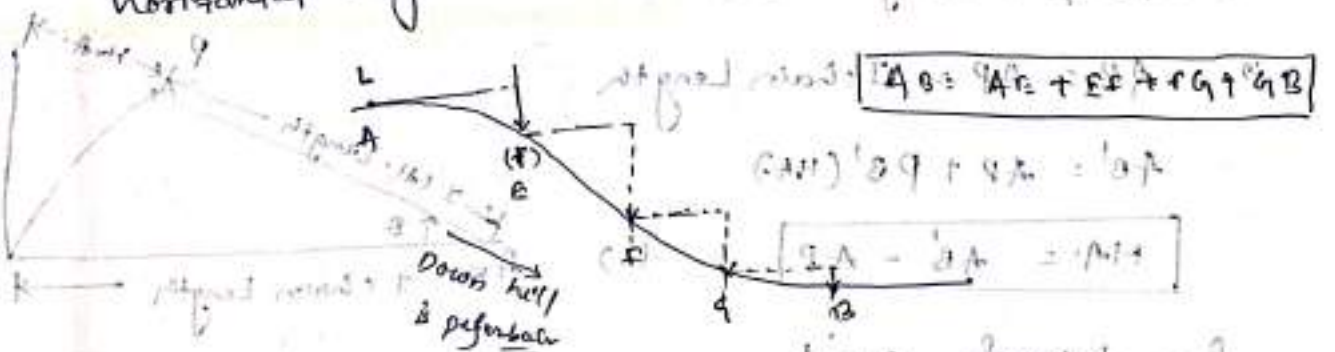
(a) ON SMOOTH LEVEL GROUND :-

If distance measured on ground is longer than one's chain length, it is necessary to establish intermediate points via ranging.

- Two person → (1) Leader (2) follower
- → Leader move forward along survey line & goes on inserting arrows at end of chain and follower keep collecting it.
- At end of measurement, no. of arrows collected by the follower indicate no. of full chain length measured.
- → Leader → arrow (fix) → one chain length
  follower → arrow (collect)
- → Generally → Leader → 10 arrow.

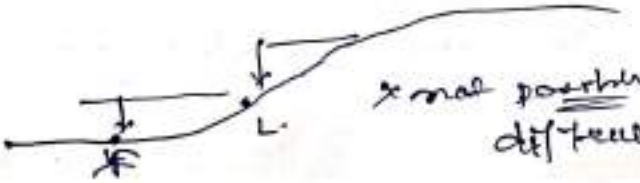
(b) ON SLOPING GROUND :-

- When it is not possible to keep chain horizontal & elevation difference b/w two point is large then this method is adopted.
- It also known as "stepping" or breaking the chain method
- It consist of measuring the distance on ground in short horizontal length.



Note:-

- It is more practable to chaining downhill then uphill.
- Because when we uphill chain follower has to hold the chain horizontal with its zero mark exactly above the point on the ground.

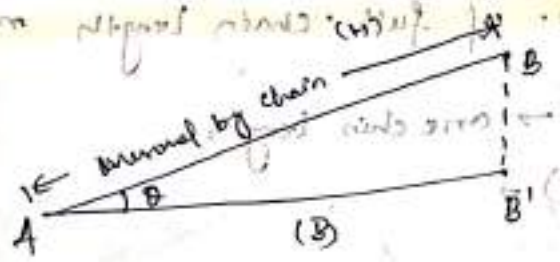


2. INDIRECT METHOD:-

(a) ON UNIFORM SLOPING GROUND:-

→ Sloping angle is measured by clinometer or by abney level.

$\therefore \cos\theta = \frac{\text{base}}{\text{Hyp}} = \frac{AB'}{AB}$



$$AB' = AB\cos\theta$$

(b) HYPOTENUSE ALLOWANCE METHOD:-

→ For this method, correction is applied in field at every chain length.

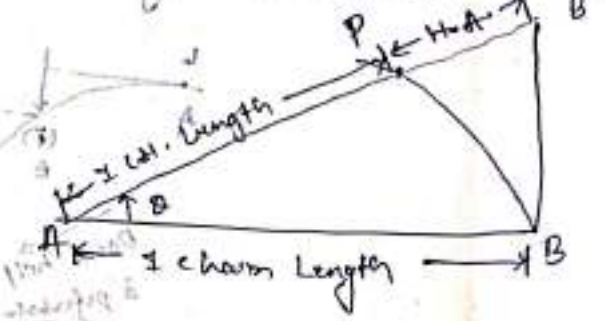
→ When chain is streached on the slope arrow is put some distance forward at end. This distance is called Hypotenuse Allowance (HA)

→ $AB \neq AB'$ (Hypotenuse)

$AB = AP = 1$ chain Length.

$AB' = AP + PB'$ (HA)

$$HA = AB' - AP \quad \text{---(i)}$$



From triangle ABB'.

$\cos\theta = \frac{\text{base}}{\text{Hyp}} = \frac{AB}{AB'}$

$AB' = \frac{AB}{\cos\theta} = AB\sec\theta$ $\quad \therefore AB = 1$ chain length.

$$AB' = (1 \text{ chain length})\sec\theta$$

from eq^n (i) and (ii)

$HA = PB' = AB' - AP$

$PB' = (1\text{ chain length}) \sec\theta - 1\text{ chain length}$

$PB' = 1\text{ chain length}(\sec\theta - 1)$

$HA = 1\text{ chain length}(\sec\theta - 1)$

$\sec\theta = 1 + \frac{\theta^2}{2} + \frac{5\theta^4}{24} + \ldots$ put θ is very small

$\theta^2 \to$ neglected

$HA = 1\text{ chain length}\left(1 + \frac{\theta^2}{2} - 1\right)$

$HA = 1\text{ chain length} \cdot \frac{\theta^2}{2}$

θ = angle $= \frac{1}{n} = \frac{\theta^2}{2} = \frac{1}{2n^2}$ ← slope $= \frac{1}{n}$

$HA = 1\text{ chain length}\left(\frac{1}{2n^2}\right)$

Fremen's Hypotenuse Allowance (HA):

$HA = 1\text{ chain length}(\sec\theta - 1)$

$HA = 1\text{ chain length}\frac{\theta^2}{2}$

$HA = 1\text{ chain length}\left(\frac{1}{2n^2}\right)$

Example

100 links θ given find HA = ?

$HA = 100\text{ links}\left(\frac{\theta^2}{2}\right)$

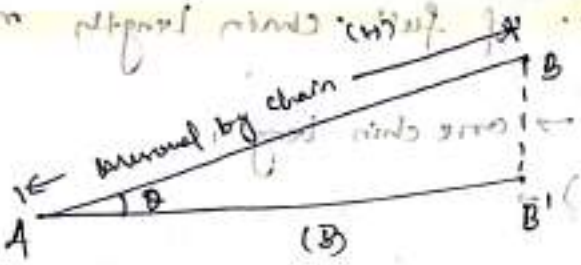
$HA = 50\text{ links}\,\theta^2$

$= 50\theta^2$ link

2. INDIRECT METHOD:-

(a) ON UNIFORM SLOPING GROUND:-

→ Sloping angle is measured by clinometer or by abney Level.



$\therefore \cos\theta = \frac{Base}{Hyp} = \frac{AB'}{AB}$

$$AB' = AB \cos\theta$$

(b) HYPOTENEUSE ALLOWANCE METHOD:-

→ For this method, correction is applied in field at every chain Length.

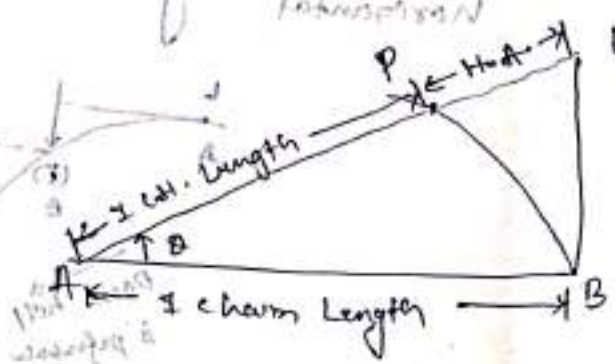
→ When chain is streached on the slope around is put some distance from ward at end. This distance is called "Hypotenuse Allowance (HA)"

→ $AB \neq AB'$ (Hypotenuse.)

$AB = AP =$ 1 chain Length.

$AB' = AP + PB'$ (HA)

$$HA = AB' - AP \quad \text{---(i)}$$



From triangle ABB'.

$\cos\theta = \frac{base}{Hyp} = \frac{AB}{AB'}$

$AB' = \frac{AB}{\cos\theta} = AB \sec\theta$ $\quad \therefore AB =$ 1 chain Length.

$$AB' = (\text{1 chain Length}) \sec\theta$$

from eqn (i) and (ii)

HA = PB' = AB' − AP

PB' = (1 chain Length) sec θ − 1 chain Length.

PB' = 1 chain Length (sec θ − 1)

HA = 1 chain Length (sec θ − 1) imp

Now Sec θ = $1 + \frac{\theta^2}{2} + \frac{5\theta^4}{24} + \dots$ But (i) θ → very small

θ → neglected

HA = 1 chain Length $\left(1 + \frac{\theta^2}{2} - 1\right)$

HA = 1 chain Length · $\frac{\theta^2}{2}$ imp. Formula

θ → replace as $\frac{1}{n}$ :: $\frac{\theta^2}{2} = \frac{1}{2n^2}$ ← tan θ = Slope = $\frac{1}{n}$

HA = 1 chain Length $\left(\frac{1}{2n^2}\right)$ imp

FORMULA: Hypotenuse Allowance (HA):

V. imp

HA = 1 chain Length (sec θ − 1)

HA = 1 chain Length $\frac{\theta^2}{2}$

HA = 1 chain Length $\left(\frac{1}{2n^2}\right)$

Example

100 Links ✓ Given. Find HA = ?

HA = 100 Links $\left(\frac{\theta^2}{2}\right)$

HA = 50 Links θ^2

50 θ^2 Links Ans

ERROR AND CORRECTIONS IN CHAINING :-

* Error & Corrections :- Error & mistakes in chaining may arise from one or more sources like error in chain length, poor straightening, careless holding, variation of temperature, misreading etc.

The error can be of 2 types

(a) Compensating Error

(b) Cumulative Error

(a) Compensating Error :- $e \propto \sqrt{L}$

These error try to compensate & do not affect survey work much.

* Incorrect holding & marking of arrow.
→ Plumbing may incorrect during stepping on slope.

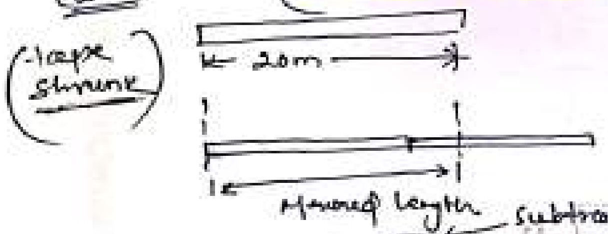
(b) Cumulative Error :- $e \propto L$

There are occur in same direction & tend to accumulate

→ Length of chain shorter then standard length.
→ Not applying sag correction / slop correction.

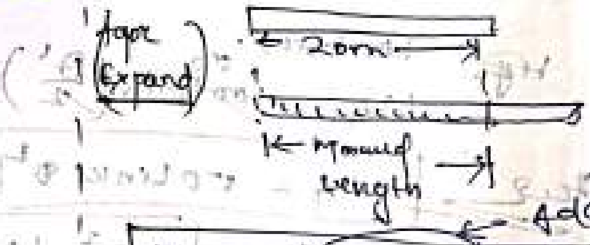
* Correction (Concept used in question) < too Long / too short

case-I



** Measured Length > Actual Length

** Correction → -ve



Measured Length < Actual value

Correction → +ve

Error = Measured value − True Value / Actual value

(Error = MTV)

Correction = True value − Measured value

Error = − Correction

(b) CUMULATIVE ERROR

(1) Correction due to standardisation :- may +ve or -ve

Applied on both tape/chain survey.

True × True = Wrong × Wrong

$$l \times L^{(TV)} = l' \times L'^{(MV)}$$

(T.L chain) (W.L chain)

$$\text{True/Actual distance}(L) = \left(\frac{l'}{l}\right) \times L'$$

$$\text{True Area}(A) = \left(\frac{l'}{l}\right)^2 \times \text{Measured Area (Wrong)}$$

$$\text{True Volume}(V) = \left(\frac{l'}{l}\right)^3 \times \text{Measured Volume}$$

$$A = \frac{W}{T} \times ML$$

where

l = nominal length of chain/tape

L = True distance measured on ground (with nominal chain/tape)

L' = Wrong length of chain/tape (Shrunk, Expand)

L' = Wrong distance, measured on ground by wrong tape/chain.

Correction = True value − Measured value

Correction due to standardisation $= L - L'$

$$= \frac{l'}{l} \times L' - L'$$

$$= \frac{l'L' - lL'}{l}$$

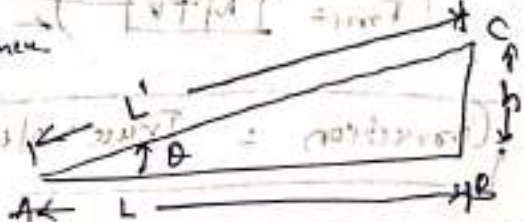
$$C_{s\,shrink/exp} = \frac{L'\left(\frac{l'-l}{l}\right)}{l}$$

$$C_a = (l' - l)\frac{L'}{l}$$

(2) Slope Correction: (Always -ve)

AB = Actual distance / true distance

AC = Measured distance.



AC > AB

MV > AC [Correction = -Ve (always)]

→ Slope correction is always negative.

(i) If slope angle (θ) is known:-

Correction = Actual value − measured value

= AB − AC

= L − L'

= L − L' cos θ

$C_{slope} = L'(\cos\theta - 1)$

$C_{slope} = -L'(1 - \cos\theta)$

(ii) If 'h' is known:-

h = elevation between B & C point.

$C_{slope} = L - L'$ ∵ from triangle ABC.

$= L - \sqrt{L^2 + h^2}$ — (1) $AC = \sqrt{AB^2 + CB^2}$

$L' = \sqrt{L^2 + h^2}$

by solving eq (1)

$C_{slope} = -\frac{h^2}{2L}$

Expand

$C_{slope} = \frac{h^2}{2L} + \frac{h^4}{8L^3} + \frac{h^6}{16L^5}$

Note:-

If higher term are not neglected then slope can increase by $\frac{h^4}{8L^3}$

$$C_{slope} = -L'(1-\cos\theta)$$

$$C_{slope} = \frac{-h^2}{2L'}$$

∴ Always -ve

TAPE CORRECTIONS :—

(3) CORRECTION for PULL/TENSION. — May be -ve or +ve

If pull applied to tape during measurement is more than * standard pull at which it is standardized, then length of tape increase.

Pull → $P_{apply} < P_{std}$ → Sag [C_p -ve]

$P_{apply} > P_{std}$ → Length ↑ [C_p +ve]

$$C_p = \frac{(P - P_s)L}{AE}$$

where

C_p = Correction due to pull

P = Applied pull

P_s / P_0 = standard pull

L = Measured Length

A = C/A of tape.

E = Modulus of elasticity of tape.

(4) TEMPERATURE CORRECTION :— May be +ve or -ve

Due to increase or decrease in temperature the length of the tape increase or decrease due to this the temperature correction is required to apply to, to get the actual length.

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

where

α = Co-efficient of thermal expansion of tape.

T_m = Mean temperature during measurement.

T_0 = Standard temperature.

L = Measured Length.

C_T = Temperature Correction.

$T_m > T_0 \rightarrow C_T \rightarrow +ve$

$T_m < T_0 \rightarrow C_T \rightarrow -ve$

Eg:-

27°C temp → Std temp of tape

- 90°C temp at time of measurement → $T_{std} < T_m$ → (Expand)
- 45°C temp at time of measurement → $T_{std} > T_{measurement}$ → Shrunk

8) Sag Correction:- Always -ve

→ When tape is supported at the two end, then it is always sag downwards due to its self weight. Thus apparent length measured is large as compare to the actual length and thus the correction is negative.

→ Sag correction is always -ve.

$$\uparrow C_{sag} = \frac{W^2 L^3}{24 P^2 l} \quad \text{---} (1)$$

where P = applied pull

W = weight of the tape per unit / length.

L = Length of the tape.

from eqn -(1) & (2)

$$C_{sag} = \frac{(W^2 L^2) l}{24 P^2}$$

1m tape → (W) N

30m tape → 30 × W N

1m tape → RW = N → (3)

↓

W = weight of tape

$$C_{sag} = \frac{W L}{24 P^2}$$

$$C_{sag} = \frac{W^2 L^3}{24 P^2 \cdot n^2}$$

W → Weight of tape

n = number of equal span.

w → weight / unit length of tape

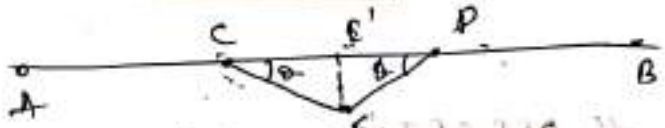
6. CORRECTION DUE TO WRONG ALIGNMENT :- Always -ve

→ This type of error occours when the survey line is not properly ranged out.

→ the measured distance is always greater than actual distance. and hence this correction is always negative.

Actual → ACE'DB

Measured → ACEDB



Measured Value(MV) > Actual value(AV)

↳ Correction = -ve.

∴ Correction = AV − MV

$= (CE' - E'D) - (CE + ED)$

$= (CE' - CE) + (E'D - ED)$

$= (CE\cos\theta - CE) + (DE\cos\theta - DE)$

$= CE(\cos\theta - 1) + DE(\cos\theta - 1)$

$= (\cos\theta - 1)(CE + DE)$ ← Measured Length.

Wrong alignment = Measured Length $(\cos\theta - 1)$

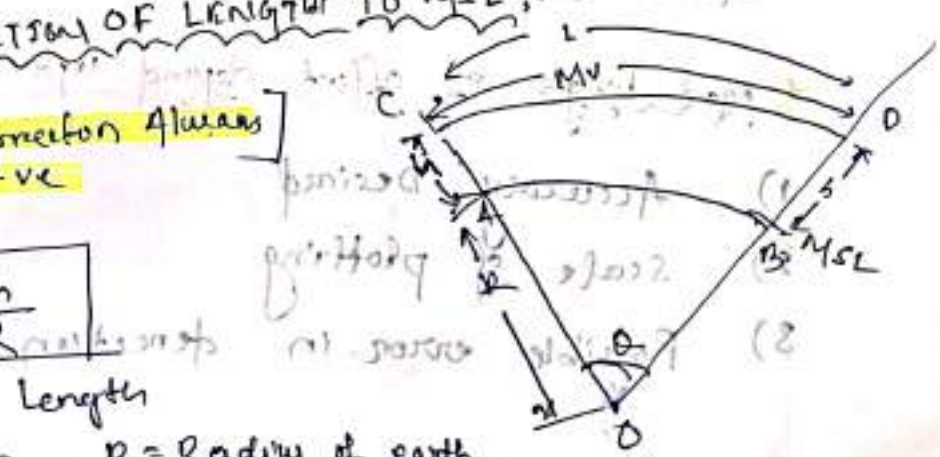
If $EE' = h$

$$\text{Correction} = -\frac{h^2}{2L'}$$

$L' = CE + ED$ (Measured Length)

7. CORRECTION/REDUCTION OF LENGTH TO MSL :-

CD > AB → [Correction always -ve]



$$C_{MSL} = -\frac{Lh}{R}$$

Where L = Measured Length

h = elevation, R = Radius of earth.

Note:-
Normal tension is the pull or tension when applied to a suspended wire equalize the correction due to pull and sag.

$$\frac{w^2 l^3}{24 P^2} = \frac{(P' - P_0) L}{AE}$$

* P = Normal tension.
Po = standard pull

OFFSET :-

The distance measured left or right of chain line to locate the details like boundary, building edge.

It may :-

1) Perpendicular
2) Oblique →

LIMITING / MAX LENGTH of OFFSET :-

* We limit the Length of offset for true length because there are more chance of error if offset is very Long.

→ Max length of offset is determined from consideration the error produce in plotting detail should not exceed 0.25 mm or 0.025 cm.

→ 0.25 mm is minimum value that human eye can determinate on paper

Max length of offset depend upon :

1) Accuracy Desired
2) Scale of plotting
3) Possible error in direction and length.

Error in laying offset may due to following :-

1) Error in Laying only/ Direction only.

2) When error is in direction (Angle) as well as Length. measurements.

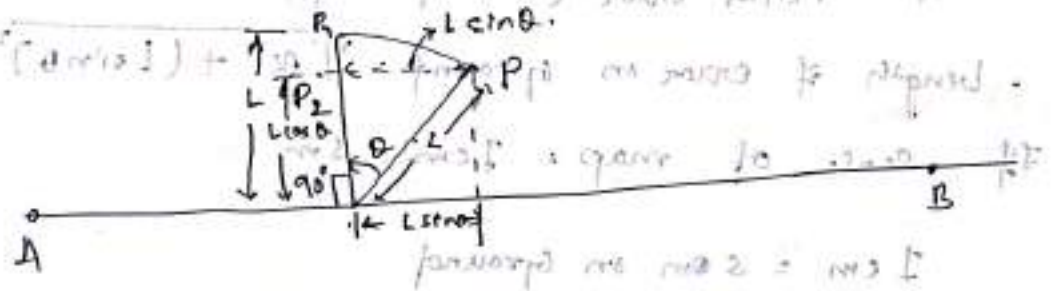
1) Error in laying only/ Direction only :-

P = actual point on ground

P_1 = Point Located on paper

θ = error in laying direction.

Length of error on ground $P P_2 = L \sin\theta$



Scale: 1 cm = S m

S meter Ground → 1 cm in sheet.

1 meter Ground → $\frac{1}{S}$ cm in sheet.

$(L \sin\theta)$ on ground = $\left(\frac{L\sin\theta}{S}\right)$ cm on sheet

Length of error in sheet = $\frac{L\sin\theta}{S}$ cm.

$$\frac{L\sin\theta}{S} \leq 0.025 \text{ cm}$$

$$L \leq \frac{0.025\, S}{\sin\theta}$$

$$L_{max} = \frac{0.025\, S}{\sin\theta}$$

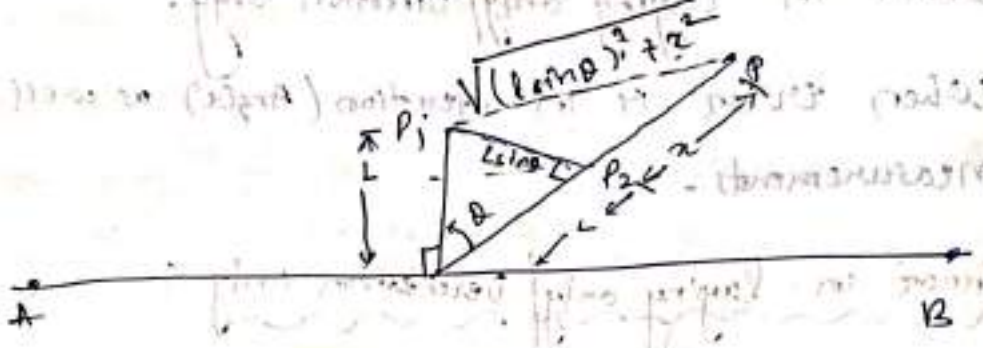
where

L = Limiting length of offset in direction.

S = Scale.

θ = Error

(2) Error in laying direction & linear measurement :-



P = actual point on ground

P_1 = Point on paper

θ = error in laying direction, $P_1P_2 = L\sin\theta$

x = error in linear measurement.

PP_1 = Total error (on Ground)

Length of error in ground = $\sqrt{x^2 + (L\sin\theta)^2}$

If Scale of map : 1 cm = s m

1 cm = s cm on Ground

s m on ground = 1 cm on sheet

1 m on ground = $\frac{1}{s}$ cm on sheet

$\sqrt{(L\sin\theta)^2 + x^2}$ on ground = $\frac{\sqrt{(L\sin\theta)^2 + x^2}}{s}$ cm on sheet

$$\frac{\sqrt{(L\sin\theta)^2 + x^2}}{s} \leq 0.025$$

L = Limiting length of offset

$$\frac{\sqrt{L(\sin\theta)^2 + x^2}}{s} = 0.025$$

$$(L\sin\theta)^2 + x^2 = (0.025 \cdot s)^2$$

$$(L\sin\theta)^2 = (0.025 \cdot s)^2 - x^2$$

$$L = \frac{\sqrt{(0.025 \cdot s)^2 - x^2}}{\sin\theta}$$

(L = Limiting length)

Calculate the Limiting Length (m) of the offset. If the maximum allowable error in laying offset 2 degree. The scale of the map is 1cm = 100m.

Sol:- $\theta = 2^\circ$, scale = 1cm = 100m

$$L = \frac{0.025 \cdot S}{\sin\theta}$$

$$= \frac{0.025 \times 100}{\sin 2^\circ} = 71.63\ m$$ Ans

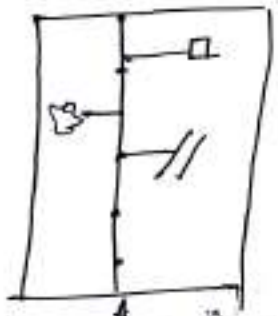
FIELD BOOK:-

→ A book in which chain or tape measurements are entered is called field book.

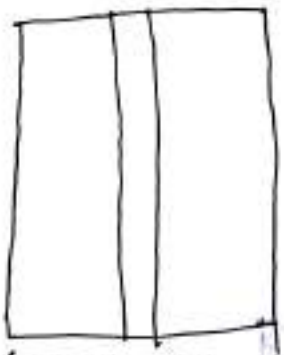
→ It is a book of size 20cm x 12cm.

→ Double-line field book is most commonly used for ordinary work & Distance between two point is entered between line (1.5cm to 2cm apart / 12.5 to 15mm apart).

→ Single line field book is used for large scale detailed dimension work.



(Single line fB)



(Double line fB)

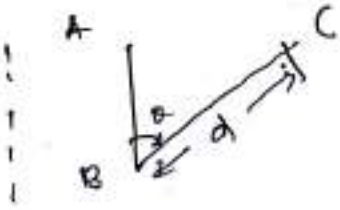
CH-3 : COMPASS SURVEY

Intro

It is the branch of surveying in which a point is located by angular and liner measurement.

distance :- Chain / Tape

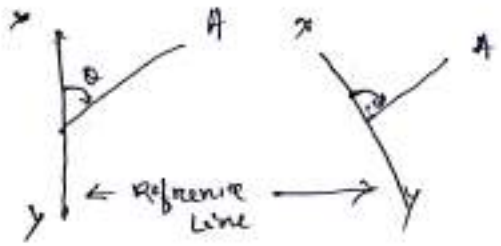
Angle :- Compass
- Horizontal Angle
- Vertical Angle.



2 measurement.

we can only measure horizontal angle.

Ex



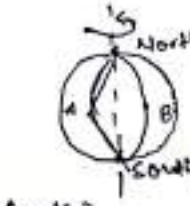
DEFINITIONS

1. MERIDEAN :-

It is relatively fixed direction w.r.t. which bearing of survey line are measured.

(a) TRUE MERIDIAN :-

→ Treue Meredian represent treue north and true south direction at that place.

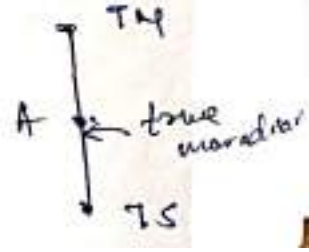


South)

→ for Plain Survey (Area is small) true maradian assumed to be parallal.

→ True maradian is always remain Constant for a particular station / point.

→ If In case of geodatic survey true maredian will will converge at poles.



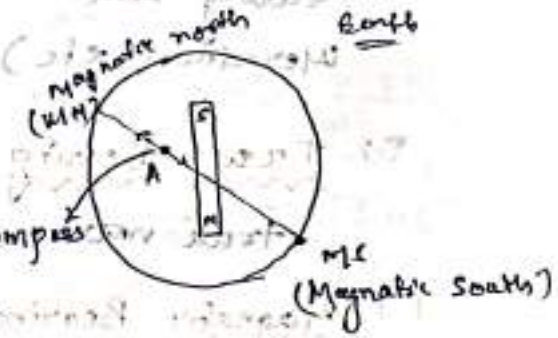
75

B. MAGNATIC MERIDIAN :-

→ Magnatic meridian at a point is direction indicated by freely suspended needle, needle in compass.

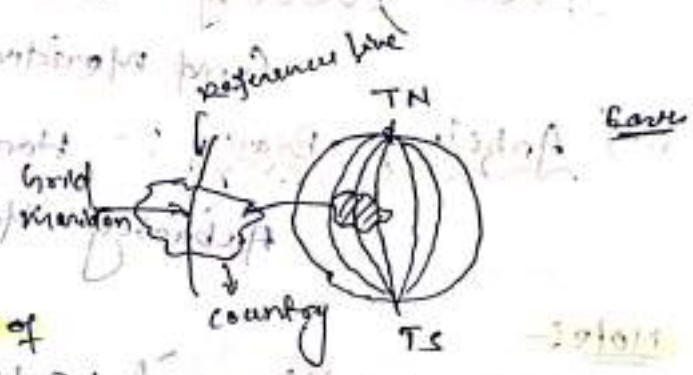
→ It indicates the direction of Magnatic north and Magnatic South.

→ Magnatic meridian will change with time.



C. GRID MERIDIAN :-

→ For survey of country town meridian passing through the count centre of the country is same time called as reffference meridian known as grid meridian.

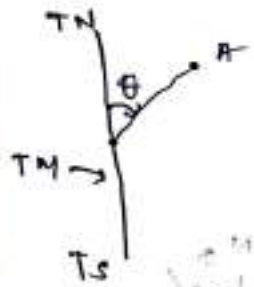


D. ARBTRARY MERIDIAN :-

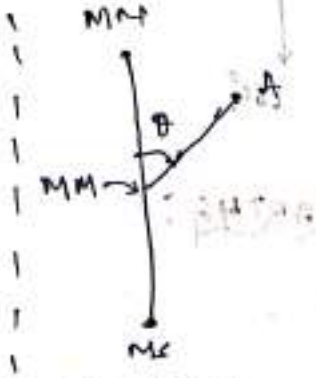
→ Meridian taken along any convenient direction (Assumed meridian) is known as arbtrary meridian.

Eg→ Tower, Chimney, etc.

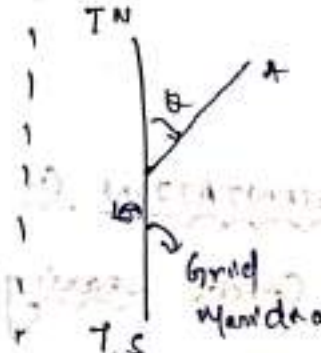
BEARING :-
(Angle)



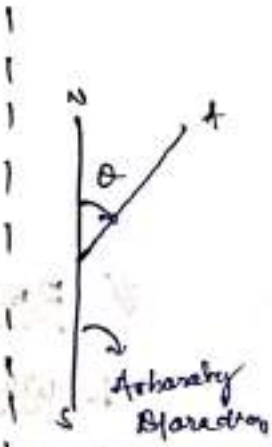
True Bearing



Magnatic Bearing



(Grid Bearing)



(Arbitrary Bearing)

» Bearing :- It is the horizontal angle made by between survey line and reference line (True meridian, Magnetic Meridian, etc)

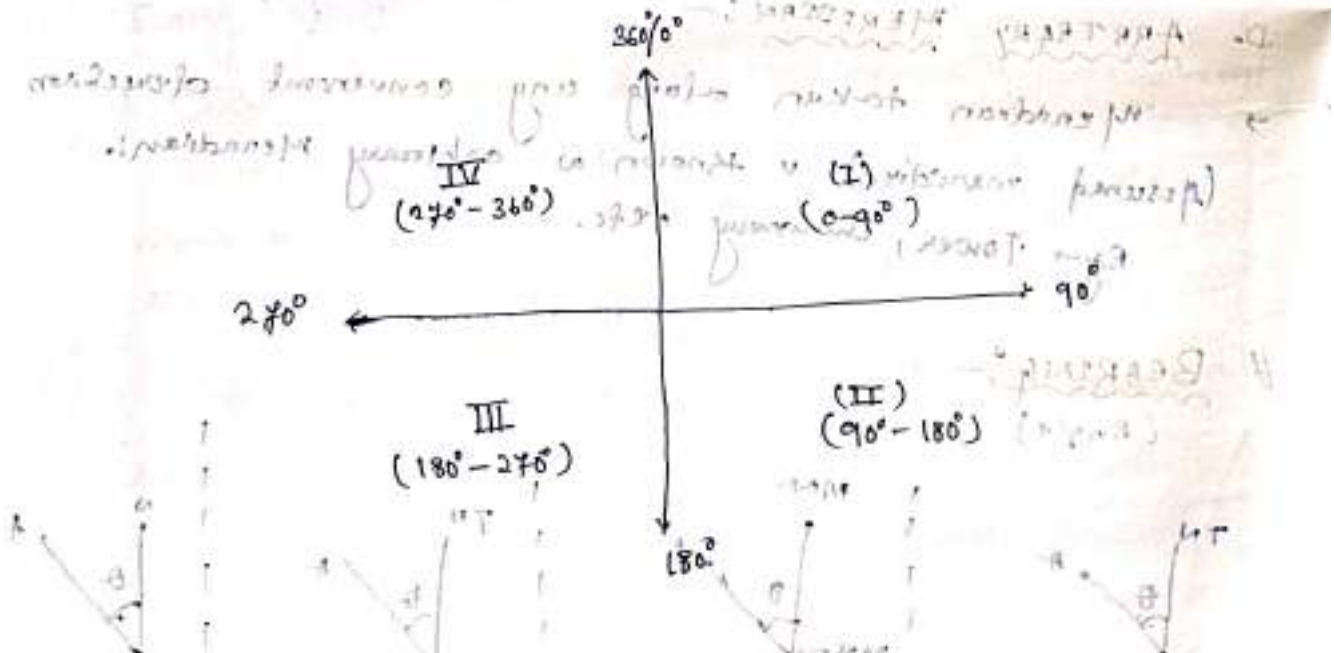
(i) True Bearing :- It is the horizontal angle between true meridian and survey line.

(ii) Magnetic Bearing :- It is the horizontal angle measure between Magnetic meridian and survey line

(iii) Grid Bearing :- Horizontal angle measured between Grid meridian and survey line.

(iv) Arbitrary Bearing :- Horizontal angle measured b/w Arbitrary meridian and survey line.

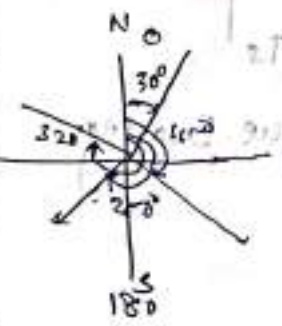
Note:-
True meridian and a true bearing will always remain same at any place w.r.t. time.



REPRESENTATION OF BEARING :-

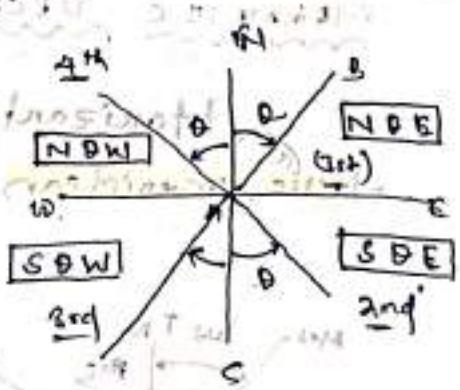
I. Whole Circle bearing :-

→ Reference :- north.
→ direction :- clockwise
Angle :- 0 to 360°



Eg :- WCB of 30°
WCB AB = 30°
AC = 120

2. Quadrantal Bearing :- / Reduce Bearing :-



→ Reference :- North or South.

→ Direction :- Clockwise or Anticlockwise

→ Angle :- 0 to 90°

1st Quadrant → NOE
2nd Quadrant → SOE
3rd Quadrant → SOW
4th Quadrant → NOW

CONVERSION :-

Rule: Draw → Correct

WCB → QB			QB → WCB	
WCB	QB		QB	WCB
1. 30°	N 30° E		N 60° E	60°
2. 120°	S 60° E (120−120)		S 30° E	150° (180−θ)
3. 220	S 40° W (220−180)		S 60° W	240° (180+θ)
4. 320	N 40° W (360−320)		N 20° W	340° (360−θ)

NOTE :-

* AZIMUTH :- WCB

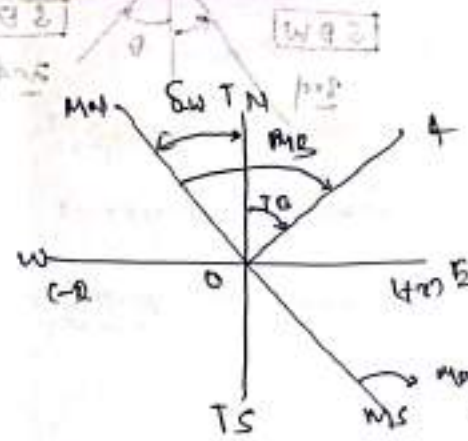
→ Bearing are sometime called azimuth. It is always measured clockwise from north of the reference meridian.

→ It is always measured from 0° to 360°.

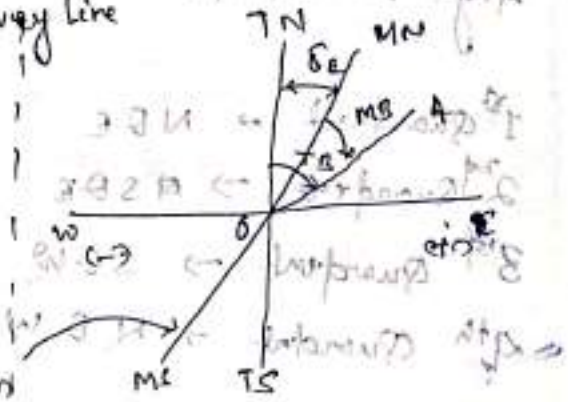
→ It may called whole circle bearing (WCB).

MAGNETIC DECLINATION :- (8)

Horizantal angle between Magnatic meridian and true meridian is termed as Magnatic declenation.



OA = Survey line



Magnatic Meridian

δ_w = western declenation
= (-ve) declination

δ_E = Eastern declenation
= (+ve) declination.

Note

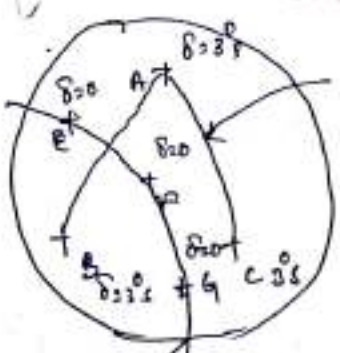
Magnatic declenation may very from time to time (because of magnatic meridian will also very with time)

Isogonic Line :- Same declination

The line passing through points on earth surface. at which declanation is same is known as iso-gonic line.

Agonic Line :- Zero declination

These are those isogonic line at which declination is zero.



Isogonic line.

Isogonic line (δ=0)

Agonic line.

VARIATION IN MAGNETIC DECLINATION :-

1. SECULAR VARIATION :-

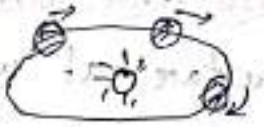
Secular variation of declination occour contenously over a long period of time. for Eg :- approx 170 year (more 300 year).

2. ANNULAR VARIATION :-

→ Variation of declination from year to year at a place from mean position of year.

→ It is because of Rotation of earth around the sun.

→ Annual rate of change of annual variation is generally 1 - 2 min. 1-2 minut of arc



3. DIURNAL VARIATION :-

→ It is change in declination at a place in 24 hr/day.

→ It is due to rotation of earth about its own axis. It also depend upon.

(a) Geographical position of place (near the equator > pole)
(b) Season of year (More summer, > Less winter)
(c) Time of day (More → day, > Less → Night)

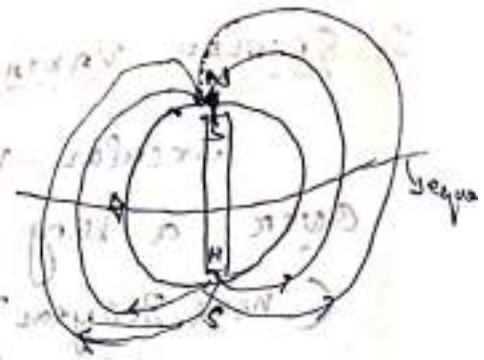
4. IRREGULAR VARIATION :-

→ It is due to the natural phenomenon earthquake, volcanic eruption, cyclone, Tsunamis etc.

→ In general value may be of order of 1 degree.

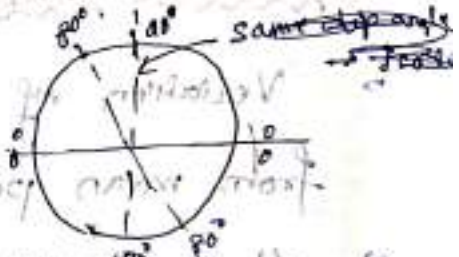
ANGLE OF DEPRESSION (DIP)

→ It is the vertical angle b/w magnetic field line w.r.t Earth surface



→ At pole angle of dip = 90°

→ At equator angle of dip = 0°



→ Isoclinic line → Line joining same angle of dip.

→ Aclinic line → Same Isoclinic line where dip θ = 0°.

Isoclinic line :- line passing through point on earth surface at which dip is same.

Aclinic Line :- The isoclinic line which passes through point of zero dip.

NOTE

Imp for Numericals

1. True bearing, Magnetic bearing, δ.

Any of 2 Given →

- TB, δ ⇒ MB = ?
- MB, δ ⇒ TB = ?
- MB, TB ⇒ δ = ?

2. True bearing :- Constant with time

1990 → TB = 38°

2023 → TB = 38°

Past data TB = Present TBr

Problem in class note for reference

Note

MB > TB → δ_W

MB < TB → δ_E

Note

true bearing of Sun at noon → 180°

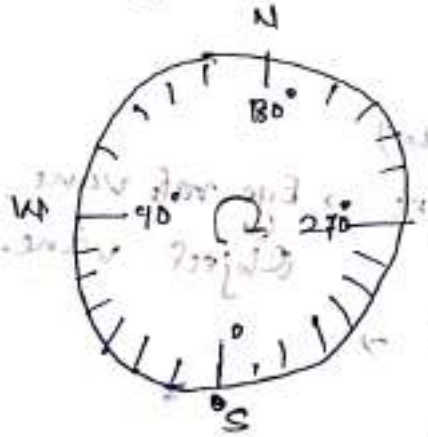
Eg MB of Sun at noon = 182°, δ = ?

Ans MB = 182°
TB = 180° (data)
δ = 182° − 180°
= 2° W Ans

TYPE OF COMPASS

Prismatic Compass	Surveyor Compass
1. Broad Shape Needle	1. Pointed or Edge bar Needle.
2. It measures WCB (0–360°)	2. It measure quadrental bearing (0–90°)
3. Tripod is not required	3. Tripod is required.
4. Needle is attached to graduated circle.	4. Needle is free to move
5. Graduated circle will not rotate with line of sight.	5. Graduated circle is rotate with line of sight.
6. In prismatic compass Sighting and reading can be done simultaneously.	6. Sighting and reading can not be done, simultaneously.

(Prismatic Compass)

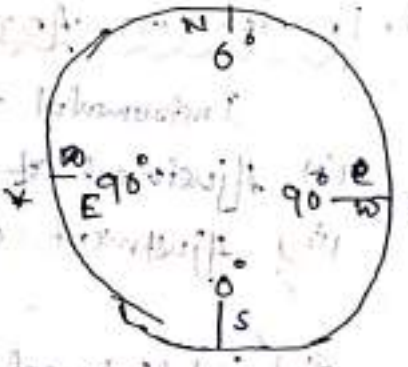


Marking Graduation of Compass

Zero → South (Mark)

LC = 30'

(Surveyor Compass)

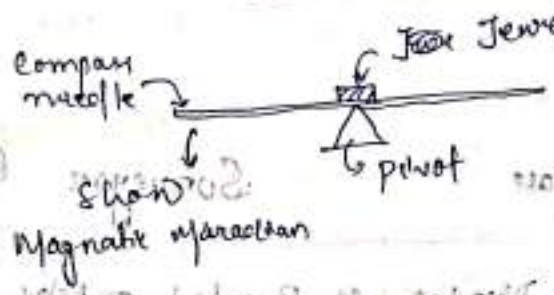


N & S = 0°
E & S = 90°

LC = 15'

Note:-

The compass needle is made up of a cylindrical bar of magnetised steel/iron. It is hung from conical jewel bearing supported on hard pivot.



PRIOR TO OBSERVATION - ADJUSTMENTS :-

(1) TEMPORARY ADJUSTMENT :-

→ the adjustments are made at every set up of the instrument shifted

(i) Centring :- Tripod is placed over the station & Compass is fixed on tripod. Plumbbob is hung from centre of the compass.

(ii) Levelling :- Compass is levelled by eye judgement

(iii) focussing of Prism (only prismatic)

2. PERMENENT ADJUSTMENT :-

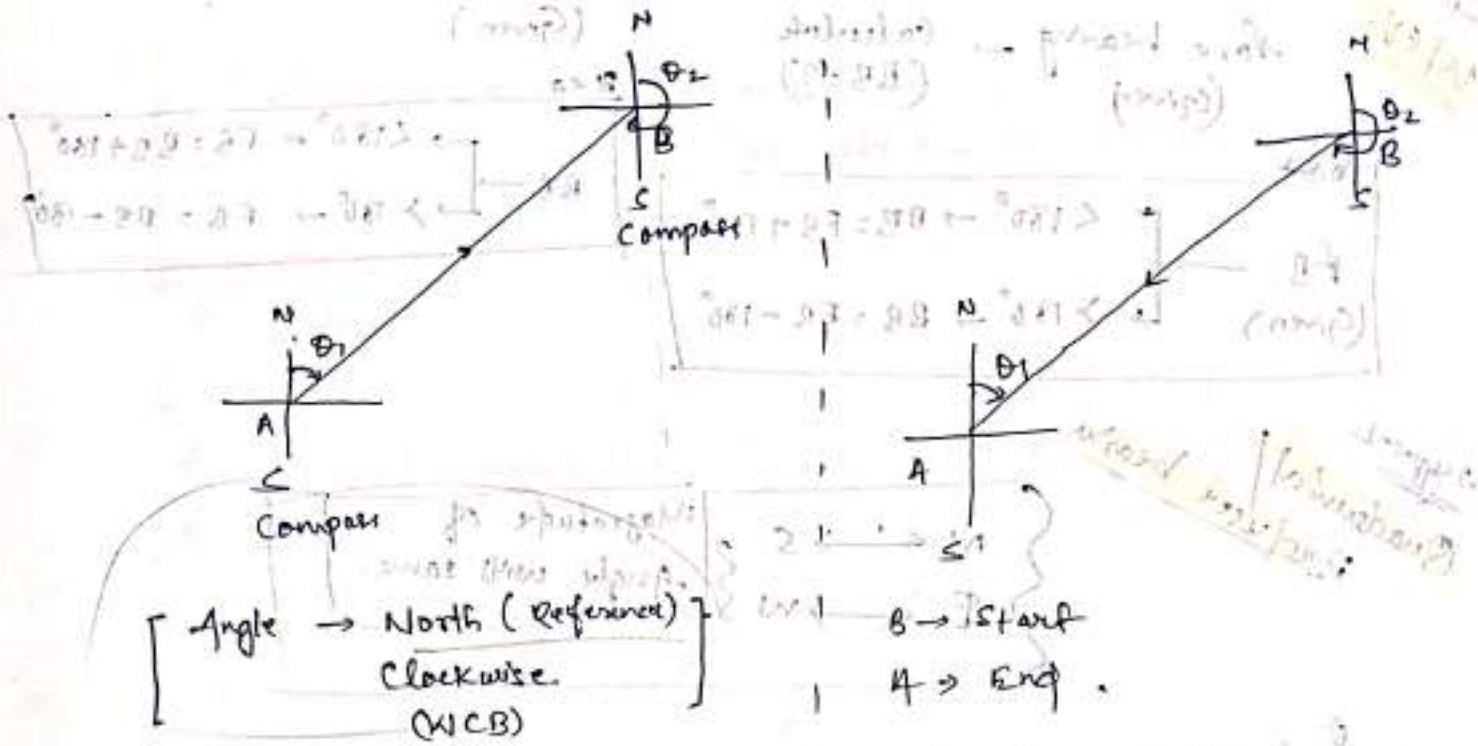
Instrumental Adjustment

(i) Adjustment of level (level tube)

(ii) Adjustment of Sight vane → Eye vane
Object vane

(iii) Adjustment of reticle →

FORE BEARING AND BACK BEARING :-



[Angle → North (Referred) Clockwise. (WCB)]

B → Start
A → End.

A → start
B → END
Fore bearing of AB = θ1
Back bearing of AB = θ2

B fore Bearing of BA = θ2
Back bearing of BA = θ1

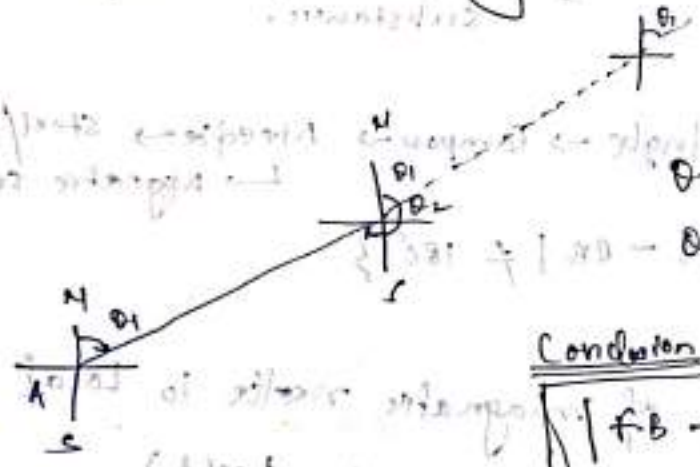
Note

FB of AB = BB of BA BB of AB = FB of BA

***

* Fore Bearing :- Bearing of line measured in the direction of survey is called "FB of line".

* Back Bearing :- Bearing of line measured opposite to the direction of survey line is called "BB of line".



$\theta_2 - \theta_1 = 180^\circ$

$\theta_1 - \theta_2 = -180^\circ$

Condition

$\lvert FB - BB \rvert = 180^\circ$

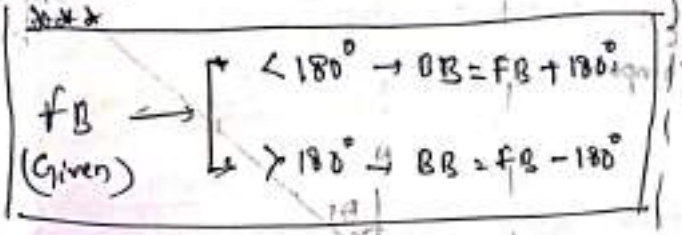
***

Type-1

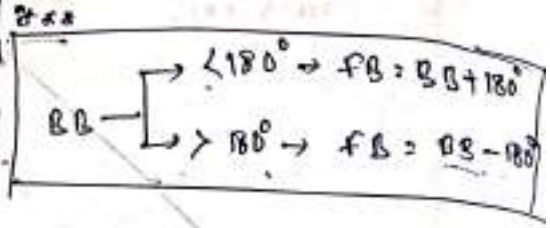
WCB

Question (Exam)

fore bearing → Calculate back bearing (BB=?)
(Given)

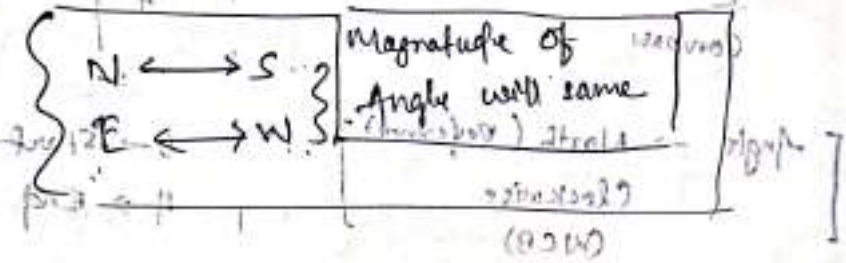


BB → fB = ?
(Given)



Type-2

Quadrantal Bearing



Example

(i) FB of line 150°, BB = ?

BB = 150° + 180° = 330°

(ii) FB of line 250°, BB = ?

BB = 250 - 180 = 70°

(iii) FB of line N 20° W

BB = ?

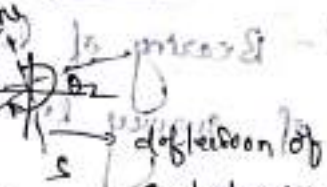
BB = S 20° W

BB = S 20° E

LOCAL ATTRACTION

At site

Angle → compass
distance → chain/tape



Angle → Compass → Needle → steel/iron
↳ Magnetic substance

$\{\theta \mid |FB - BB| \neq 180°\}$

→ The deflection of magnetic needle to Local magnetic field (other than earth magnetic field)

Eg → Iron fence, steel pipes, electric wair, vehicle etc

$|FB - BB| = 180°$ [no local attraction on two station]

$|FB - BB| \neq 180°$ [Either both the station are affected from LA or only one station]

Numericals

Example

In the Given question find out which station is free from local attraction calculate corrected bearing of line DE, EA, AB.

Line	FB	BB	$\lvert FB - BB \rvert$	
AB	75°5' + 30' = 75°35'	254°20' − 254°−31' Correction = 1°.28'	179°15'	
BC	115°20' − 1°15' = 114°35'	296°35' (No error)	181°15'	
CD	265°35' (no error)	345°35' (no error)	180°00'	CD free from local attraction
DE	224°50' (no error)	44°5' Correction error +45' 44°50'	180°45'	
EA	304°50' + 45' = 305°35'	125°5' 125°35' Error = +30' Correction	179°45'	

FB of DE = 224°50'

Correct BB of DE = 224°50' − 180° = 44°50'

Error = 44°50' − 44°5' = 45'

Correct FB of EA = 305°35'

" BB of EA = 305°35' − 180° = 125°35'

Correct FB of AB = 75°5' + 30' = 75°35'

BB of AB = 75°35' + 180° = 255°35'

Numerical

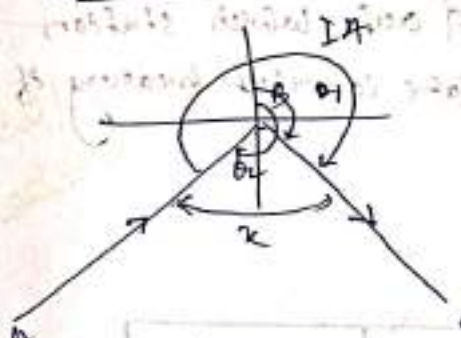
$1^\circ = 60 \text{ min} = 60'$

$1' = 60 \text{ sec} = 60''$

If angle [-ve → add 360° ; > 360° → subtract 360]

INCLUDED ANGLE:-

EXTERNAL



θ_1 = FB of BC

θ_2 = BB of AB

$x = \theta_2 - \theta_1$

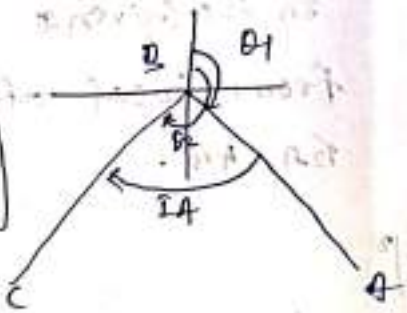
$IA = 360^\circ - x$

$= 360^\circ - (\theta_2 - \theta_1)$

$IA = (\theta_1 - \theta_2) + 360^\circ$

[Previous line to next line clockwise direction]

INTERNAL



$IA = \theta_2 - \theta_1$

IA = FB of line BC − BB of AB

In general

IA = FB of Next line − BB of previous line

***

Generally,

$IA = [\text{FB of Next line} - \text{BB of previous line}] + 360^\circ$ ***

→ When two survey line meet at a point then the angle enclosed b/w them is termed as included angle.

→ Included angle either be exterior or interior angle.

→ In survey Included angle always measured from preceding (Previous) line to forward (Next) line.

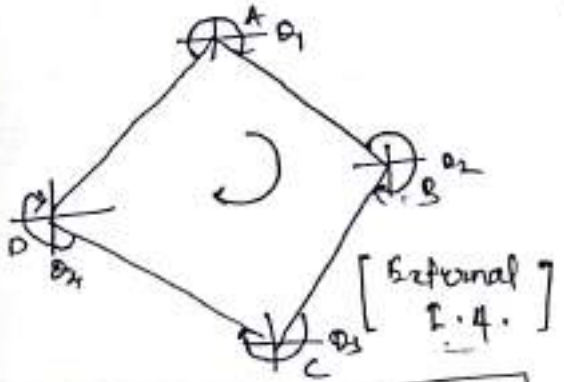
→ Always measured in clockwise direction.

***

$IA = \text{FB of next line} - \text{BB of Previous line}$

(i) If value is -ve → add 360°

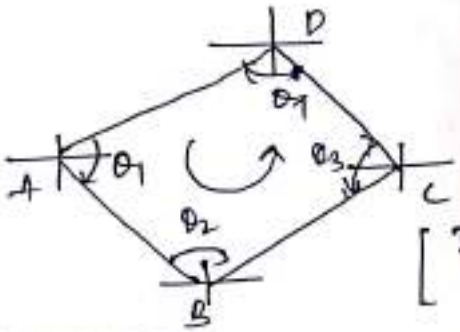
Case 1 [Clockwise]



[External I.A.]

$$\theta_1 + \theta_2 + \theta_3 + \theta_4 = (2N + 4)\,90^\circ$$

Case 2 [Anti Clockwise]



[Internal I.A]

$$\theta_1 + \theta_2 + \theta_3 + \theta_4 = (2N - 4)\,90^\circ$$

Note:-

In compass traversing linear measurement of traverse line is done with the help of chain/tape & angle are measured with compass.

→ Traverse in "Anticlockwise" direction is performed its are have Internal included angles.

→ Traverse in "clockwise" direction included angle are External

→ In close traverse sum of internal angle must be observed must be equal to, theoretical sum of angle.

$(2N-4)\,90^\circ$ [for Internal IA] → Anticlockwise.

$(2N+4)\,90^\circ$ [for External IA] → clockwise.

[Sum of IA]

N → number of survey line.

CH-1 : THEODOLITE

It is use to measure horizantal and vertical angle in survey work.

CLASSIFICATION :-

A. ON THE BASIC OF ROTATION OF TELESCOPE :-

1. TRANSIT THEODOLITE :-

→ These are the theodolite which can be reversed by revolving the telescope in vertical plane about 180°.

2. NON-TRANSIT THEODOLITE :-

→ These are the theodolite which can not be reversed by revolving the telescope in vertical plane about 180°.

B. ON THE BASIC OF ACCURICY :-

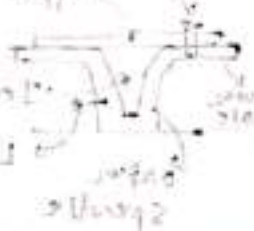
1. VERNIER THEODOLITE :-
In this vernier are used for taking reading.

Least count → 20 sec

2. OPTICAL THEODOLITE :-
Reading are taken with the help of micrometer fitted on them.

Least count → 1 sec

COMPONENT OF THEODOLITE



1. LEVELING ASSEMBLY :- (Levelhead)

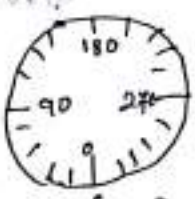
- Trivet → (Attach to tripod)
- Tri brach →
- foot screw →

→ The assembly will help in proper leveling of instrument.

2. HORIZANTAL ASSEMBLY :-

- Lowerplate
- Upper plate
- Level tube / Bubble tube.

* Lower plate → Main scale mark/reading [Scale plate]
  ↳ Graduation
  ↳ degree & minute
* Upper plate → vernier scale mark.
  ↳ graduation
  ↳ minute and second



(Main scale)

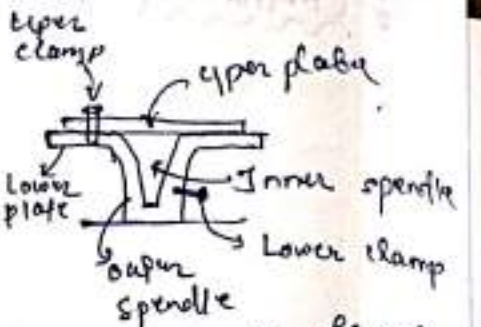
LC = 20 min

(Vernier Scale)

LC = 20 sec

Note

* Lower plate is attach to outer spendle
* Upper plate is attach to inner spendle

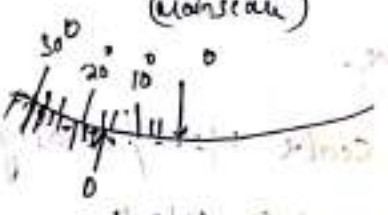


* When Lower clamp is tighted lower plate is fixed.
* when both the screw or clamp tight .so there is no rotation of instrument & between plates.
* If Lower plate is clamp (tight) & upper plate ~~clamp~~ Coclamp (Loosen) we can measure a horizantal angle b/w two points.
* If upper plate is ~~#~~ clamp (tight) and lower plate is unclamped (Loosened) . then there is no movement between a scale but instrument can be rotate in Horizantal direction.

V. imp ~~*~~ for minor rotation / fine adjustment tangent screw is provided.

* The size of the theodolite can be defined by Lower graduation circle & generally size of theodolite varies from 8 to 15 cm.

Reading



Reading = $10°20' + (\text{Least count}) \times 6$ (Exact match · RLS & VI elevation)

$= 10°20' + (20'' \times 6)$

$= 10°20' + 120'$

$= 10°22'$ Ans

3. ALIDATE ASSEMBLY :—

- Vertical circle
- Telescope
- Altitude level tube / Bubble tube
- A frame.

→ It is top most assembly which include telescope supported by two standard of scale of Letter A.

Telescope :—

→ It is mounted on Horizontal axis / trunnion axis.

→ for Sighting :— telescope is rotate about horizontal axis about vertical plane.

Vertical Circle :—

On vertical circle main scale are marked & vernier scale move with telescope.

Altitude bubble :— Bubble tube on vertical circle.

Note :—

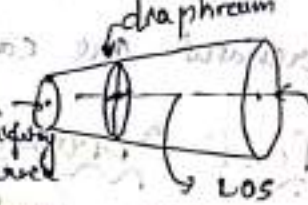
Horizontal / Trunnion Axis :— Axis about which telescope can be rotated in vertical plane.

Vertical / Azimuth Axis :— Axis about which telescope can be rotated in horizontal plane.

IMPORTENT DEFINATION :—

1. Line of sight :—

→ It is a imaginary line passing through intersection piece of crosshair of diaphragm & optical centre of objective.



→ Line of in horizontal plane is called "Line Of Collimation".

4. Axis of Level tube:—

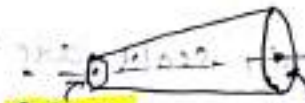
→ It is a straight line tangential to the longitudinal curve of level tube at its center.

→ Axis of level tube is horizontal when bubble is at central center.

Bubble tube.

3. Axis of telescope:—

→ It is the line joining the optical center of object glass to centre of eye-piece.



9. Transit:—

It is the operation of revolving the telescope through 180° in vertical plane about the horizontal axis. The operation is also called plunging or reversing.

5. Right face Observation:—

When vertical circle of the theodolite is on the right of the observer, then the theodolite is said to be in face Right condition and the corresponding measurement are called as face right measurement.

6. Left face Observation:—

When the vertical circle of theodolite is on the Left of the observer, then the theodolite

is called to be in face left condition and the corresponding measurement are called as face left measurement.

7. Changing face :-
It is the operation of bringing the telescope the face left condition to face right condition and vice versa.
It is done by
→ I transiting
→ I swinging

8. Telescope Normal :-
The telescope is said to be normal position when vertical circle is on left of the observer & bubbl tube is up

9. Telescope Inverted :-
The telescope is said to be inverted position when vertical circle is on the Right of the observer and bubble tube is on down.

10. Swing the telescope :-
It is the operation of revolving the telescope in the horizontal plane about the vertical axis. Clockwise rotation is called right swinging and anticlockwise rotation is called as left swinging.

11. Double Sighting :-
It is the process of making the horizontal and vertical measure twice. viz. One is telescope normal face left and other with in inverted (face right) condition.

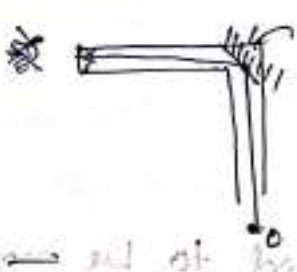
12. Centering :—

→ It is operation of setting up the instrument exactly over the station mark.

→ A plumb bob suspended from the underside hook of the instrument box is used for centering purpose.

→ In windy condition → It is done by "Optical Plumet"

Theodolite



fully silvered

optical plumet

13. Vertical axis :—

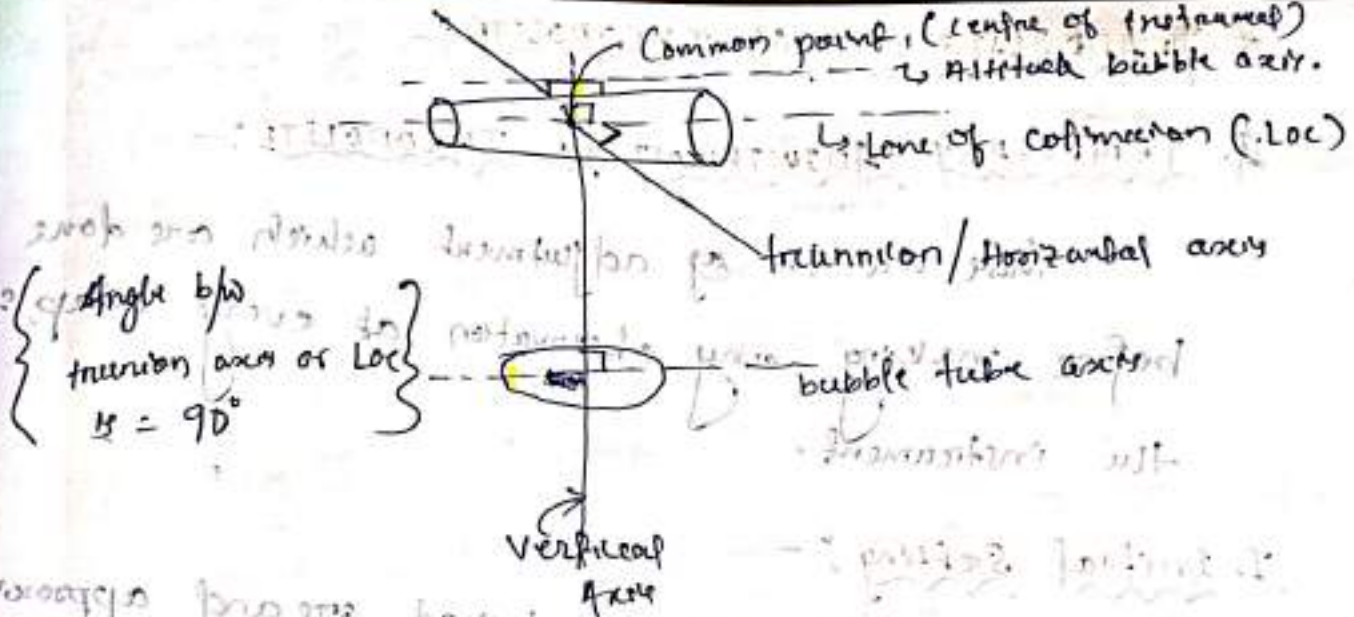
The vertical axis of the theodolite is the axis about which instrument rotate in the horizontal plane and this axis is also called a azimuth axis. The telescope and the horizontal circle are rotate about the vertical axis, independent of each other.

14. Horizontal Axis :—

It is the axis about which a telescope rotate in the vertical plane. It is also called as trunnion axis or the transverse axis.

15. Lining in :—

It is the process of establishing intermediate points with theodolite on given straight line where end are visible.



Imp # FUNDAMENTAL LINES :-

1. Horizontal circle must be ⊥ to vertical axis
2. Vertical circle must ⊥ to Horizontal axis / trunion Axis
3. Axis of plate level must ⊥ to vertical axis.
4. Line of collimation also always ⊥ to Horizontal axis.
5. for Horizontal position of telescope and for altitude bubble is at the centre reading on vertical circle must be zero.
6. Line of sight, Trunnion axis & vertical axis must meet at common point (termed as centre of instrument)
7. When theodolite is level LOC must parallel to altitude bubble axis.

By changing the face following error can be established:-

1) Error due to line of collimation not ⊥ to horizontal axis.
2) Error due to horizontal axis not ⊥ to vertical axis.
3) Error due to LOC not ⊥ parallel to the axis of altitude level.

ADJUSTMENT OF THEODOLITE :-

A. TEMPORARY ADJUSTMENT OF THEODOLITE :-

These are the adjustment which are done before making any observation (at every setup of the instrument.)

1. Initial Setting :-

→ fixing the theodolite on tripod and approximate Levelling is done with help of tripod legs.

→ adjustment of height of theodolite.

2. Centering :-

→ Bringing the vertical axis of theodolite exactly over the station mark.

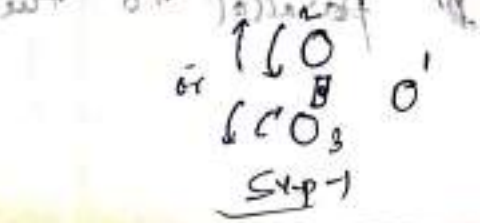
→ for centering plumb bob or sometimes optical plumat is used.

3. Levelling :-

This means work making the vertical axis truely vertical. This is done with foot screws.

steps → ① take the plate bubble tube to the centre of any two foot screw and rotate the foot screw both the foot screw to the same direction.

② Shift the position of bubble tube and set the 3rd foot screw.



4. Focusing of Eye piece :—

→ Point the telescope to the sky or hold a piece of white paper in front of telescope

→ Move the eye piece in and out until sharp black colour & image of cross hair is seen.

5. focusing of Object Lens :—

→ Direct the telescope towards the object for observation turn the focusing screw until image of object is Clear and sharp.

PERMANENT ADJUSTMENT :—

The permanent adjustment of theodolite are so arranged in sequance that next adjustment does not disturb the result obtain from previous adjustment.

1. PLATE Level TEST :— Make to the plate bubble centered so that vertical axis of theodolite is truely vertical.

2. Cross hair Ring test :— vertical class hair should lie in plane perpendicular to horizontal axis.

3. Collimation in Azimuth test :— Make the line of sight perpendicular to Horizontal axis.

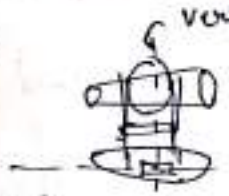
4. Spire test :— Make horizontal axis perpendicular to vertical axis.

5. Bubble tube Adjustment :— Telescope Make the bubble central when Line of sight is horizontal.

LOS ⊥ Altitude bubble tube axis

6. Vertical Arc test :- Make vertical circle index error zero when Line of sight ⊥r to vertical axis.

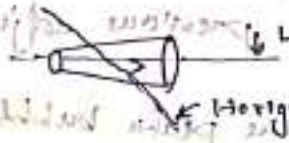
Figure Representation

①


(1) Plate level test (Make instrument truely vertical)

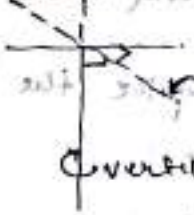
②


(Cross hairs ring test)

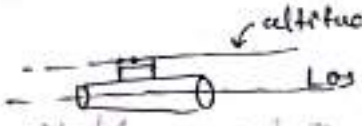
③


LOS/LOS ⊥r transit/Horizontal axis

(Collimation in Azimuth test)

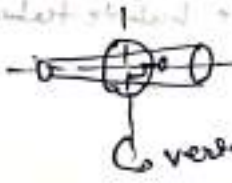
④


(Spirit test)

⑤


LOS ∥ altitude bubble axis (bubble at centre)

(Level tube test)

⑥


Vertical circle (zero) angle mark ⊥r to vertical axis

(Vertical Arc test)

MEASUREMENT OF HORIZONTAL ANGLE :-

Measurement of horizontal angle by horizontal circle of telescopic of theodolite by operating clamp screws.

Note

i) Upper clamp screw } tight → No Moment (fix).
Lower clamp screw }

ii) Upper clamp screw → ~~tight~~ Loose
Lower clamp screw → ~~Loose~~ tight → Horizontal angle measurement.

iii) Lower clamp screw → loose → any movement.
Upper clamp screw → tight → No change in reading

* There are 2 method of ~~taking~~ Horizontal angle measurement.

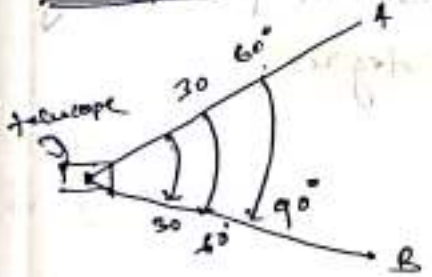
1. Method of Repitation.
2. Method of Reiteration.

1. METHOD OF REPITATION :-

→ In method of repetation to measure an angle b/w two station, it means to measure it two or more times and value of angle is obtained by averaging it.

→ It is preffer for measurement of ~~angle~~ single angle where more accuracy is required.

Example



Steps

(i) adjustment
(ii) A - sight → Reading 0°
(iii) Lower fix → B site. → 30°
upper loose angle
(iv) upper tight → no change relay
Lower loose back to horizontal position

* take both the reading of angle from both face left & face right and averaging it.

$$\frac{\text{face left} + \text{face right}}{2}$$

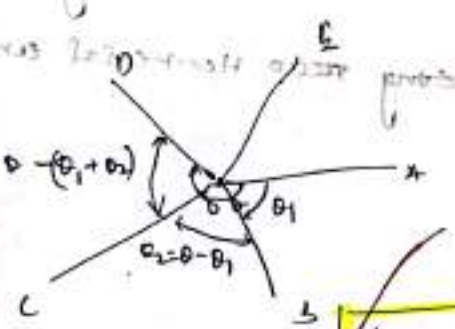
2. METHOD OF REITERATION :-

→ In generally preferred when several angle are to be measured at a perticular station.

→ All angle are measured successfully & finally the horizontal is closed.

→ Generally face left observation made in clockwise direction, where as face right should measured in anticlockwise direction.

Eg.



(i) A → Reading θ

(ii) B → Lower fix upper lines $= 30^\circ$

(iii) Measured both of same angle from face left & face right.

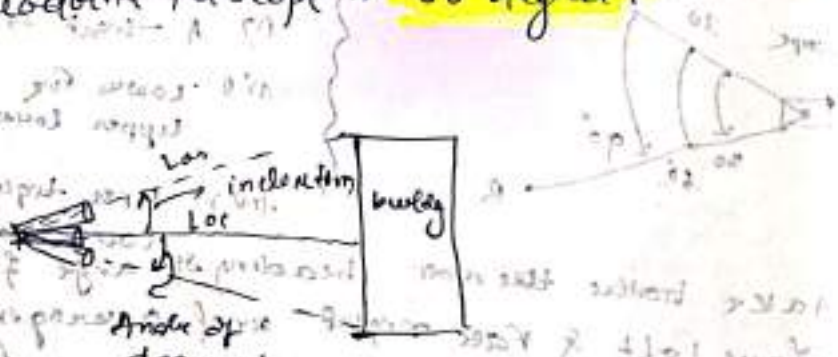
$$\text{Angle } \theta = \frac{\theta_1(F.L) + \theta_1(F.R)}{2}$$

MEASUREMENT OF VERTICAL ANGLE :-

→ Vertical angle is angle between line of sight and horizontal.

→ It may angle of elevation and depression, depending on object.

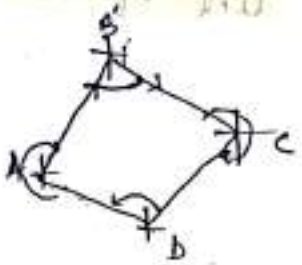
→ The maximum vertical angle that can observed practically with theodolite telescope is 68 degree.



MEASUREMENT OF DIRECT ANGLE :-

→ An angle measure clockwise from preceding line to next line is called direct angle

→ This method is adopted for close traverse in theodolite.



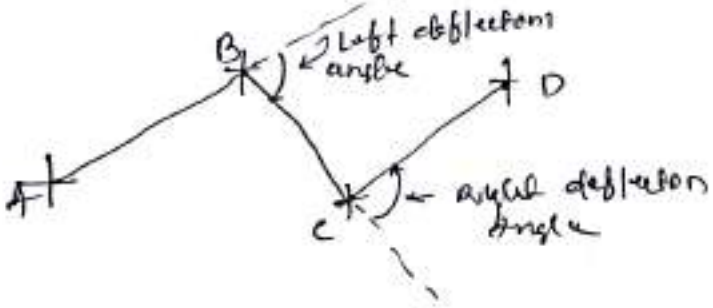
MEASUREMENT OF DEFLECTION ANGLE :-

→ A angle of deflection angle is the angle, made b/w prolongation of preceding line and following line.

→ When angle is measured clockwise, it is called right deflection angle. angle

→ When angle is measured anticlockwise, it is called Left deflection angle

→ It is vary from 0 to 180°.



ERROR :-

The source of error in angle measurement may arise from imperfection in adjustment and construction of theodolite.

1. Vertical Index error :- Axis is not vertical (Imperfect plate level)
(Plate level test)

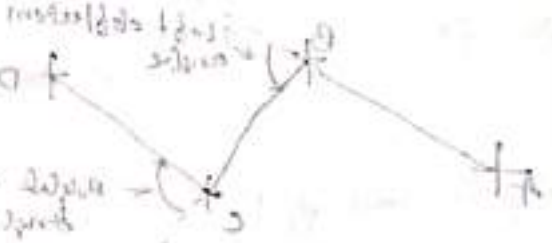
2. Lateral collimation error :- LOC not perpendicular to horizontal axis.
(Collimation in Azimuth test)

3. Horizontal axis error :— horizontal axis not perpendicular to vertical axis.
(Spair test)

4. Vertical collimation Error :— line of altitude level not parallel to line of collimation.
↓
(Level tube test)

Note

- Vertical Index Error → plate level test
- Lateral Collimation Error → Collimation in Azimuth test
- Horizontal axis Error → Spair test
- Vertical Collimation Error → Level tube test



CH-5: TRAVERSING : Latitude & Departure

→ Traversing is the type of surveying in which number of connected survey lines and the framework and direction of survey lines are measured with help of angle measuring instrument and length is measured with "Chain or tape".

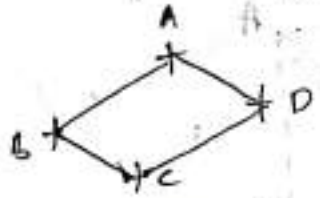
- Linear measurement → tape / chain
- Angular measurement → theodolite / compass

→ Traverse are 2 types.

(A) Open traverse
(B) Clouse traverse.

(A) Clouse traverse:—

→ If traverse is said to be closed one if start point and end point of traverse are same; (Loop traverse) that by forming a closed polygon.



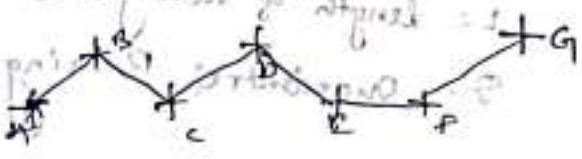
→ If traverse in which last point is known a to us is also termed as closed traverse.

B. Open traverse:—

→ An open traverse is that does not return to start point

→ Eg :- Path of highway, Railway, Canal etc.

→ Generally it not preferred because it cannot be adjusted.



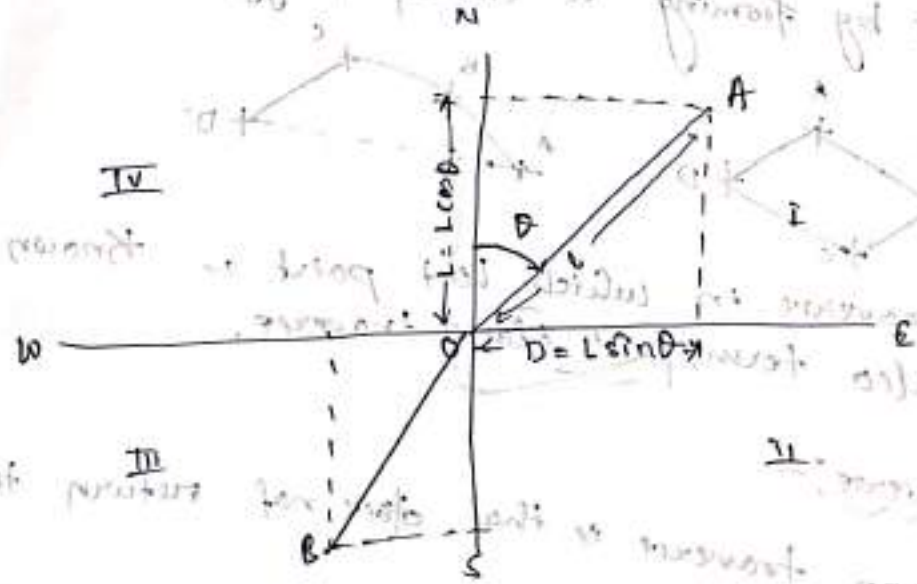
METHOD OF TRAVERSING :—

1) By chain → Linear measurement → chain/tape.
   → Angular → chain/tape
   → Accuracy is least.

2. Free or Loose Needle Method :—
   → Linear measurement → chain/tape.
   → Angular measurement → ** Compass [FB & BB Calculate]
   → (Magnetic bearing)

3. Fast Needle Method :—
   → Linear measurement → ~~chain~~ chain/tape.
   → Angular measurement → Theodolite **
   (Most Accurate)

LATITUDE AND DEPARTURE :—



Latitude (L) = $L\cos\theta$
Departure (D) = $L\sin\theta$

L = length of survey line
θ = Quadrantal Bearing.

* Latitude :— Latitude of a line is its projection on Y axis i.e N-S axis (vertical axis) or reference meridian.

* Departure :— Departure of a line is its projection on (X axis) E-W axis (Horizontal) or ⊥r to reference meridian.

* Distance measured towards North is known as Northing of line

* Distance measured towards South is known as Southing of line.

Example

type1 Line = PQ = 10m

$\theta = 30°$

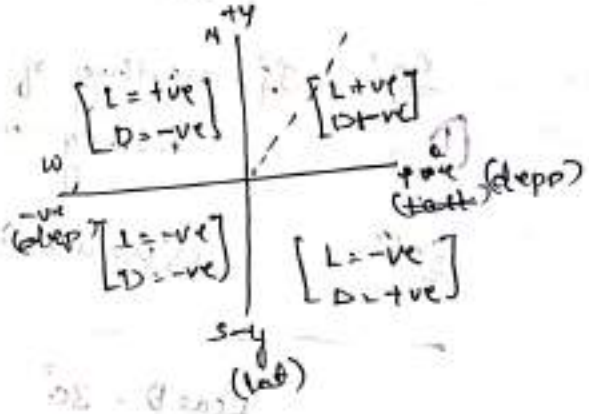
Calculate Lat and dep ?

sol Latitude (L) = $10 \cdot \cos 30°$

Departure (D) = $10 \cdot \sin 30°$

type2 If latitude of line is negative and departure of line will +ve. then line will lie in which Quardents.

Ans ⇒ 4th Quardent



type3 Latitude = -30 m.

departure = +30 m

quardent = ?

Ans 2nd Quardent.

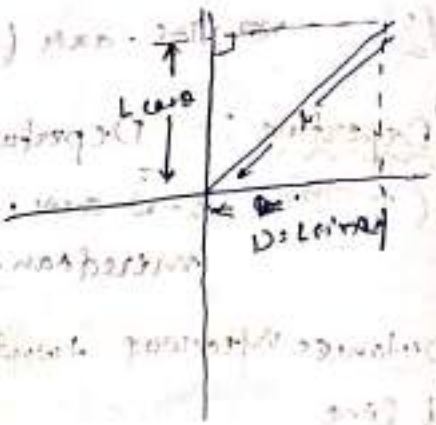
V. Imp

$\tan\theta = \frac{P}{B}$

$\tan\theta = \frac{L\sin\theta}{L\cos\theta}$

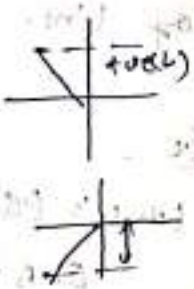
$\tan\theta = \frac{D}{L}$

$\theta = \tan^{-1}\left(\frac{D}{L}\right)$



Exam: find the direction of survey line = θ = ?

* Northing or Southing of line :- Latitude



Northing	Given →	Latitude +ve
Southing	Given →	Latitude −ve

* Easting or Westing of line :- Departure

Easting	→ departure →	+ve
Westing	→ " →	−ve.

Eg:- If Northing of line AB = 30 m.
Easting " " AB = 10 m.
Find Quadrant = 1st quadrant

Sol^n

$L\cos\theta = 30$

$L\sin\theta = 10\ m.$

$\tan\theta = \frac{1}{3}$

$\theta = \tan^{-1}\left(\frac{1}{3}\right)$

(2). Northing of line = 20m.
Easting of line = 10m.

Quardent = 1st quardent

$\theta = \tan^{-1}\left(\frac{10}{20}\right) = \tan^{-1}\left(\frac{1}{2}\right)$

$\theta = 27^\circ$

→ Calculate WCB = ?

WCB of line = $360 - 27 = 333^\circ$ Ans

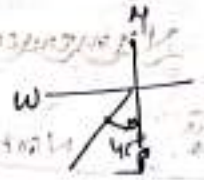
(3) Latitude = −30m.
departure = −20m. } quardent = 3rd

or calculate WCB of line

QB of line = $\tan^{-1}\left(\frac{30}{20}\right)$

$= \tan^{-1}(1.5)$

$= S\,45^\circ W.$



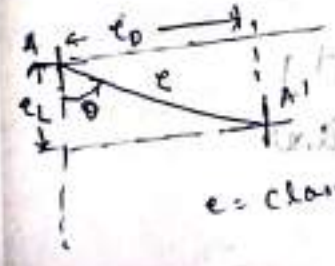
WCB of line = $45 + 180 =$

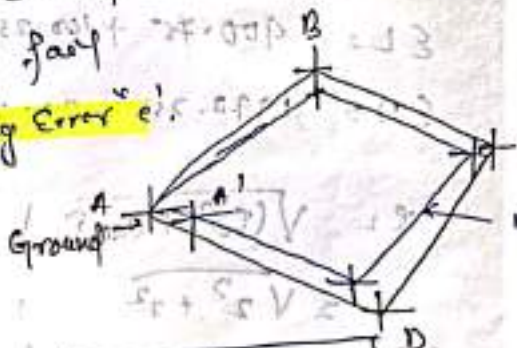
$= 225^\circ$ Ans

Note!-
→ +ve and −ve sign of latitude and departure represent quardent of the given line. (Angle does not affected by this sign).

ERROR OR CLOUSER/CLOSING ERROR:-

→ Distance by which traverse fail to clause. is known as Closing Error 'e'.





Angle-Error
distance Error

Closer Error (e) = $\sqrt{(e_L)^2 + (e_D)^2}$

e_L = error in Lattitude = Sum of all the latitude $\neq 0$

e_D = error in Departure. Sum of all the departure $\neq 0$.

$\Sigma L = L_1 \cos\theta_1 + L_2 \cos\theta_2 + L_3 \cos\theta_3 + \dots + L_n \cos\theta_n$

$\Sigma D = L_1 \sin\theta_1 + L_2 \sin\theta_2 + L_3 \sin\theta_3 + \dots + L_n \sin\theta_n$

for closed traverse

$\Sigma L = 0$ $\quad e = 0$

$\Sigma D = 0$

ΣL = Sum of all latitude

ΣD = Sum of departure

direction of closing error

$\tan\theta = \frac{e_D}{e_L}$

Example Numerical :-

chain line	Northing	Southing	Easting	Westing
AB	400.75	—	199.25	300.5
BC	100.25	—	299.75	
CD		199		200.5
DA		300	—	

Close traverse

Closer Error ?

direction of closer Error ?

Sol^n

$\Sigma L = 400.75 + 100.25 + (-199) + (-300) = 2 = e_L$

$\Sigma D = 199.25 + 299.75 + (-300.5) + (-200.5) = -2 = e_D$

$e = \sqrt{(e_L)^2 + (e_D)^2}$ $\quad \tan\theta = \frac{2}{2}$

$= \sqrt{2^2 + 2^2}$ $\quad \theta = \tan^{-1}(1)$

$= 2\sqrt{2}$ $\quad \theta = 45^\circ$ (N.E)

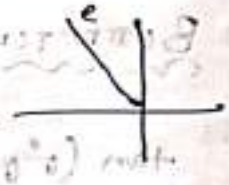
$\tan\theta = \frac{e_D}{e_L} = \frac{2}{2} = 1$

Error line lie in 4th Quadrant.

WCB = ?

$= 360° - 45°$

$= 315°$



Num 2

If the sum of northing traverse exceed the sum of southing by $\sqrt{3}$ m and sum of easting exceed the sum of westing traverse by 1m, the resultant closing error and its true bearing is respectively = ?

Sol^n Given

$e_L = \sqrt{3}$ m

$e_D = 1$ m

$e = \sqrt{(e_L)^2 + (e_D)^2} = \sqrt{(1)^2 + (\sqrt{3})^2} = \sqrt{1+3} = \sqrt{4} = 2$ m.

true bearing $= \tan\theta = \frac{e_D}{e_L}$

$\theta = \tan^{-1}\left(\frac{e_D}{e_L}\right) = \tan^{-1}\left(\frac{1}{\sqrt{3}}\right)$

$\angle N\ 30° E$

Ans $e = 2$m, $\theta = N\ 30° E$

BALANCING OF TRAVERSE :-

- If traverse is blanced by appling corration to latitude and departure. It is known as balancing of traverse or adjustment of traverse.

- Method to blance the traverse. (2 Method)

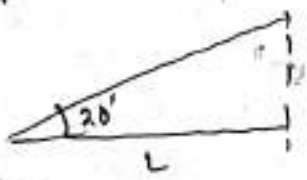
1. Bowditch Rule
2. Tranet Rule

METHOD TO BALANCE THE TRAVERSE :-

(1) BOWDITCH RULE :-

$\tan(0°0'20'') = 9.6962 \times 10^{-5}$

$\tan(20'') = \frac{1}{10313}$



Theodolite (20") :- → Distance → 10313 m distance → 1m error
Measure accuracy
Both instrument are measuring with same accuracy.

→ This Method is used when both linear and angular measurement are taken with same accuracy.

→ This Method is also known as Compass Rule

Assumptions :-

- Error in Linear Measurement $\propto \sqrt{L}$
- Error in Angular Measurement $\propto \frac{1}{\sqrt{L}}$

L = Length of Line.

→ In this Method error is distributed in the length of line.

Total Error in Latitude of line = total closing Error in Latitude × Length of line / Perimeter of

Correction in Latitude = − (total error in Latitude) × Length of line / Perimeter of line

Eg :-

AB, BC, CD .... l_1, l_2, l_3 ... $\theta_1, \theta_2, \theta_3$

AB Correction → $-\left[e_L \times \frac{l_1}{l_1+l_2+l_3}\right]$

$e_L = l_1 \cos\theta_1 + l_2 \cos\theta_2 + l_3 \cos\theta_3 \neq 0$

AB correction : $- e_L \times \frac{l}{\Sigma l}$

Total Error in departure of line = error in departure $\times$ $\frac{\text{Length of line}}{\text{Perimeter of traverse}}$

total correction in departure : $-$ error in departure $\times$ $\frac{\text{Length of line}}{\text{perimeter of traverse}}$

2. TRANSIT RULE :—

⇒ This method is preferred when angular measurement are more precise than linear measurement.

⇒ Error is distributed in latitude and departure.

Error in Latitude = total error in latitude $\times$ [$\frac{\text{Numerical value of Latitude}}{\text{sum of all latitude without correction of sign (Arithmatic sum)}}$]

Eg:- AB = $l_1 \cos\theta_1$, BC = $l_2 \cos\theta_2$ ... $\Sigma L \neq 0$, e_L (error)

AB Correction = $(-e_L) \times \left(\frac{30}{30+50+\ldots}\right)$

Correction in latitude = $-e_L \times \left(\frac{\text{Numerical value of latitude}}{\text{Arithmatic sum of all Latitude}}\right)$

Correction in departure : $-e_D \times \left(\frac{\text{Numerical value of Departure}}{\text{Arithmatic sum of all departure}}\right)$

Definations

* Relative Error of Closure :- $e_R = \frac{e}{P}$

e : closer error.

P = perimeter of traverse.

* Angular Error of closer :- [Measured Angle — Theoretical Angle]

↓ (Internal)

$(2N-4)90°$

↓ (Included)

State

* Angular error of closer it should not exceed $\rightarrow K\sqrt{N}$

K = least count of instrument

N = total no. of sides of traverse

Note :-

SCC JE (Adjustment of bearing) :-

Exam

Closed traverse → No. of side = N

e = error in bearing of last line (i.e. WCB)

Very imp

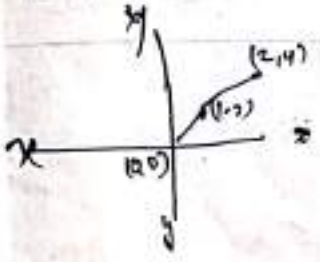
Correction in first line $= \frac{e}{N}$

" 2nd line $= \frac{2e}{N}$

" 3rd line $= \frac{3e}{N}$

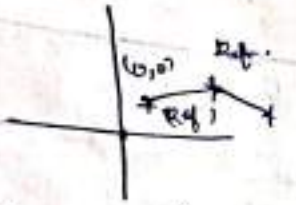
" n line $= \frac{ne}{N}$

* Independent co-ordinates



→ Measured w.r.t common origin.

* Consecutive co-ordinates :-

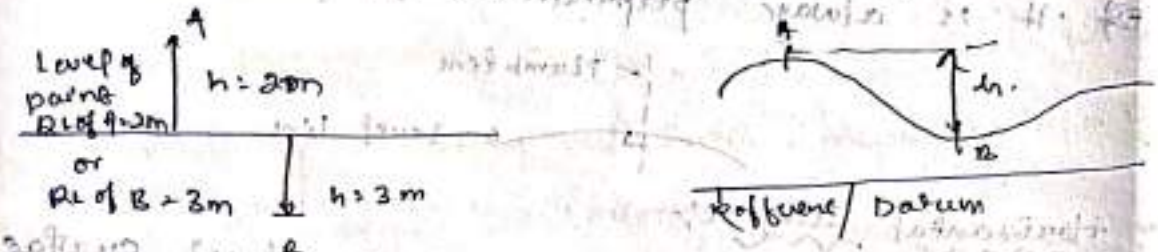


Measured from previous station

CH-6 :- LEVELLING :-

INTRO

The vertical height of a point above or below a datum are referred as level or reduce level and operation of determining difference of elevation of points w.r.t each other on earth surface is called Levelling.



Elevation :-

Vertical distance of a point above or below the datum surface.

* Altitude :-

~~Vertical distance of a point above or below~~

Vertical distance of a point measured w.r.t mean sea level as reference.

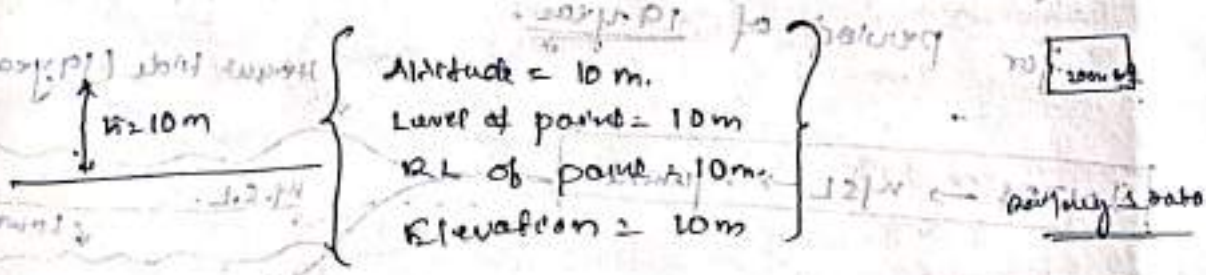
Note

Reference → mean sea Level (MSL) → Datum → Reduce Level (RL).

Altitude.

↓

Elevation.



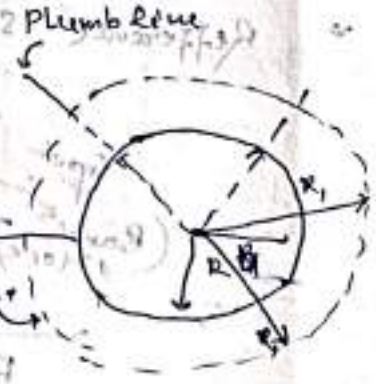
Level Surface :-

Shape of earth = ~~Geoid~~ Geoid.

Assume :- R = 6371 km

↓

Sherpe Sphere

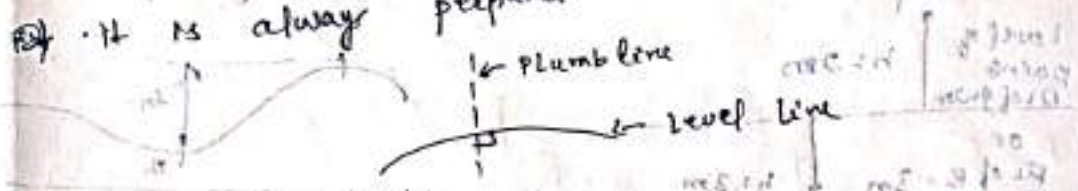


* Curved surface on which every point is equidistant from centre of earth.

* Level surface is curved surface

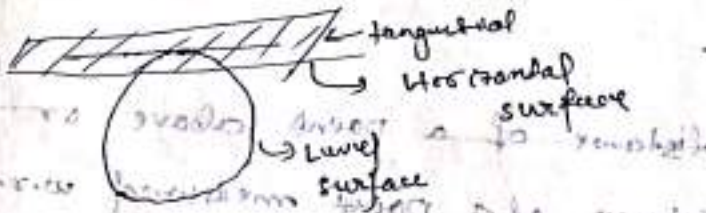
* Level Line :-

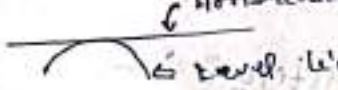
Any line Located on level surface is level line & It is alway perpendicular to plumb line.



* Horizontal surface :-

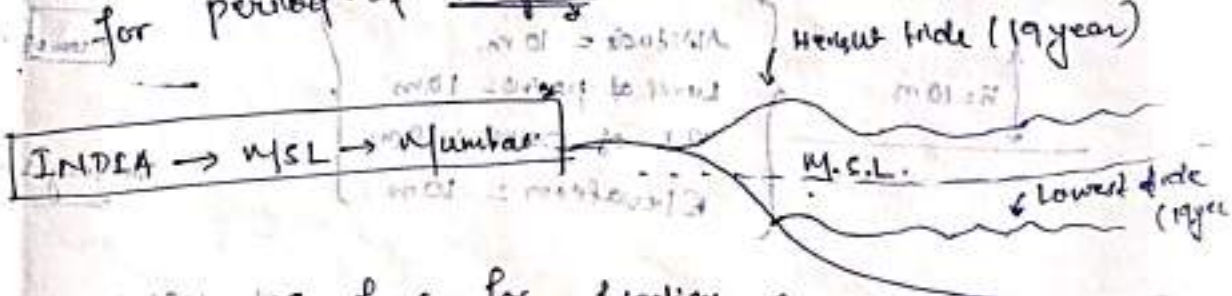
Any surface tangential to the level surface is known as Horizontal surface A any line drawn tengential to level line is horizontal line.



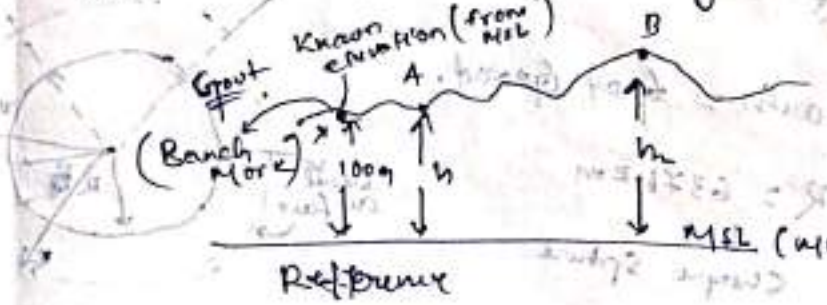


Mean Sea Level :-

It is obtained by averaging hourly of highest & lowest tides level at different point on sea for period of 19 year.



* Reference surface for finding RL of new point.



* Bench Mark :-

Are fixed reference points of known elevation & there are very important as they serve reference for finding RL of new points.

* Classification :-

(1) GTS Bench Mark :-

Great trigonometric survey B.M. are there which are established by "Survey of India" department with high accuracy throughout the country.

(2) Permanent Bench Mark :-

Established by, PWD department, Irrigation department etc, Located at close interval (for local survey).

Eg :- Railway station,

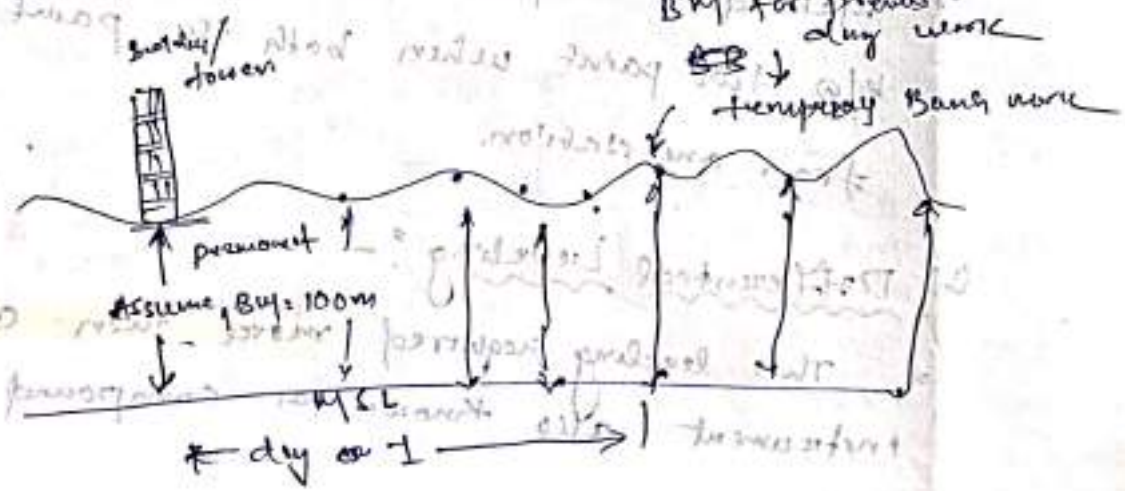
(3) Temporary Bench Mark :-

Are established temporarily required to continue execution of previous day work.

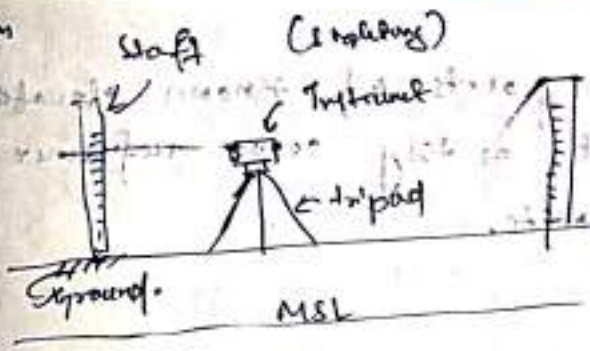
(4) Arbitrary :-

Are benchmark whose elevation is assumed.

Example



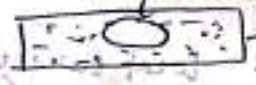
Levelling



Type Of Levelling :—

(1) Direct Levelling :-

→ Most common type of leveling also most precise Levelling.
(Bubble & center)



→ (spirit, alternate, ethional)

Bubble Tube

↓

(Top view)

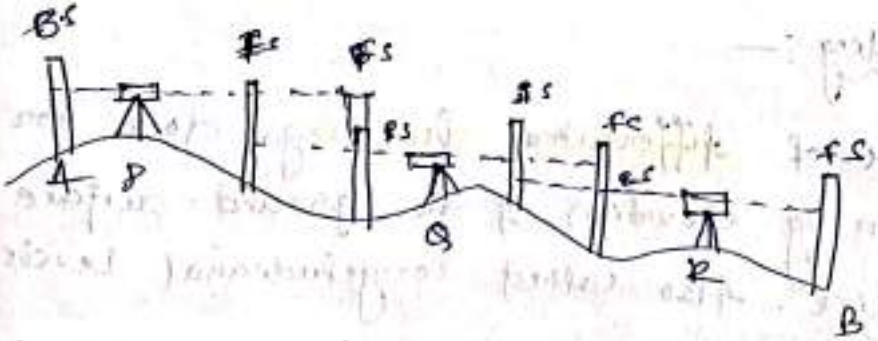
(a) Simple Leveling :—

← Only one setting of instrument is done

→ Method or used to determine the elevation of two point when both the point are visible from one station.

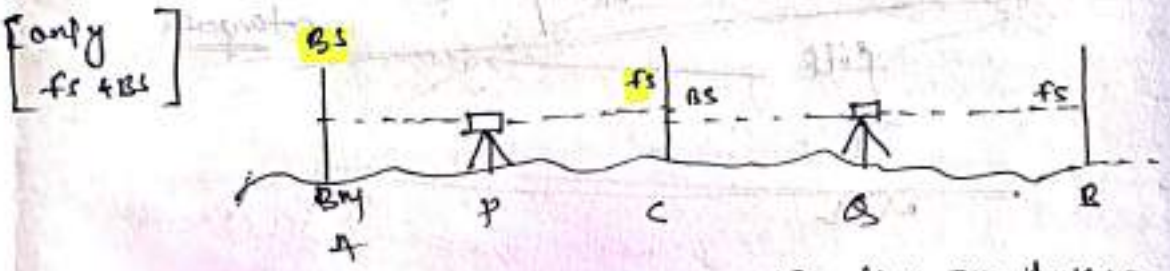
(b) Differential Leveling :—

→ This leveling required more than one setting of instrument also known as compound Leveling.



(C) fly Levelling :-

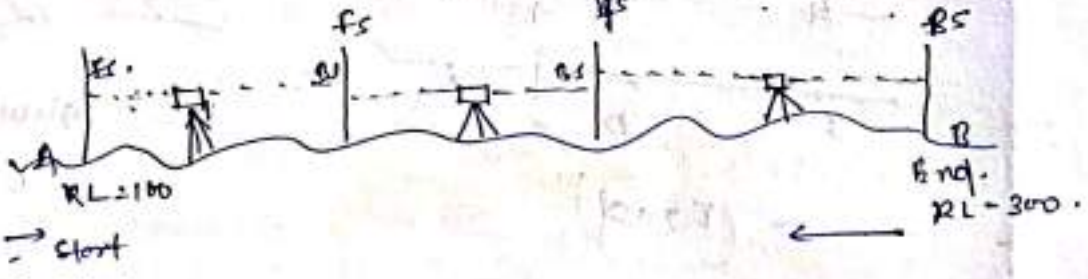
- The Type of differential levelling done for the purpose of determination of appox elevation of different point. generally done for Reconnaissance of area or for appox checking of level.



- Only fore sight and back sight Reading are taken no intermediate points located.

D. Check Levelling :-

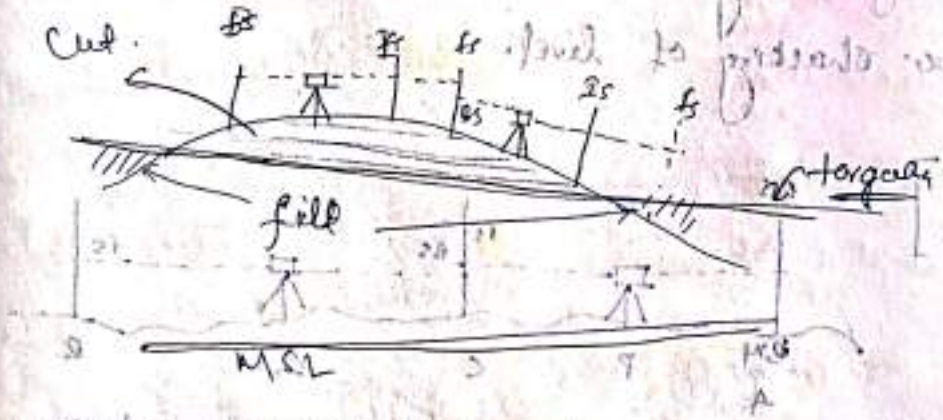
Generally check leveling is done at end of the day work from last station to staring station for checks checking of week. days work.



e. Profile Levelling :—

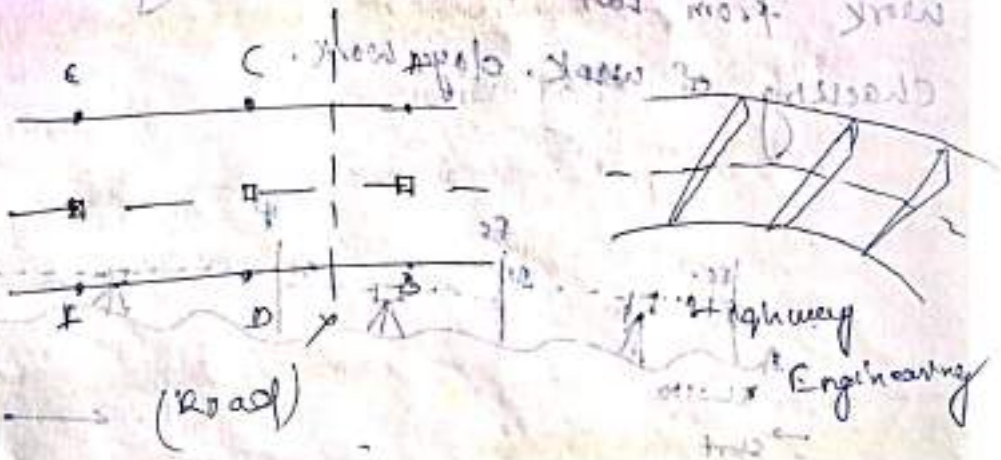
The type of differential levelling, done for purpose of determining elevation of the ground surface along a fixed line. Also called longitudinal Levelling.

It is very useful for project like construction design of sewer, pipelines, highway, roadway etc and to determine cut and fill.



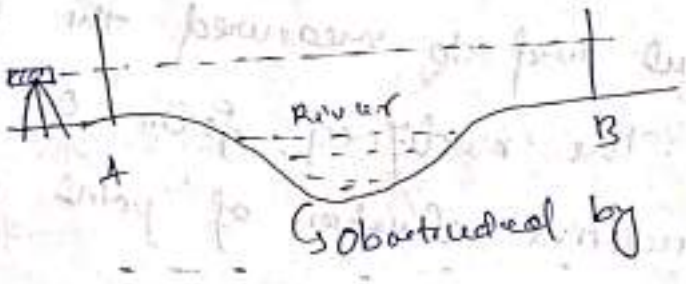
f. Cross-sectional Levelling :—

It is the operation of levelling to determine the elevation of the points at right angle on either sides of the centre line of proposed route.



6. Reciprocal Levelling :-

This method is used for determination of diffrent difference of elevation of two point which are are separated by quite apart and it is not possible. to set instrument midway b/w there point.



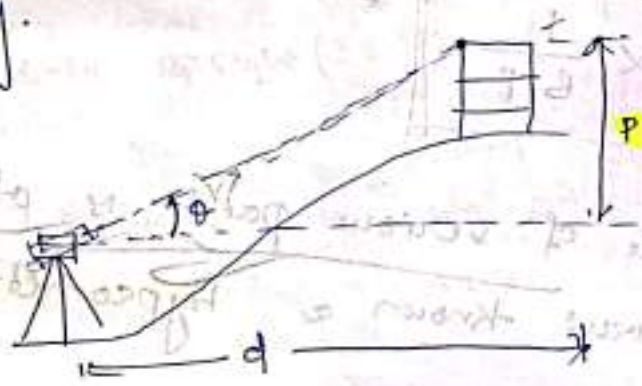
Obstructed by River / valley - etc.

2. INDIRECT LEVELLING :-

(a) Trigonometric Levelling :-

→ In this difference of elevation is determined indirectly from horizontal distance and vertical angle.

→ Trigonometric relation are used termed trigonometric levelling.



$$\tan\theta = \frac{P}{B}$$

$$P = B \tan\theta \quad \text{or} \quad P = d \tan\theta$$

B. Barometric Levelling :-

→ Elevation of various points are determined indirectly from the changes in atmospheric pressure.

$$\text{Atm. pressure} \propto \frac{1}{\text{elevation}}$$

→ Instrument used to measured the pressure is called barometer. The modified form of barometer used to find relative elevation of point on earth surface is "altimeter".

C. Hypsometric Barlevelling :-

→ In this difference of elevation is determined by noting temp at at which water boil. Stand ∅-boiling.

P→ Boiling temp

$$\text{elevation} \propto \frac{1}{\text{B.P}}$$

→ The altitude of various point is obtained by using instrument known as Hypsometer.

Note :-

DIRECT LEVELING :-

A. Single levelling
B. Differential levelling
C. fly levelling
D. Check levelling
E. Profile levelling
F. Cross sectional levelling
G. Reciprocal levelling.

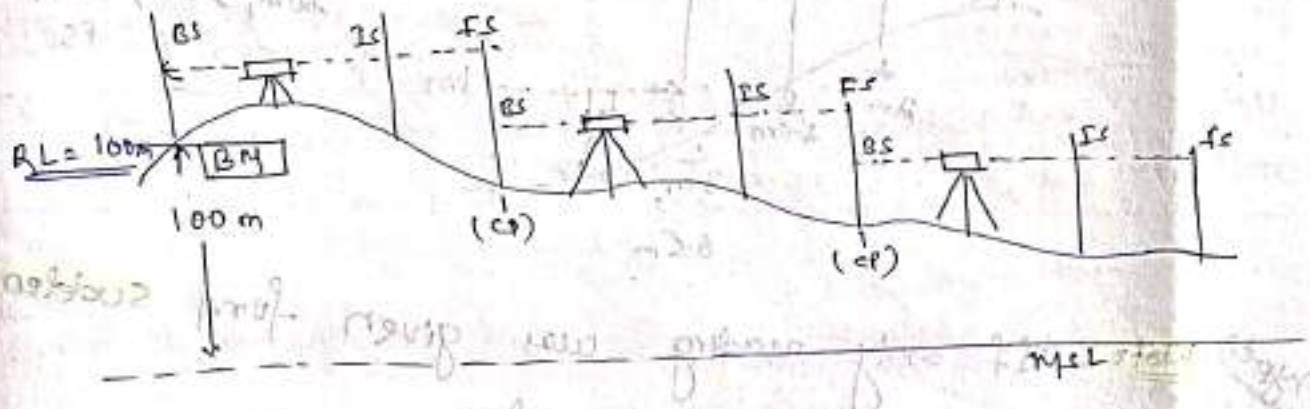
INDIRECT LEVELLING :-

A) Trigonometric Levelling

B) Barometric Levelling

C. Hypsometric Levelling.

PROCEDURE OF LEVELLING :-

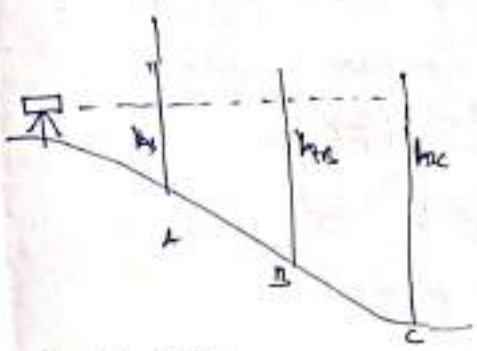


* Back Sight (BS) :- first reading on staff of a point where RL is known.

* Fore Sight (FS) :- Last reading on staff of point before changing the instrument station.

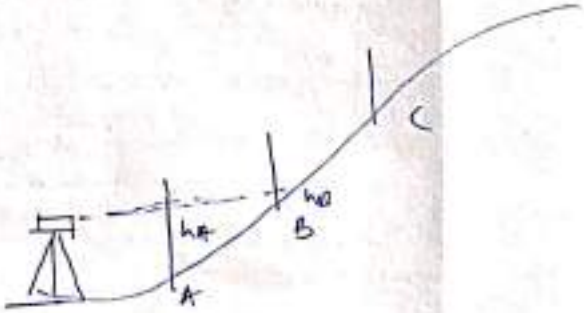
* Intermidiate Sight (IS) :- All reading in b/w fs and BS made with staff.

* Change point (CP) :- The point on which both the FS and BS reading taken during the operation of leveling.



$h_A < h_B < h_C$

Reading increase → Ground fall



$h_A > h_B$

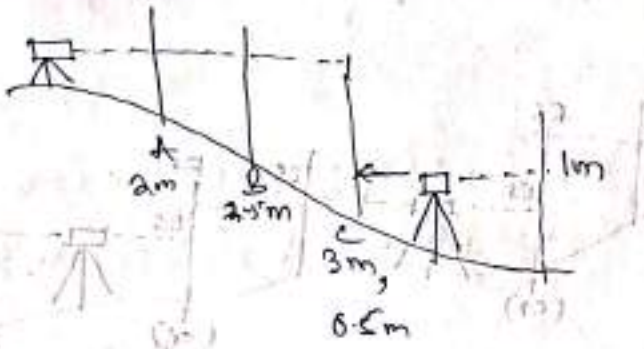
Reading decrease → Ground fall.

Conclusion

Consecutive reading will decrease if there is rise of ground and consecutive reading are increase when the fall of ground.

Example - change point

(1)



Eg

CP

2m, 2.5m, 3.1m, 0.5m, 1m

FS FS BS BS

Note: If only reading was given find sudden change in reading change point.

Example

1. Consider following Reading (Assume 4m)

CP

0.300m, 0.800m, 1.600m, 2.300m, 3.500m, 0.800m, 1.600m

BS IS IS FS BS FS

2. Consider following Reading (Assume 4m)

CP

0.300m, 0.800m, 1.600m, 2.300m, 3.500m, 0.800m, 1.600m

BS IS IS FS BS FS

• Instrument station :- ⊙ station where RL is to be determined/
↳ (Staff placed)

METHOD TO CALCULATE RL OF DIFFERENT POINT :-

(a) Rise and fall Method.

(b) Height of Instrument Method / Height of Collimation Method.

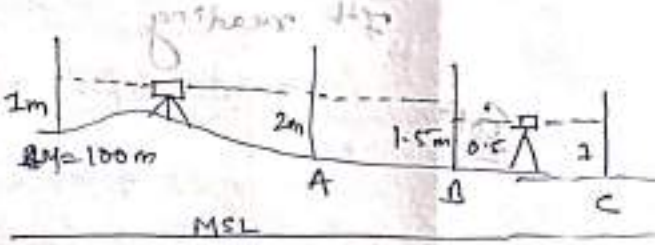
A. RISE AND FALL METHOD :-

Rise/fall = Previous Reading − Present reading

−ve = fall
+ve = Rise

Step-1

for station 'A'



Rise/fall = 1m − 2m
= −1m (fall)

for station B

Rise/fall = 2 − 1.5
= 0.5 m (Rise)

RL at any station = RL of Previous Station

RL at any station = RL at prev. station + (Rise/fall)

Step-2

RL at A = RL of BM ± (Rise/fall)
= 100 + (−1)
= 99 m (Ans)

RL at B = RL at A ± (Rise/fall)
= 99 + 0.5
= 99.5 (Ans)

For station C

Rise/fall = 0.5 − I

= 0.5 m. (fall)

RL at C = RL at B ± (Rise/Fall)

= 99.5 + (−0.5)

= 99.5 + −0.5

= 99 m.

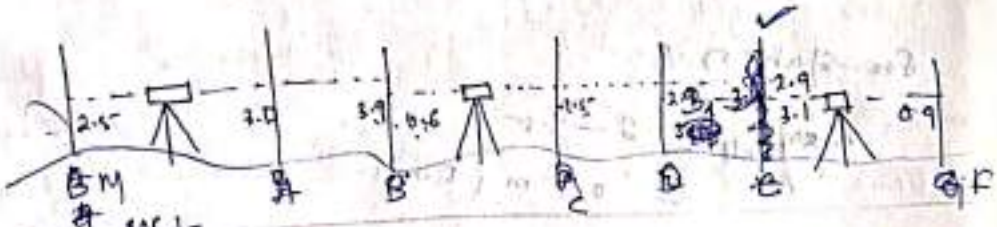
Numerical

Example problem

(1) 2.5, 3.0, 3.9, 0.6, 1.5, 2.3, 2.9, 3.10, 0.9

CP CP

RL at BM = 100 m. Instrument is sifted after 3rd and 7th reading



Station	BS	IS	FS	Rise	Fall	RL
(BM) A	2.5					100 m
B		3.0			0.5	99.5
C	0.6		3.9		0.9	98.6
D		1.5			0.9	97.7
E		2.3			0.8	96.9
F	3.1		2.9		0.6	96.3
			0.9	2.2		98.5
	ΣBS = 6.2 m		ΣFS = 7.7	ΣRise = 2.2	ΣFall = 3.7	

Note:-

for checking the calculation will be correct or not.

$$\text{Check} = |\Sigma BS - \Sigma FS| = |\Sigma Rise - \Sigma Fall| = |\text{Last RL} - \text{First RL}|$$

in previous question

Check:

$|\Sigma BS - \Sigma FS| = |6.2 - 7.7| = 1.5$

$|\Sigma Rise - \Sigma Fall| = |2.2 - 3.7| = 1.5$ } same

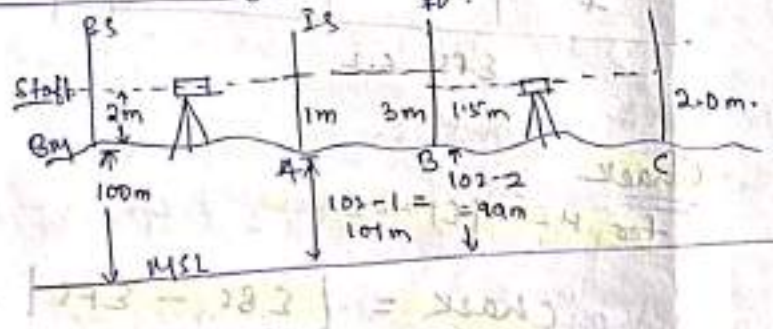
$|\text{Last RL} - \text{1st RL}| = |98.5 - 100| = 1.5$

no-error

B. HEIGHT OF INSTRUMENT METHOD:-

Height of instrument (HI) = RL of BM + BS

RL of any station = HI − Reading



Sol^n HI = 100 + 2 = 102 m.

RL of A = 102 − 1 = 101 m

RL of B = 102 − 3 = 99 m

HI of B: RL of B + B.S

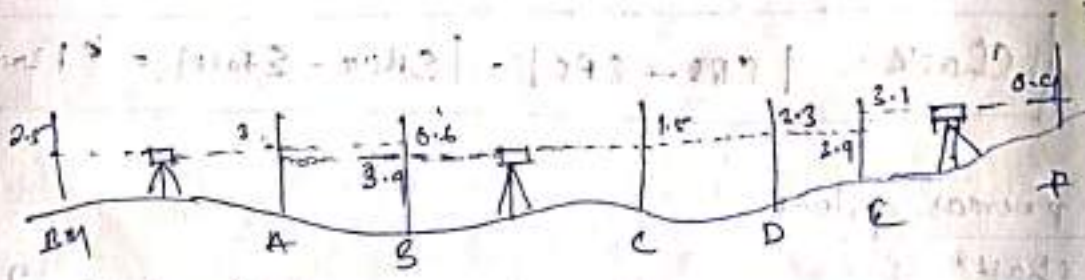
2 99 + 1.5 = 100.5 m.

RL of C = 100.5 − 2.0 = 98.5 m.

Numerical

Same as previous Numerical Solve In HI method.

Q



Sol^n By HI Method

RL = 100 m at BM

Station	BS	IS	FS	HI	RL
BM	2.5			102.5	100
A		3			99.5
B	0.6		3.9	99.2	98.6
C		1.5			97.71
D		2.3			96.9
E	3.1		2.9	99.9	96.3
F			0.9		98.5

ΣFS = 6.2

Check for HI METHOD

Check = |ΣBS − ΣFS| = |Last RL − first RL|

1.5 = 1.5

Hence

NOTE

→ Rise and Fall Method provide check on intermediate sight. (More accurate)

→ Height of instrument is more rapid.

→ Height of instrument Method when no-of observation are taken from a single point.

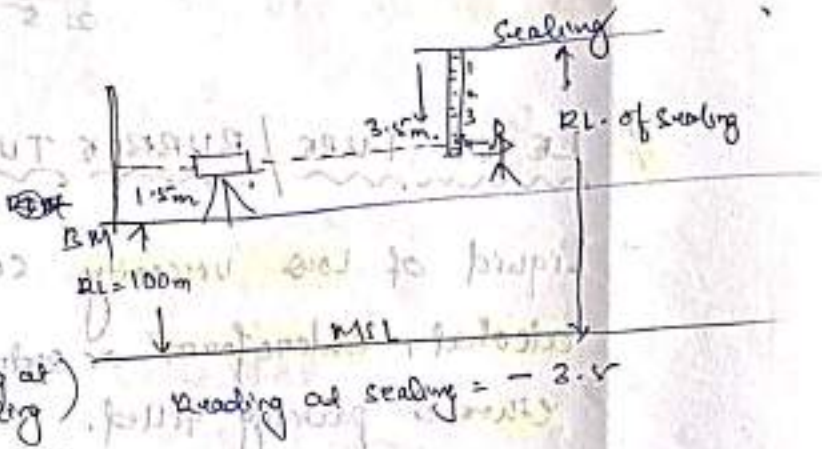
INVERTED STAFF READING :-

When point whose elevation is to be determined is above the line of collimation height of instrument. Eg:- underside of beam, arches, etc. In such case, staff is placed in inverted position with its base at concerned point.

Inverted staff reading is always negative (-ve).

Example

Calculate RL of sealing.



HI = RL of BM + BS

= 100 + 1.5

= 101.5 m.

RL of sealing = HI − (Reading at sealing)

Reading at sealing = −3.5

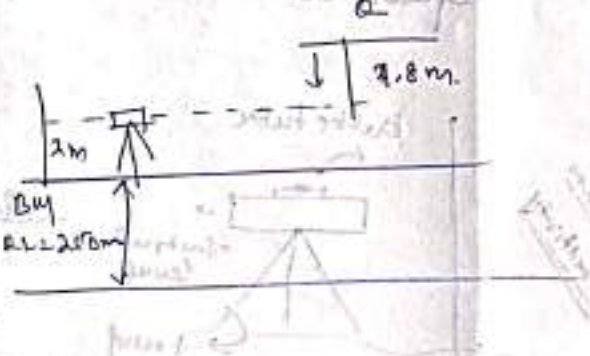
= 101.5 − (−3.5)

= 101.5 + 3.5 = 105 m.

Example Questions :-

from an instrument BS is taken as 2m at BM of RL = 250m. FS is taken inverted staff Q as 1.8m. Calculate RL at Q = ?

Soln



RL = 250m

HI = 250 + 2 = 252m

RL at Q = 252 − (−1.8)

= 252 + 1.8 = 253.8 m

Ans

) BS = 1.56 m, inverted staff FS at A = 2m, RL at BM is 150m. Calculate RL at A = ?

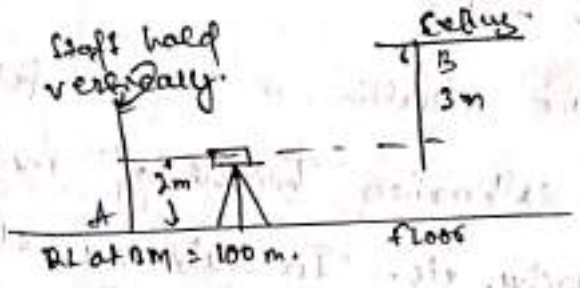
Soln

RL at A = (150 + 1.56) − (−2)

= 151.56 + 2

= 153.56 Ans

(2)



Calculate height of Room = ?

Soln = Height of Room = Reading at A + Reading at B.

2 ~~2+3~~ 2+3

2 5 m

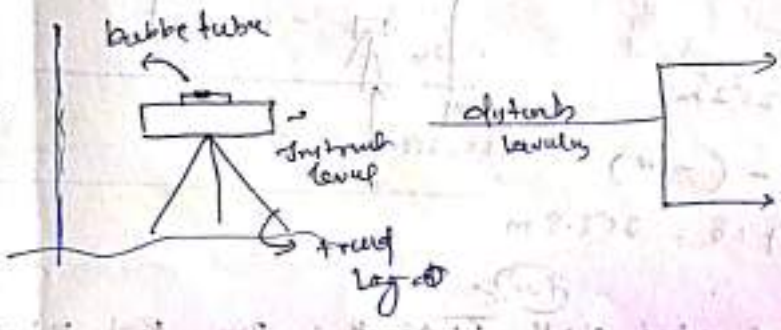
LEVEL TUBE / BUBBLE TUBE / SPIRIT LEVEL :-

→ Liquid of Low viscosity such as Spirit/ alcohol, Chloroform or ~~sulp~~ sulphuric ether is partially filled.

→ Bubble tube is filled with liquid which do not show much variation in temperature.

→ Graduation are spaced 2 mm equal distance.

Diagram Sensitivity

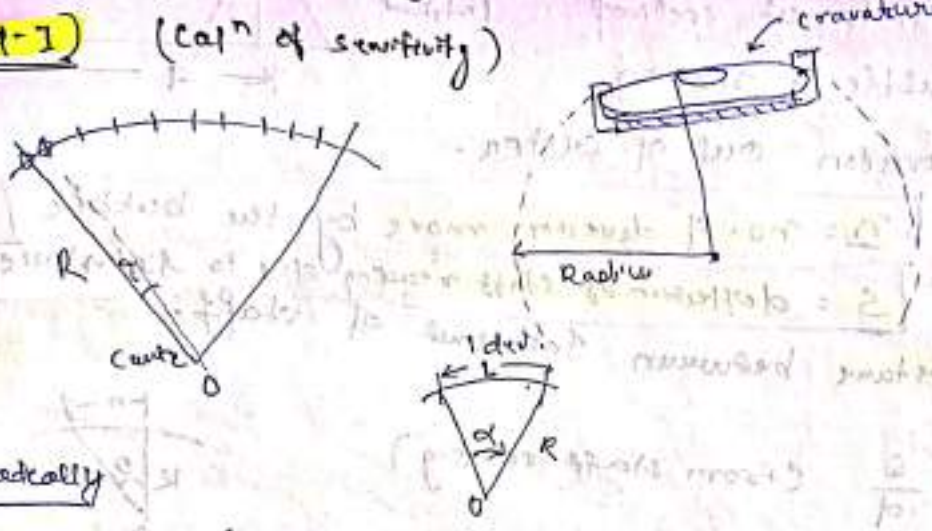


Sensitivity → Theoretically → Sensitive → Active

Sensitivity of level tube :-

⇒ It is defined as angle subtended at centre of the bubble tube by one division of tube in seconds.

(Method-I) (Cal^n of sensitivity)



Mathematically

angle = $\frac{\text{arc}}{\text{radius}}$

$$\alpha = \frac{L}{R} \text{ (Radian)}$$

α = angle

L = length of 1 division

R = Radius of curvature

Assume

L = 2 mm

$$\alpha = \frac{(2\times10^{-3})\,m}{R\,(m)} \times 206265$$

Formula (1) $\alpha = \frac{l}{R}$ (Radian) **

Radian → degree

$$\alpha = \frac{l}{R} \times \frac{180}{\pi}$$

Formula (4) $\alpha = \frac{412.53}{R}$ V. Imp

R in meter

L = 2 mm.

α = Sensitivity

Formula (2) $\alpha = \frac{l}{R} \times \frac{180}{\pi}$ (Degree) ***

$1^\circ = 60\text{ min}$, $1' = 60$ sec

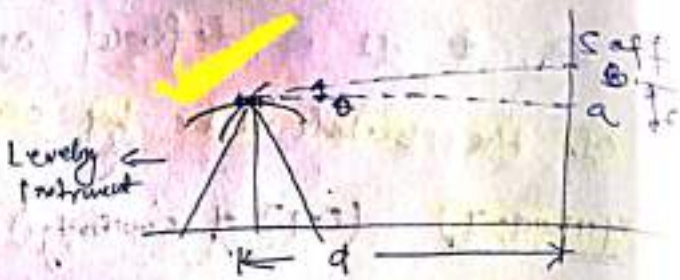
$1^\circ = 60 \times 60$ sec

$$\alpha = \frac{1}{R} \times \frac{180}{\pi} \times 60 \times 60 \text{ (second)}$$

Formula (3) $\alpha = \frac{l \times 206265}{R}$ second ** V. Imp

Method-2 (Col^n of Sensitivity)

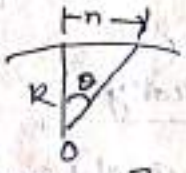
- When bubble is at center
  Reading of staff = a
- When instrument inclined and bubble is moved 'n' division out of center.



n = no. of division move by the bubble
S = deflection of staff reading due to disturbance

- **d = distance** between Instrument & staff.

$\theta = \frac{S}{d}$ (from staff reading)



θ = angle ⊕ → when angle is move "n" division
"n" division move ⟶ angle center = θ
1 division move ⟶ angle $\frac{\theta}{n}$

$\alpha = \frac{\theta}{n}$

$\alpha = \frac{S}{dn}$ radian.

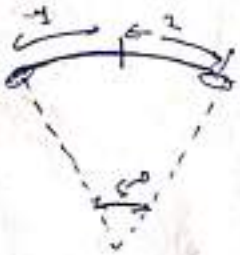
$\alpha' = \frac{S}{nd} \times 206265$ second

factor Affecting Sensitivity :-

(1) Radius of curvature (R) :-

$\alpha = \frac{1}{R}$

(more Sensitive)



(case-1)

2 division → r°
1 division = $\frac{r}{2}$ = 2°30'

(case-2)

1st division → r°
1 division → $\frac{r}{r} = 1^\circ$

angle ↓ → Sensitivity ↑

angle ↓ → Radius ↑

① Radius of curvature ∝ Sensitivity

② Diameter of Bubble ∝ Sensitivity

3. Viscosity of liquid :-

$$\text{Viscosity} \propto \frac{1}{\text{Sensitivity}}$$

④ Inner Surface of level tube smooth :-

Smoothness ∝ Sensitivity

⑤ Length of Bubble :-

Length of bubble ∝ Sensitivity

6. Temperature :-

$$\text{Temperature} \propto \frac{1}{\text{Sensitivity}}$$

⑦ $$\text{Surface tension} \propto \frac{1}{\text{Sensitivity}}$$

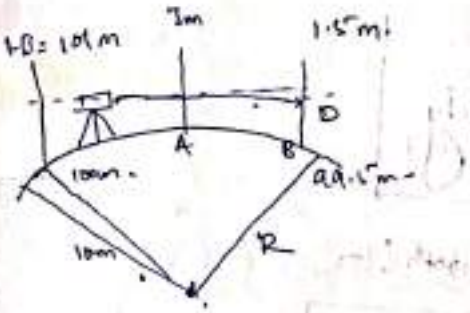
Note

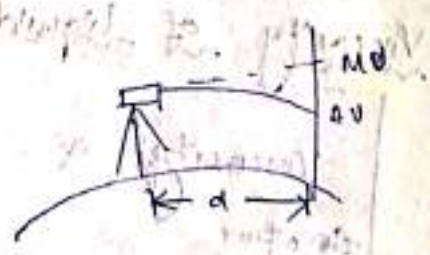
Direct Relation	Inverse Relation
Radius of curvature	Viscosity
Dia of Bubble	Temperature
Smoothness	Surface tension
Length of bubble	

CORRECTION :-

1) Curvature Correction
2) Refraction Correction
3) Combined Correction.

1. Curvature Correction :-





Measured value < Actual value

Correction = -ve

→ The effect is to be considered when sights are long because Difference b/w Level line and Horizontal Line increase as distance of staff station from instrument.

→ Horizontal line is tangential to level surface at a point.

$$\text{Curvature Correction} = \frac{-d^2}{2R}$$

d = distance between Instrument and staff (km)

R = Radius of earth. (6371 km)

Unit

$$C_c \text{ (km)} = \frac{d^2 (km^2)}{2 (km)} \rightarrow km$$

$$C_c = \frac{-d^2}{2 \times 6371} = -\frac{d^2}{12742} \text{ (km)} \quad (R = km)$$

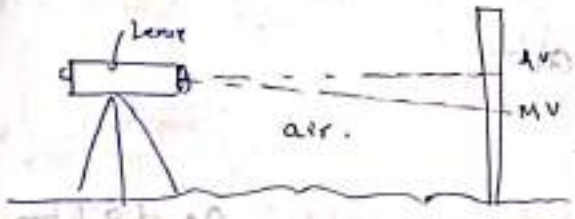
$$C_c = [-7.848\, d^2] \text{ (km)}$$

$$C_c = -0.0785\, d^2 \quad (m) \qquad [C_c = m,\ d = km]$$

Combine Curvature Correction in (meter)

$$C_c = \frac{-d^2}{2R} \quad (km)$$

2. Refraction Correction :—



MV < AV

Correction Due to Refraction C_R = positive

Refraction correction

$$C_R = \frac{1}{7} C_c$$

$$C_R = \frac{1}{7} \frac{d^2}{2R}$$

$$C_R = \frac{d^2}{14R}$$

d = km, R = km, C_R = km.

$$C_R = \frac{0.0785\, d^2}{7}$$

$$C_R = 0.0112\, d^2$$

d = km, C_R = meter.

3. Combine Correction :—

$$C = C_c + C_R$$

$$C = -0.785 d^2 + 0.0112 d^2$$

$$C = -0.0673 d^2$$

C = Combine correction (m)

d = distance b/w instrument and staff (km)

Eg :- BSF

$d = 1\,Km$, $C = ?$

Sol^n $\boxed{C = -0.0673\ m}$

② (JE) $d = 2\,Km$. $C = ?$

Sol^n $C = -0.0673 \times (2)^2$

$\boxed{C = -0.2692}$

② $d = 2\,Km$, Staff reading = 2.5 m, calculate Corrected Staff reading.

Sol^n Given $d = 2\,Km$.

Step 1 $C = -0.0673 \times (2)^2$

$= -0.2692$

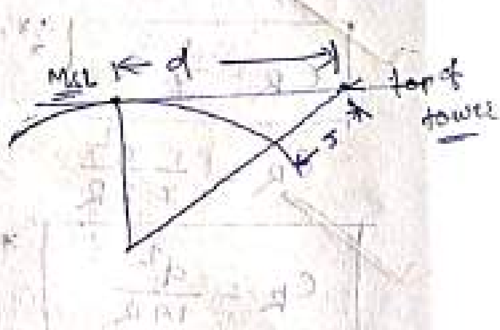
Step 2 Corrected staff reading = $2.5 - 0.2692$

$= 2.2308\ m$ (Ans)

Distance above Visible Horizon :-

Case - I

$C = 0.0673\, d^2$ (C in m, d in Km)



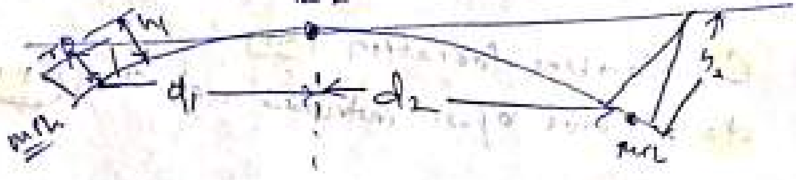
$h = 0.0673\, d^2$ (h in m, d in Km)

$d = \sqrt{\dfrac{h}{0.0673}}$

Be Careful! (Very Imp)

$\boxed{d = 3.85\sqrt{h}}$ (d in Km, h in m)

Case - II



$d = d_1 + d_2$

$= 3.85\sqrt{h_1} + 3.85\sqrt{h_2}$

$$d = 3.85\left(\sqrt{h_1} + \sqrt{h_2}\right)$$

(km) (m)

h_1: elevation of observer eye above MSL (m)

h_2: Elevation of the top of tower above MSL (m) / height of tower

Example - Questions :-

(1) An observer standing on deck of ship just see the top of a light house which is 100 m above the MSL. If height of observer eye is 8 m above the MSL determine / Calculate the distance between observer and light house.

Soln

$h_1 = 8$ m

$h_2 = 100$ m

$d = 3.85\left(\sqrt{h_1} + \sqrt{h_2}\right)$

$= 3.85\left(\sqrt{8} + \sqrt{100}\right)$

$= 3.85 \times (2.82 + 10)$

$= 49.38$ km

(2) Same q. as above. MSL of eye = 0 m.

Soln

$h_1 = 0$, $h_2 = 100$ m.

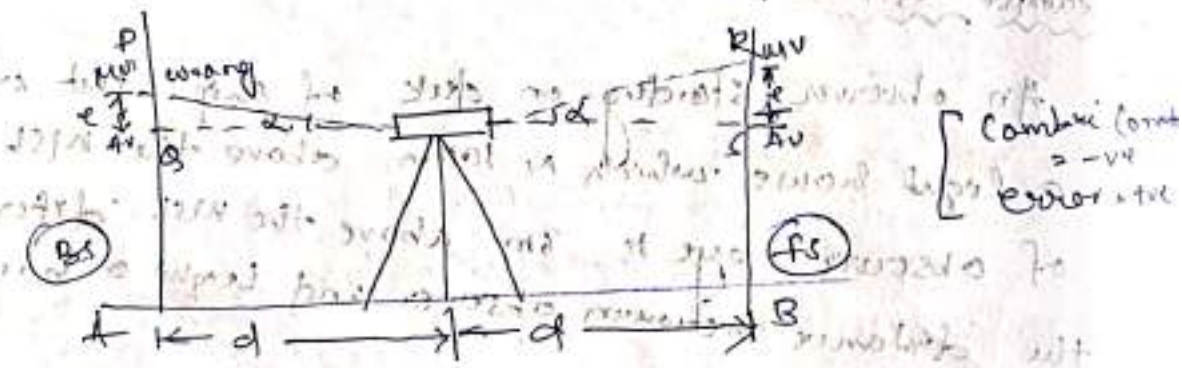
$d = 3.85\sqrt{h_2}$

$= 3.85\sqrt{100}$

$= 38.5$ km

Note!-

- In case of longer sight error due to curvature of earth and refection can be eliminated by keeping the instrument at equal distance from station B where BS and FS is taken.
- ✓ ds in the nature and magnitude of corrator :- same for both fs and BS, then both are eliminated



for BS

$$\tan\alpha = \frac{PQ}{d}$$

for fs

$$\tan\alpha = \frac{RS}{d}$$

- here, α = same
  d = same

Level difference = AP − BR

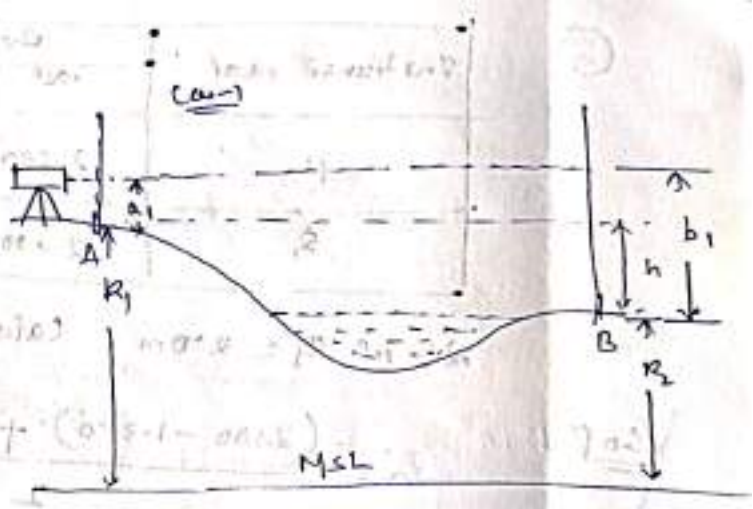
= (AP − e) + (BR − e)

= AP − e + BR + e

= AP − BR (not any effect of error)

RECIPROCAL LEVELLING :-

* Due to ⊗ obstruction intermediate sight can not be Located. Then Reciprocal levels adopted.

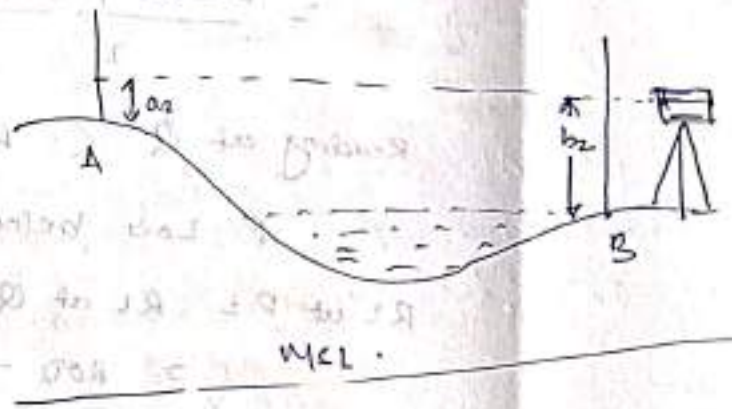


Case-1

$h = (b_1 - a_1)$

Case-2

$h = (b_2 - a_2)$



Instrument near	Reading at 'A'	Reading at 'B'
A	a_1	b_1
B	a_2	b_2

** Very Imp

RL difference b/w A & B = $\frac{(b_1 - a_1) + (b_2 - a_2)}{2}$ **

→ ~~If $b_1 > a_1$~~

→ If $b_1 > a_1$ → station B will be Below station A

$a_1 > b_1$ → station A will be below station B.

Example-Problems :-

① h = ?

RL of A = 100m.

find RL of B = ?

Reading at	station A	Station B
Instrument near A	1.5 m	2.0 m
Instrument near B	1.8 m	3.2 m

Soln

$$h = \frac{(2.0 - 1.5) + (3.2 - 1.8)}{2} = 0.95 \text{ m.}$$

* Reading at B > Reading at A, ⊗

RL of B = RL of A − h = 100 − 0.95

= 99.05 m. Ans

(2)

Instrument near	Reading at	
	P	Q
P	2.500 m	1.550 m.
Q	2.800 m	1.250 m.

RL of Q = 200m, Calculate RL of P = ?

Soln

$$h = \frac{(2.500 - 1.350) + (2.800 - 1.250)}{2}$$

$$= \frac{1.150 + 1.550}{2} = \frac{2.700}{2} = 1.350 \text{ m.}$$

Reading at Q < Reading at P

P Lies below Q

RL of P = RL of Q − h

= 200 − 1.350

= 198.650 m.

Note:-

→ Generally it is used to determine the difference in elevation of two points on opposite bank of river or deep valley.

→ Reciprocal leveling eliminate the need of applying correction due to "Curvature of earth" and "Refraction" and "collimation error".

→ Error due to parallax is not eliminated.

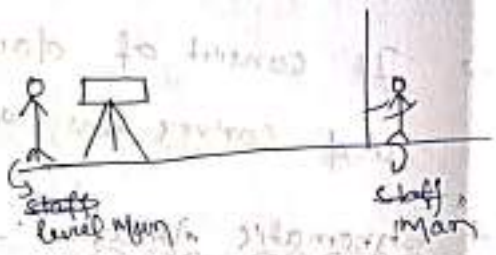
INSTRUMENT USED IN LEVELING

* LEVEL
* STAFF : Self Reading staff and Targate staff.

* STAFF :-

(A) Self reading staff :-

In self reading staff reading is taken by level man.



(i) Solid staff → general Length - 3m

(ii) folding staff :- usually Length - 4m.
width = 75 mm, thickness = 18 mm.

(iii) Telescopic staff :- Generally Length = 4m.

(B) Targate staff :-

It is provided with a lenger & clamping screw with Vernier attached to it.

In targate staff reading will taken by staff man.

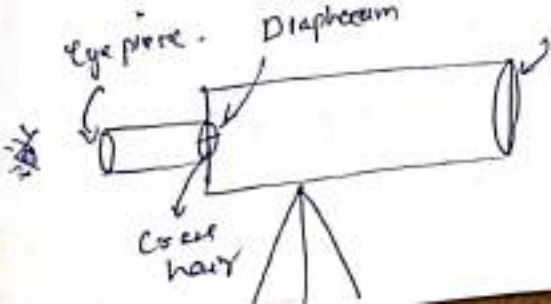
Note ~~Least count of staff~~

Note

Least count of staff = 5mm **

2 Ulternet black and white reading ~~are taken~~ are given.

SURVEYING TELESCOPE :-



(i) Objective Lense :-

→ It consist of ~~double~~ Compound lens with double convex lens and concava convex lense.

→ Two lens are in contact with each other so as to reduce "Chromatic abration" and "spherical aberation"

→ It consist of double convex lense with Crown glass and convex lens with flint glass → CANADA BALSAM.

* Chromatic Abration :- different colour formation.

* → Rim of light are split into 7 colour.

→ Absence of chromatic Abration is known as "Achromatism".

* Spherical Abreation :-

→ When outer part of lense do not bring all the ray to a common point (focal point). then the spherical abration (Blour Image)

→ Absence of spherical Abration → Aplanetism

(ii) Eyepiece :-

→ Eye piese consist of 2 plano convex lens placed at a distance of $\frac{2}{3}$ f (focal length). the eye piece also called "Ramsdom eyepiece".

(vii) Cross Diaphram :-

→ Cross hair are design to provide definite line of sight.
→ Cross hair are attach to metal ring
→ Horizontal hair are provided to read readings
→ Vertical hair check the staff vertically.

TEMPORARY ADJUSTMENT OF LEVEL :-

1. SETTING OF LEVEL :- fix, adjust height, adjust leg of level. → centering
2. Leveling Up :- Accurate level with foot screw
3. Elemination of PARALLAX :- If image from by objective is not in plane of hair it can be eleminated by focusing eyepiece & objective.

* (a) focusing Eyepiece :- Point the telescope towards the sky or plain white paper in front of objective & focus until cross hair is clear.

* (b) focusing of Objective :- Telescope is directed towards staff and focusing screw is turns till image appear clear.

Type of Telescope :-

* Internal focusing type :-
By rotation of focusing screw Length of telescope not change it will focuse internally.

* External focusing type :-
By rotation of focusing screw Length of telescope will change

LEVELLING INSTRUMENTS :-

① Dumpy Level :-

→ It can rotate horizontal plane only.

→ Simpler construction.

→ Presence compass attached.

→ Two level tube are attached.

→ It is advantageous when several adjustment are made from one setup of instrument.

② KIYE/Y Level :-

→ Telescope is support by Y-support.

→ Bubble tube is below telescope.

→ Telescope can be removed from Y shaped support by releasing clamp screw.

→ Comparely to dumpy level adjustment can rapidly tested.

③ Tilting Level :-

→ Telescope can be tilted by some degree.

→ Additional tilting screw attached.

→ Telescope can tilted through 4 degree with the help of tilting screw

→ Bubble can be centered easily.

→ Generally used for fly leveling (Reconnence survey).

Q. Automatic Level :—

→ Telescope is fixed to its support compensator attached inside telescope compensator can help instrument to level automatically.

→ Compensator is also called stabilizer.

→ Compensator means optical system to swing into exact position of LOS automatically

→ Auto level is self aligning level with certain range of tilt.

→ Circular Bubble tube

→ More precise

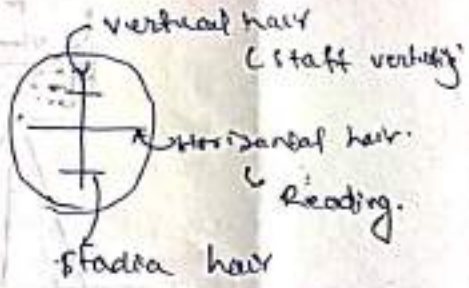
→ Mostly used nowadays.

→ Very less adjustment are required.

CH-7th

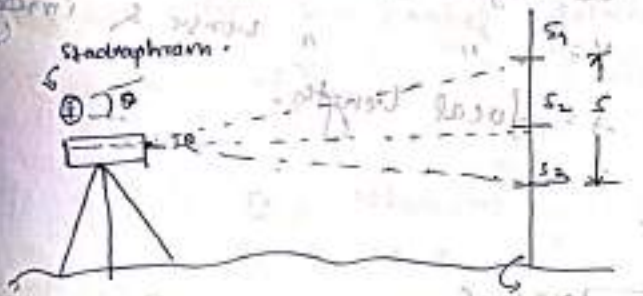
TACHEOMETRY

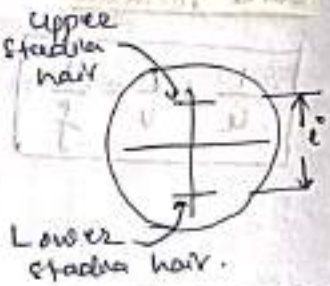
* Instrument → Tacheometer.
  - Horizontal distance
  - Angular Measurement



* Tacheometer → Transit Theodolite with Stadia hair.

* diaghram → Stadia diaphram.





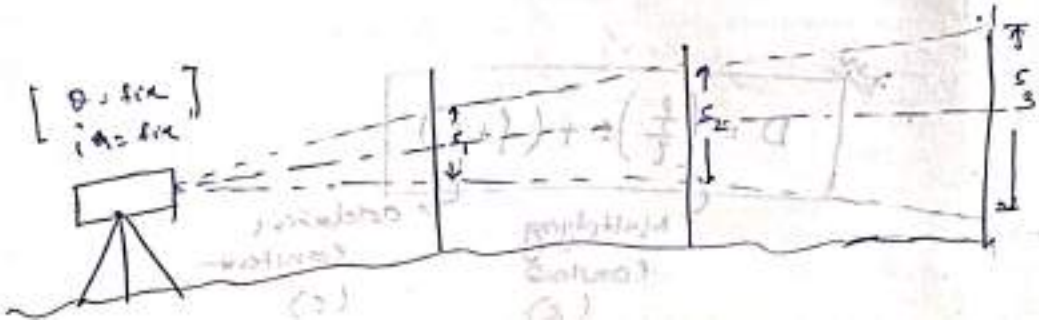
i : Stadia interval

$S_1 - S_3 = s$ => staff intercept

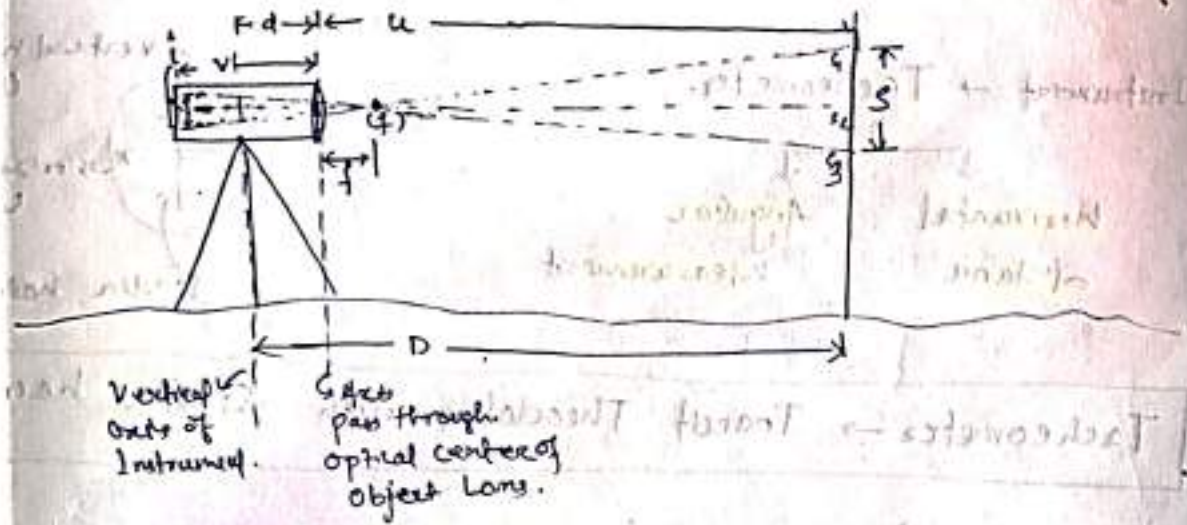
θ : Stadia angle

METHOD OF TECHEOMETRY :-

(1) FIXED HAIR METHOD / STADIA HAIR METHOD :-
- ↳ Stadia hair's fix.
- ↳ Stadia Interval fix
- ↳ Stadia angle fix.
- ↳ (S) staff intercept very.



EQUATION OF TACHEOMETRY



Lens formula

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

where

u = ~~object~~ distance b/w Lense & object.

v = " " Lense & image

f = focal length.

Tacheometric Equation :-

$$D = Ks + C$$ *** {Loc ⊥ staff} condition.

where D = Horizontal distance b/w instrument & staff

K = multiplying Constant.

$$K = \frac{f}{i}$$

f = focal length

i = stadia interval.

s = staff intercept $(s_1 - s_3)$

C = ⊕ additive Constant

$$C = f + q$$

f = focal length

q = distance b/w vertical axis of instrument and optical centre of objective.

$$D = \left(\frac{f}{i}\right)s + (f+q)$$

Multiplying Constant (K)

additive constant (C)

Anallactic Lens is provided in to tacheometer :-

↳ Convex Lense
↳ placed b/w eyepiece & objective.
↳ External focusing type telescope
↳ $K = 100$, $C = 0$
↳ $D = Ks + C^0$
↳ $D = 100s$ ***

Example - Problem:-

(1) following reading were observed with tacheometer on vertical staff (at A) when line of sight is horizontal 0.900, 1.200, 1.600m calculate the horizontal distance b/w instrument & staff. (Anallatic lense is used)

Sol^n

$D = Ks + C^0$
$= 100\,s$
$= 100\,(1.6 - 0.9)$
$= 100 \times 0.7$
$= 70m.$

(2) find the value of additive constant, focal length of objective glass = 35 cm and distance b/w instrument & object of objective

$= 25m.$

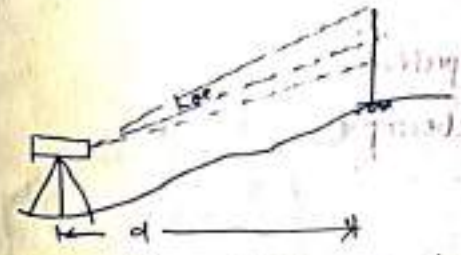
Ans

$f = 35cm.$
$d = 25m$

$C = f + d$
$= 35 + 25$
$= 60cm$

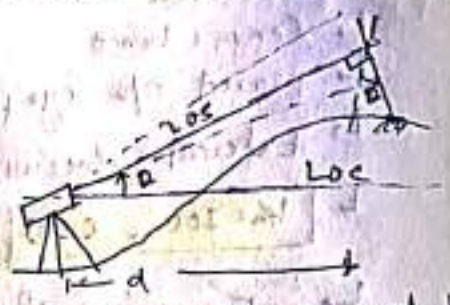
Ans

① Staff held vertical



- angle b/w LOS and staff is not 1^r or 90^D
- Line of sight is inclined

② Staff held normal



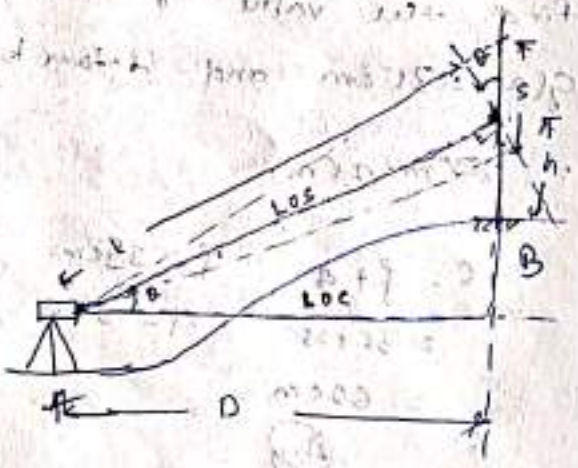
- Staff is held normal to LOS
- Angle b/w LOS and staff = 90°
- θ = angle of inclination

Distance and elevation formula for inclined Line of sight :-

1. Line of sight is inclined upward & staff held vertical.
2. Line of sight is inclined downward & staff held vertical.
3. Line of sight is inclined upward & staff held normal
4. Line of sight is inclined downward & staff held normal.

Case-1 : Line of sight is inclined upward and staff held vertical :-

θ = angle of inclination.



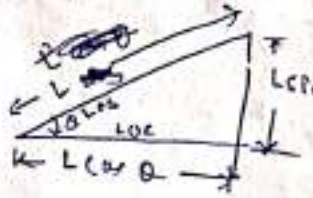
$$L = KS + C$$

$\{S' = S\cos\theta\}$ imp

$$L = KS\cos\theta + C$$

$$D = L\cos\theta$$

$$D = (KS\cos\theta + C)\cos\theta$$



D = horizontal distance b/w staff and instrument.

θ = Angle of inclination.

RL of B = HI + V(L cosθ) − h

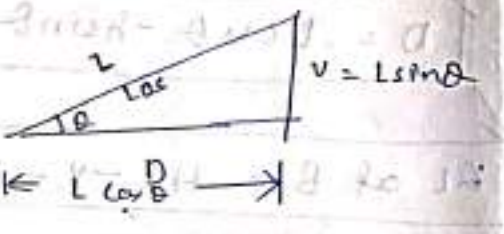
Summary

→ Angle → inclined → upward

→ Staff → vertically

$S' = S\cos\theta$

$\text{LOS}(L) = KS\cos\theta + C$



$D = L\cos\theta$

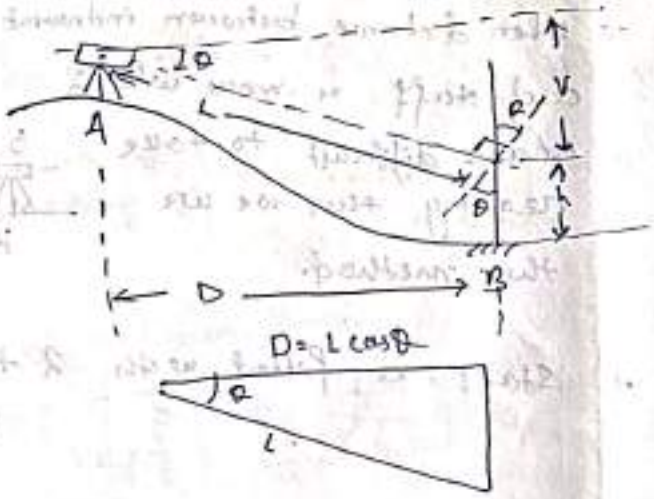
$D = (KS\cos\theta + C)\cdot\cos\theta$

$D = KS\cos^2\theta + C\cos\theta$

Case-2: Line of sight inclined downward and staff held vertically:-

θ = angle of depression.

$L = KS\cos\theta + C$



$D = L\cos\theta$

$D = (KS\cos\theta + C)\cos\theta$

RL of B = HI − V − h

Case-3: Line of sight inclined upward and staff held normal:-

θ = angle of inclination.

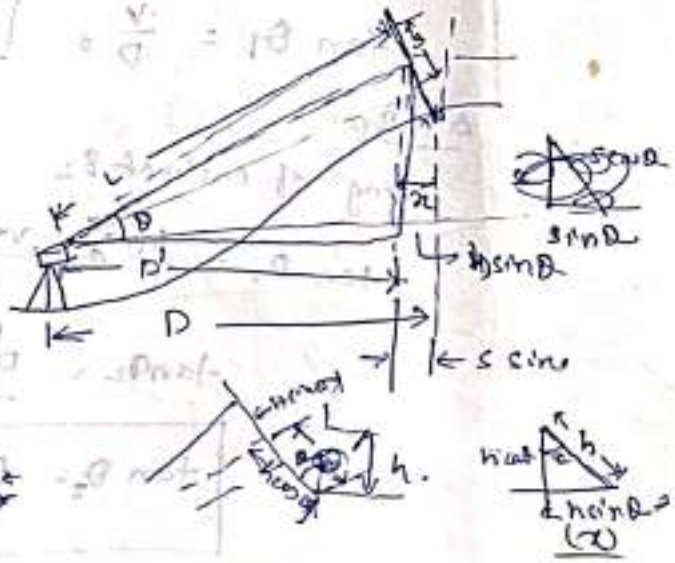
$L = KS + C$

S = staff intercept

$D = D' + x$

$D = L\cos\theta + h\sin\theta$

RL of B = HI + V − h cosθ



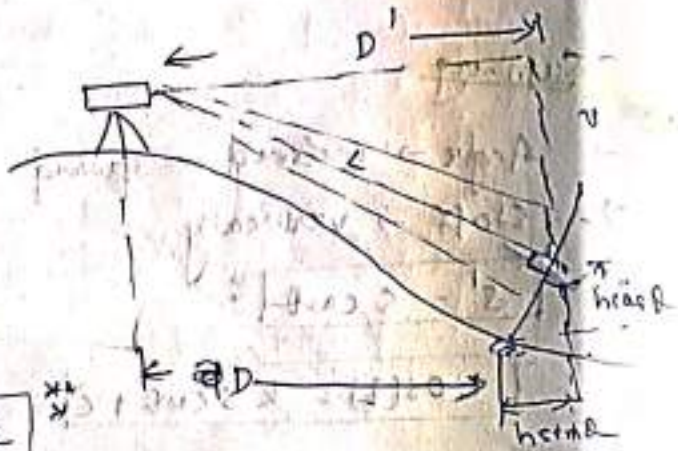
Case-4: When line of sight is inclined downward and staff held normal :-

θ = angle of depression

$L = Ks + C$

$D = L\cos\theta - h\sin\theta$

RL of B = HI − V − h cos θ

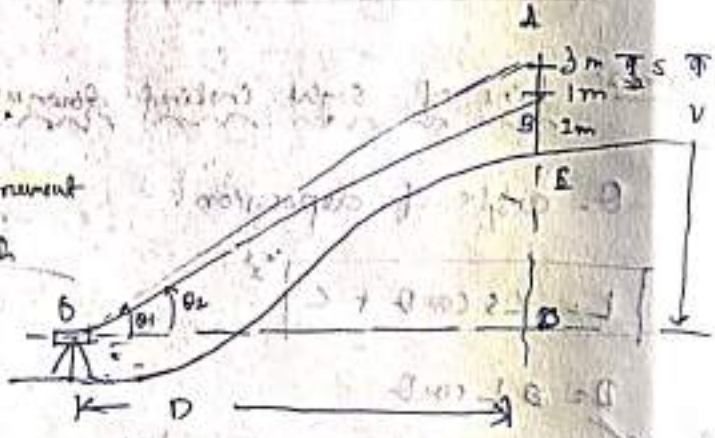


2. TANGENTIAL METHOD OF TACHEOMETRY :-

→ This method is used when diaphram is not provided.

→ When distance between instrument and staff is more which make difficult to take reading then we use this method.

→ Staff is fitted with 2 targets



Δ BAD

Angle of inclination θ_1

$\tan\theta_1 = \frac{V}{D}$ ⇒ $V = D\tan\theta_1$

Δ DBD

Ang of inclination θ_2

$\tan\theta_2 = \frac{V+S}{D} = \frac{V}{D} + \frac{S}{D}$

$\tan\theta_2 = \frac{D\tan\theta_1 - S}{D}$

$\tan\theta_2 = \frac{D\tan\theta_1}{D} - \frac{S}{D}$

$\tan\theta_2 = \tan\theta_1 - \frac{S}{D}$

$\frac{S}{D} = \tan\theta_1 - \tan\theta_2$

$D = \frac{S}{\tan\theta_1 - \tan\theta_2}$

$\tan\theta_2 = \frac{D\tan\theta_1 - S}{D}$

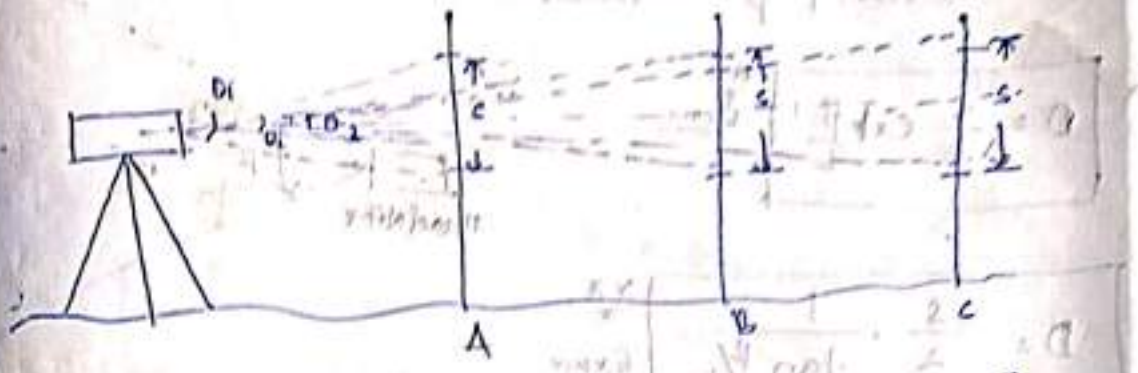
$D\tan\theta_2 = D\tan\theta_1 - S$

$D\tan\theta_1 - D\tan\theta_2 = S$

$D(\tan\theta_1 - \tan\theta_2) = S$

3. MOVABLE HAIR METHOD / SUBSTANCE BAR METHOD :-

[Micrometer screws → Vary Change station interval.]



[i = not fixed → variable
θ, α → stadia angle → not constant
s = staff intercept is constant]

- Movable hair method also termed as substance bar method".
- If substance bar is held vertical → Vertical substance bar method.
- If substance bar is horizontal → Horizontal substance bar method.

* Distance between staff and instrument..

$$D = Ks + C$$

$$K = \frac{f}{i}, \quad C = f + q$$

* Stadia Interval change → Micrometer Screw.

$$D = Ks + C$$

$$i = m \cdot p$$

$$K = \frac{f}{m \cdot p}$$

$$D = \left(\frac{f}{m \cdot p}\right) \cdot s + C$$

$$K' = \frac{f}{p}$$

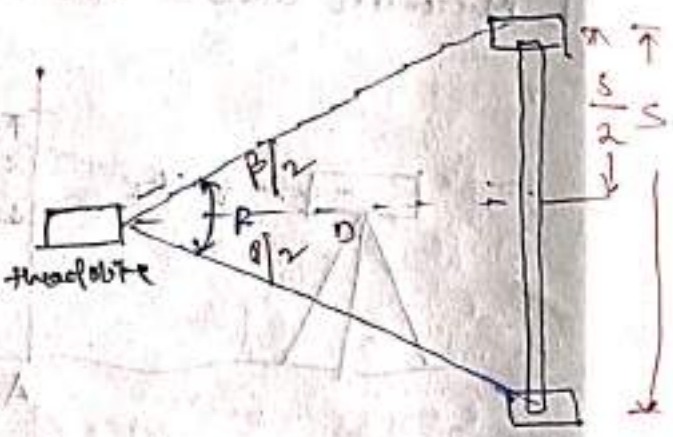
$$D = \left(\frac{K'}{m}\right) s + C$$

m = no. of revolution

p = Pitch.

HORIZANTAL SUSPEND BAR METHOD :-

S → Known, β = Calculate



$$D = \frac{S}{2} \cot\frac{\beta}{2}$$ ** Exam

$$D = \frac{S}{2} \cdot \frac{1}{\tan \beta/2}$$ ** Exam

Here, β is very small $\tan\frac{\beta}{2} \cong \frac{\beta}{2}$

$$D = \frac{S}{\beta} \times \frac{1}{\beta/\rho}$$

$$D = \frac{S}{\beta}$$ (m, Radian) $\Rightarrow$ $$\beta = \frac{S}{D}$$ ** Exam (Radian)

Radian → Second

$$\beta = \frac{S}{D} \cdot \rho\left(\frac{180}{\pi} \times 60 \times 60\right)$$

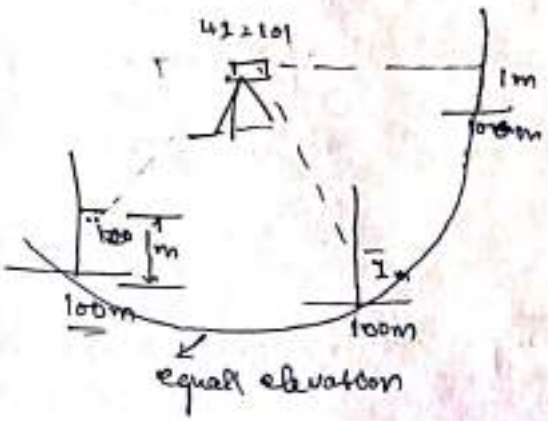
$$\beta = \frac{S}{D} \cdot 206265$$ (Sec)

$$D = \left[\frac{S}{\beta} \times 206265\right]$$ (m, Sec) ** Exam

CH8 : CONTOUR AND CURVES :

CONTOUR :-

Intro



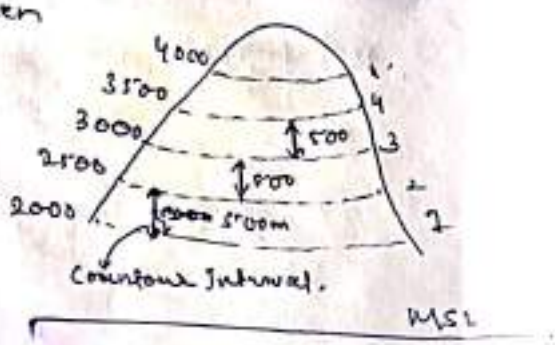
→ Countour are the Imaganary line passing through the point of equall elevation on earth surface.

→ When the counter are drawn under water, they are termed as Submarine countour or fathoms Curves or Bathymatic curve.

Contour Interval :-

→ It is the vertical distance between 2 consicative Contour.

→ Contour interval is always constant.



* Contour Interval depends upon following factor :-

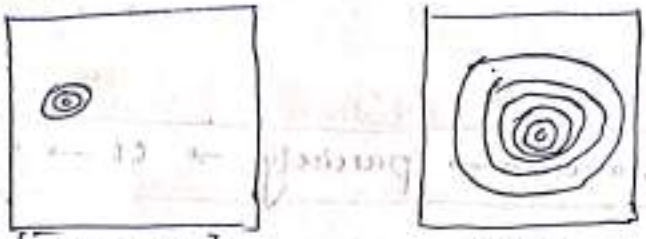
1. Scale of map :-

$$\text{Contour Interval} \propto \frac{1}{\text{scale of map}}$$

$\frac{1}{11}$ → Largescale → detailed → CI → Small

$\frac{1}{1000}$ → Small scale → CI → Large

Eg



[Index Map]
↳ Scale ∝ small
CI → Large

Plan
↳ Scale ∝ Large
↳ CI → Small

→ If scale is kept small contour interval is selected large to avoid overcrowding of contours.

Note table:-

Ground Surface	large Scale 1cm = 10 m	Intermediate Scale ex: 1cm = 10-100 m	Small scale 1cm = 100 m
FLAT	0.2-0.5 m	0.5 - 0.10 m	1-3 m.

For Topographical Maps:-
↳ Natural & Manmade feature

$$\text{Contour Interval} = \frac{25}{\text{no. of cm per km.}} \quad \text{(m)}$$

xxx Exam

Example

topographical Map scale = 1 : 50000

Contour Interval = ?

Ans

1cm = 50,000 cm.

1cm = $50,000 \times 10^{-5}$ km = 10^{-2}

1cm = 0.5 km.

1 km = 2cm

CI = $\frac{25}{\text{no. cm per km}}$

= $\frac{25}{2}$ = 12.5 m.

2. Purpose of Map :-

→ Contour interval is kept large upto 2 meter for projects like highway, Railway.

→ It is kept small as 0.5m for buildings site, dams etc.

Important construction → precisely → CI → small

3. Nature of the Country :-

→ Contour interval varies with topography of the area. It is large for steep ground and small for flat ground.

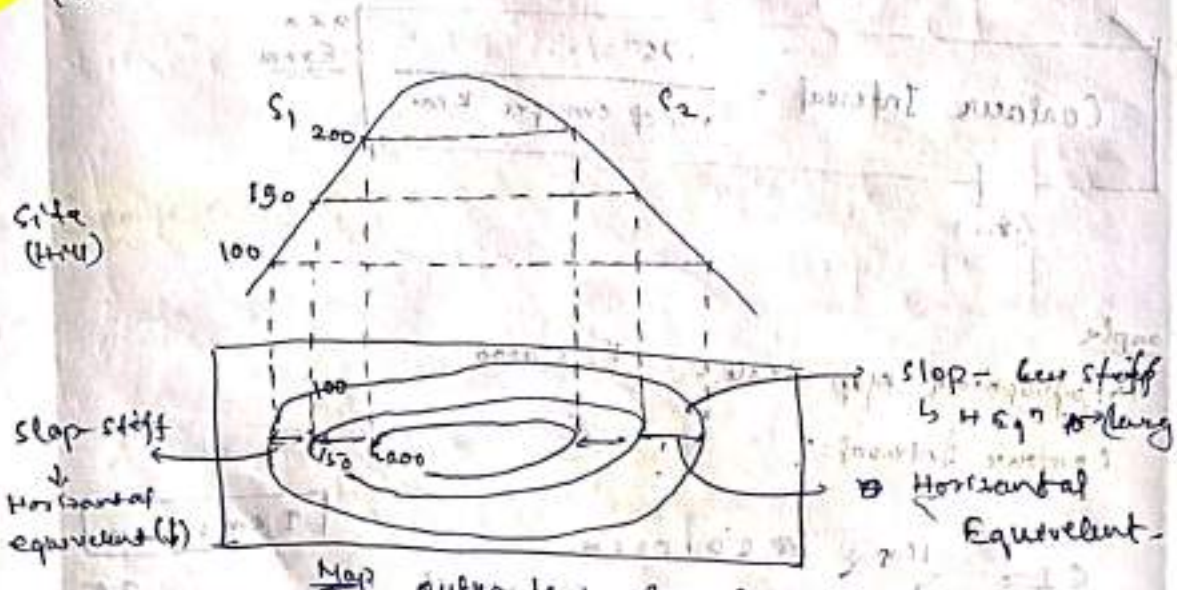
4. Time and Resources :-

→ Contour interval is kept large when time is less.

5. Fund :-

→ Contour interval kept large when fund are less.

HORIZONTAL EQUIVALENT :-



Outer to inside → RL ↑ → Hill

→ Horizontal distance b/w consecutive contours, is termed as horizontal equivalent.

→ It vary from point to point.

→ Steeper the ground → Lesser is the horizontal equivalent.

Horizontal Equivalent = $\frac{\text{Contour Interval}}{\text{gradient b/w pairs of interest.}}$

Mathematically

$H.E = \frac{CI}{Slope}$

Gradient → slope → 1 in n (V) (H)

1 in n → Vertical, Horizontal

Example:-

CI = 1m, Slope = $\frac{1}{20}$. Eq H.E = ?

Sol:-

$H.E = \frac{CI}{Slope} = \frac{1}{1/30} = 30\ m$ Ans

Contour Gradient:-

→ If line lying on ground surface throughout and maintaining a constant inclination to horizontal is termed as Contour Gradient.

→ GHAT TRACER → used for locating points on given contour gradient.

↳ Chain slope

↳ contour Gradient.

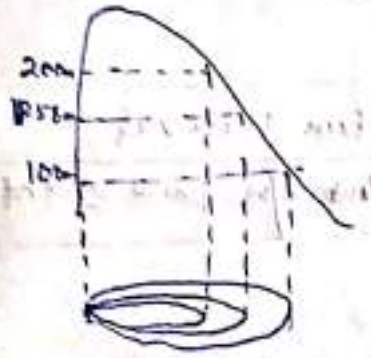
↳ slope same.

Grade Contour:-

→ The line having the equal gradient along a slope are called as grade contours.

PROPERTIES OF CONTOUR :—

* Two contour line do not intersect each other except in case of overhanging cliff.



[vertical cliff]

[Overhanging cliff]

* In case of vertical cliff [generally found near sea] contour line co-incide with each other.

* A set of close contour, having higher elevation inside lower elevation outside represent hillock/hill.

* A set of contour having lower elevation inside higher outside represent depression river, lake, valley etc.

* The direction of steepest slope is along shortest distance between the contours.

Generally a gradient 20° - gentle slope Higher gradient of 20° to 45° - steep slope

Note

A very steep slope is termed as "scrap" & Higher steep scrap is termed as "crag".

High & Lying forms :-

* Hill :- Usually with pointed peak.
* Hillocks :- Elevated land with low height & gentle slopes.
* Plateau :- Relatively even surface at top which is higher than surrounding land.

Note

Board Contour line Higher value Inside - Lower value outside

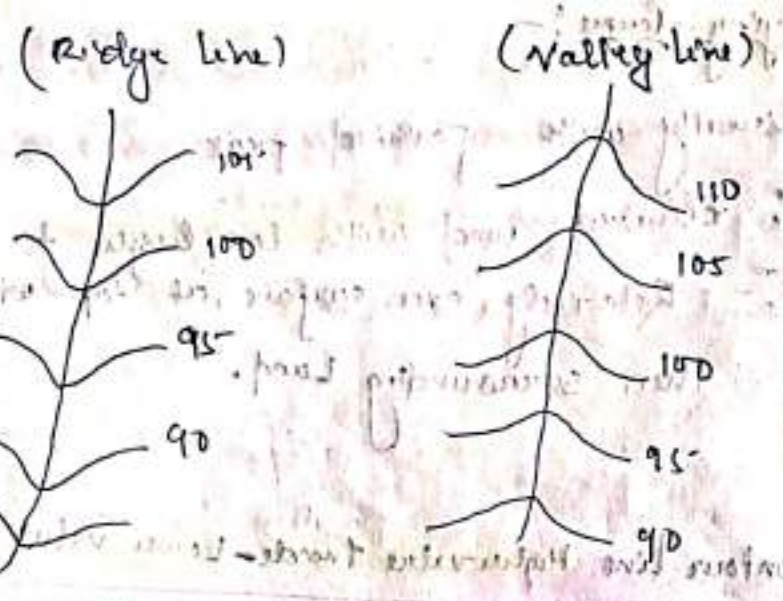
Scrap, Carg, Hill, Hillocks, Plateau

Lower Lying forms :-

* In core ground is low than surrounding land and slope is inside are gentle it is referred as depression.
* Most common are : River (Ravine), Valley etc
* Ravine is trough like depression on earth surface elongated in one direction with bottom inclined towards one side.
* When the valley floor is narrow and has steep sides on a level to terrain it is termed as gorge. "Gorge". & in mountain as "Cayons".

RIDGE LINE & VALLEY LINE :-

A water shed (or) Ridge line (line joining the height point of series of hills) and the thalweg (or) valley line (line joining the lowest point of valley) cross the contour at right angle or 90°.



SADDLE :-

→ The lowest point on the water shade are known as passes

→ A pass is narrow land passing through high mountains on either side.

→ When depression is broad and low it is known as saddle.

SPUR :-

→ A spur is formed between two river valley. Contour are similar to that at valley

Escrapment :-

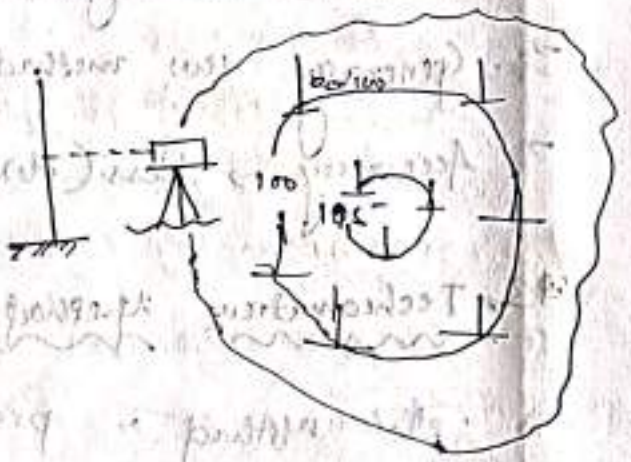
A high land having flat narrow top with steep slope on one side and gentle slope on other side is known as "escrapment".

Close contour → represent steep slope
Contour far apart → Gentle slope

METHOD OF CONTOURING :—

A) DIRECT METHOD :—

→ In this method Contour are actually traced out on ground.

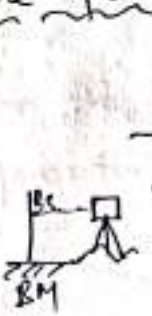


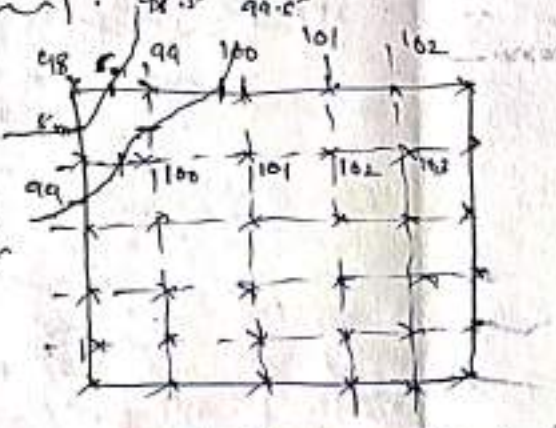
(i) Area → Small
(ii) Accuracy → Most accurate
(iii) Time → More Accurate
(iv) Scale → Large (area Small)
(v) Contour → Small
(vi) Cost → More.

B. INDIRECT METHOD :—

1) Method of Square / Square Method :—

→ Square size → [5 m to 20 m]



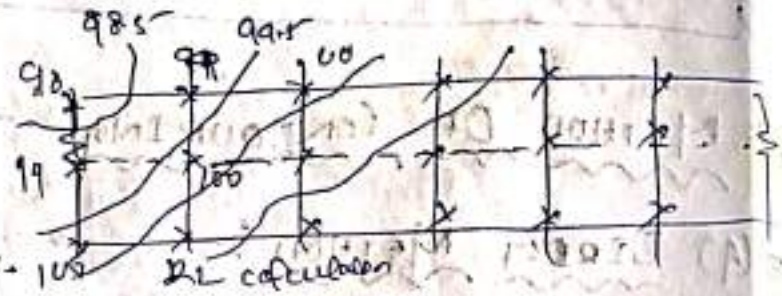


Area (Not undulated)

→ Area → Small
→ Accuracy → Less Accurate (direct method)
→ Scale → Large
→ Contour Interval → Small

12) Method of Cross Section :-

→ Prefer in the case of Railways, Highway, channel.



→ Area → Large

→ Scale → small

→ Contour Interval → Large.

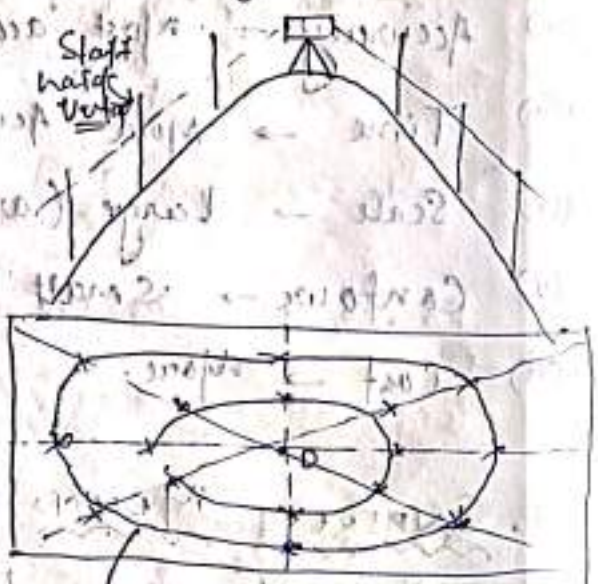
→ Generally this method is perfered for Route survey.

→ Accuracy → Less (compared to other method)

13) Tacheometric Method :-

→ This method is preferred in Hilly Area. Example

D = Ks + C



→

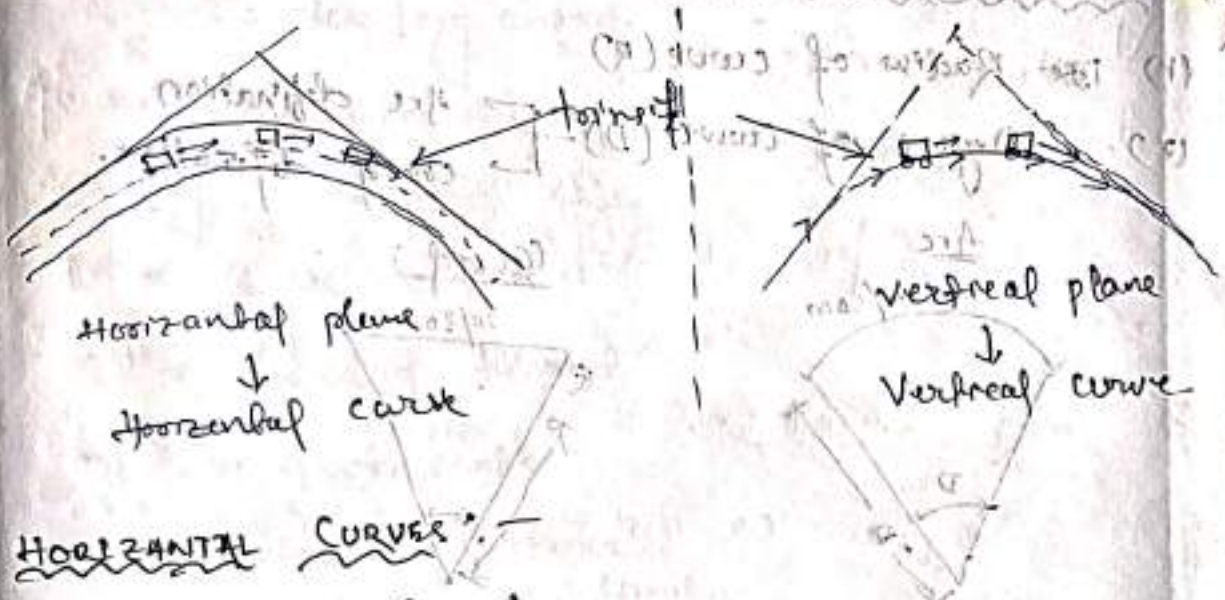
CURVES

Intro

- Curve are transition provided at intersection of two straight line.

→ Horizantal curves are provided at intersection of two line in horizantal plane.

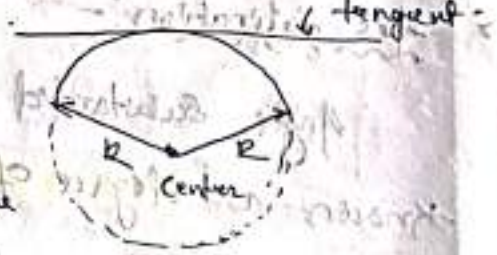
→ Vertical curve are provided at intersection in vertical plane.



HORIZANTAL CURVES :-

Type

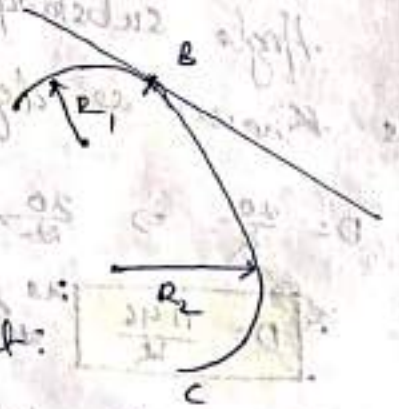
(1) Simple Circular Curve :-



→ Radius of curve → Same

→ Center of curvature is on the same side of common tangent.

2. Compound Curve :-



→ Curve with different Radius R_1 & R_2.

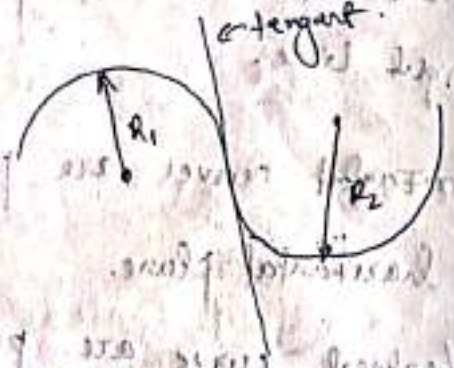
→ Center of curvature is on the same side of common tangent.

~~2. Method of Curve Section~~ :-

3. Reverse Curve :-

(i) $R_1 = R_2$

(ii) $R_1 \neq R_2$



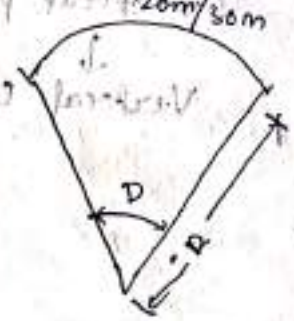
→ Center of curvature M on opposite side of the common tangent.

DESIGNATION OF CURVE :-

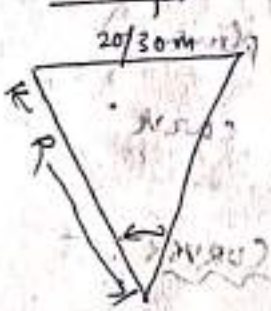
(1) Radius of curve (R)

(2) Degree of curve (D) — Arc definition / chord definition.

Arc



(Chord)



* Arc definition :-

Angle substarded by 20m/30m arc at center is known as degree of curve.

* chord definition :-

Angle substarded by 20m/30m chord at center is known as degree of curve.

(a) $D = \frac{20}{R} \Rightarrow \frac{20}{R} \times \frac{180}{\pi}$

$D = \frac{1146}{R}$

(b) $D = \frac{30}{R} \Rightarrow \frac{30}{R} \times \frac{180}{\pi} \Rightarrow$ $D = \frac{1719}{R}$

Component of Curve (Horizontal curve)

V → point of intersection

R → Radius of curve

P.C → Point of curvature (curve start)

P.T → Point of tangency (curve end / cut start)

T → Tangent Length.

PRQ → l = length of curve

PSQ → L = Long chord.

δ → deflection Angle

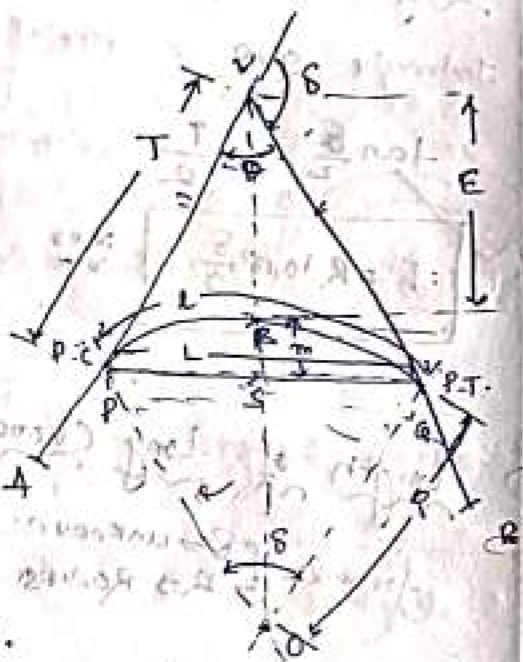
θ → intersection Angle.

AP → Back tangent

QB → forward tangent

m → mid ordinate

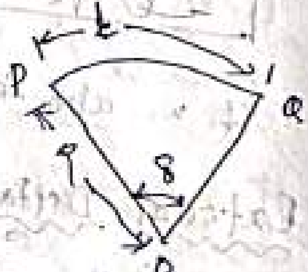
E → External Distance.



Component of simple circular curve:-

(1) Length of curve (l):-

$$\left[\delta = \frac{l}{R} \right] \text{ Radian}$$



2) $\left[\delta = \frac{180}{\pi} \times \frac{l}{R} \right]$ degree.

xxx Exam

$$\boxed{l = \frac{\pi R \delta}{180^\circ}}$$

(δ in degree)

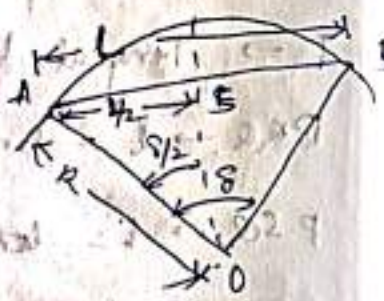
(2) Tangent Length[T] –

In triangle OVP

$$\tan\frac{\delta}{2} = \frac{T}{R}$$

$$\boxed{T = R\tan\frac{\delta}{2}}$$ ***

(3) Length of Long Chord (L)



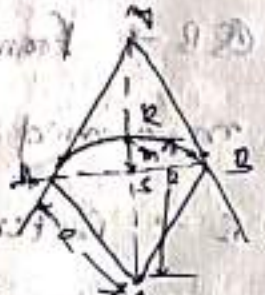
formula [δ → unknown, L = ?
R → Radius]

In triangle OAS

$$\sin\frac{\delta}{2} = \frac{L/2}{R}$$

$$\boxed{L = 2R\sin\frac{\delta}{2}}$$ ***

(4) Mid Ordinate (m) –



$$\boxed{m = OR - OS}$$

$$m = R - R\cos\frac{\delta}{2}, \quad \because \cos\frac{\delta}{2} = \frac{OS}{R}$$

$$\{OS = R\cos\tfrac{\delta}{2}\}$$

$$\boxed{m = R\left(1-\cos\frac{\delta}{2}\right)}$$ ***

→ It is also known as "Versed sine of Curve".

(5) External Distance (E) –

→ Also termed as 'Apex distance'.

OV = hypo
OP = R (B)

$$\cos\frac{\delta}{2} = \frac{R}{OV}$$

$$OV = \frac{R}{\cos\frac{\delta}{2}} = R\sec\frac{\delta}{2}$$

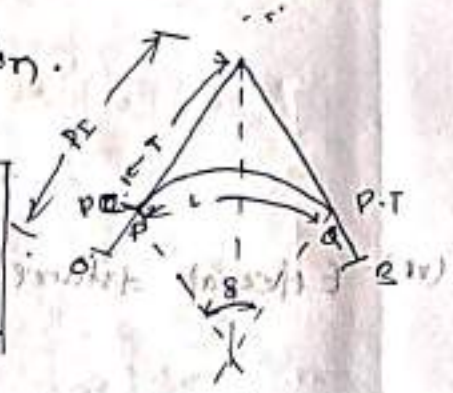
$$E = OV - OR$$

$$E = R\sec\frac{\delta}{2} - R$$

$$\boxed{E = R\left(\sec\frac{\delta}{2} - 1\right)}$$ ***

(6) Chainage at P.C. & P.T. :-

Given Chainage of Point of intersection.



Chainage of point of curvature (CP) = Chainage of PI − Tangent length

Chainage of Point of Tangency (CPT) = Chainage of PC + length of curve.

Steps To Remember

1. Length of Curve (l) = $\frac{\pi R\delta}{180}$
2. Tangent length (TL) = $R \tan\frac{\delta}{2}$
3. Length of long chord (L) = $2R \sin\frac{\delta}{2}$
4. Mid ordinate (MO) = $R\left(1-\cos\frac{\delta}{2}\right)$
   ↳ [Versine]
5. External distance (E) = $R\left(\sec\frac{\delta}{2}-1\right)$
   ↳ (Apex dist.)

Numerical Example

(1) The straight line intersect at chainage 1150 m and along of deflection is 60°. Radius curvature is 500 m dat. Calculate chainage at point of Curvature & Tangency.

Sol^n

(i) Length of curve = $\frac{\pi R\delta}{180} = \frac{\pi \times 500 \times 60}{180} = 523.59$ m.
≈ 524. m.

(ii) Tangent length(T) = $R\tan\frac{\delta}{2} = 500 \times \tan\left(\frac{60}{2}\right) = 288.69$
≈ 289. m.

(iii) Long chord = ~~2R~~ $2R\sin\frac{\delta}{2} = 2\times500\times\sin\left(\frac{60}{2}\right)$
= 500 m

(iv) M.O ordinate $= R\left(1-\cos\frac{\Delta}{2}\right)$

$= 500\times\left[1-\cos\left(\frac{60}{2}\right)\right]$

$= 66.98 \simeq 67$ m.

(vi) External distance(E) $= R\left(\sec\frac{\Delta}{2}-1\right)$

$= 500\times\left[\sec\left(\frac{60}{2}\right)-1\right]$

$= 77.35 \simeq 77$ m

(vii) Change point of curvature = 1150.5 − tangent length

$= 1150.5 - 289$

$= 861.5$ m.

(viii) Change point of Tangency = change of curvature + length of curve

$= 861.5 + 524$

$= 1385.5$ m or

SETTING OUT OF CURVE :—

1. Linear Method (Chain / tape)
2. Angular Method (Angle, distance – Chain / tape)

1. LINEAR METHODS :—

→ In this Method only chain or tape is used hence no angular measurements are taken.

→ Various linear methods for setting out circular curves are.

(a) Perpendicular offset from long chord.
(b) Perpendicular offset from tangent.
(c) Radial offset from tangent.
(d) Successive Bisection of chord
(e) Offset from chord produced.

(A) Perpendicular offset from long chord :-

$$m = R\left(1 - \cos\frac{\delta}{2}\right)$$

$$m / O_0 = \left(\sec\frac{\delta}{2} R - 1\right) \text{ or } \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$$

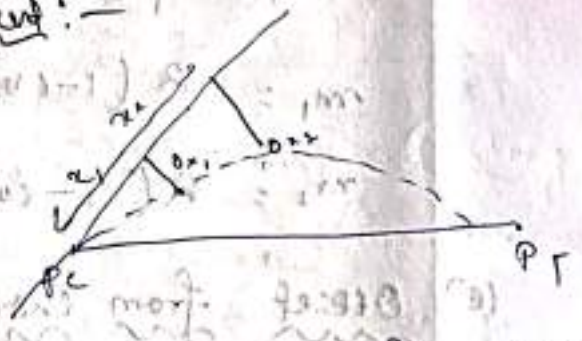
where
R = Radius
L = Long chord.

$$O_x = O_0 - \frac{x^2}{2R}$$

where
O_0 = Mid ordinate (m)
R = Radius of curve
x = distance from centre of long chord.

(B) Perpendicular offset from tangent :-

$$O_x = \frac{x^2}{2R}$$

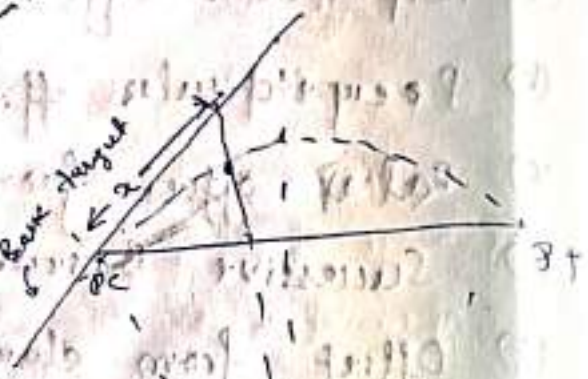


where
O_x = Length of the offset taken from tangent at distance 'x' from the P.C.
R = Radius of curve.
x = distance from point of curvature.

(c) Radial offset from tangent :—

Apex formula

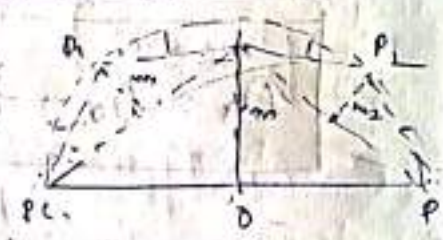
$$Ox = \frac{x^2}{2R}$$



** Note: This Method is suitable for setting out of curve of smaller Radius (Centre find easy)

(d) Successive Bisection of chord :—

$$m = R - \sqrt{R^2 - \left(\frac{L}{2}\right)^2} \Rightarrow R\left(1 - \cos\frac{\delta}{2}\right)$$



Long chord → Bisect (Apex = m)

2 chord → PC to P

2 chord → P to PT

$$m_1 = R\left(1 - \cos\frac{\delta}{4}\right)$$

$$m_2 = R\left(1 - \cos\frac{\delta}{8}\right)$$

$$m = R\left(1 - \cos\frac{\Delta}{2}\right)$$

$$m_1 = R\left(1 - \cos\frac{\Delta}{4}\right)$$

(e) Offset from chord Produced :—

C_1 = first chord O_1 = first offset

lengths

$$O_1 = \frac{C_1^2}{2R}$$

$$O_n = \frac{C_n}{2R}(C_n + C_{n-1})$$

$$O_2 = \frac{C_2}{2R}(C_2 + C_1)$$

Note :- The Method is suitable for setting out of long Curves generally perefered in Highways (theodolite is not available)

2. ANGULAR METHODS :—

(a) Deflection Angle Method / Rankine Method / one theodolite Method.

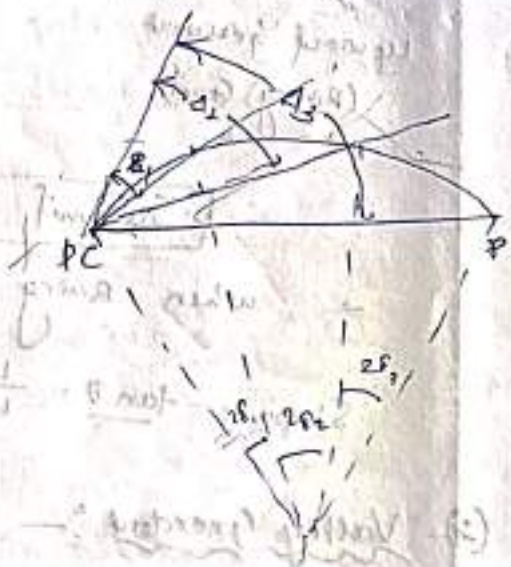
(b) Two theodolite Method.

(c) Tacheometric Method.

Note :- Angular Method are more accurate and less time consuming.

(A) Deflection Angle Method / Rankine Method / One theodolite Method :-

$$\delta_1 = \frac{c_1}{2R} \times \frac{180}{\pi}$$



$\Delta_1 = \delta_1$

$\Delta_2 = \delta_1 + \delta_2$

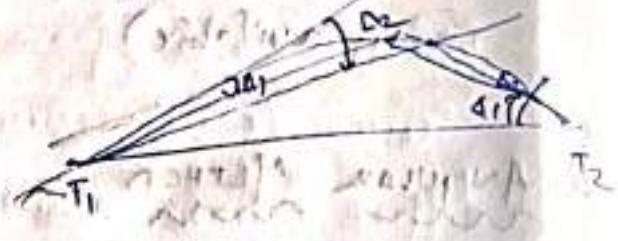
$\Delta_3 = \delta_1 + \delta_2 + \delta_3$.

2. Two theodolite Method :-

- No requirement of linear measurement.

used in Ground undulating

→ Linear measurement is not possible.

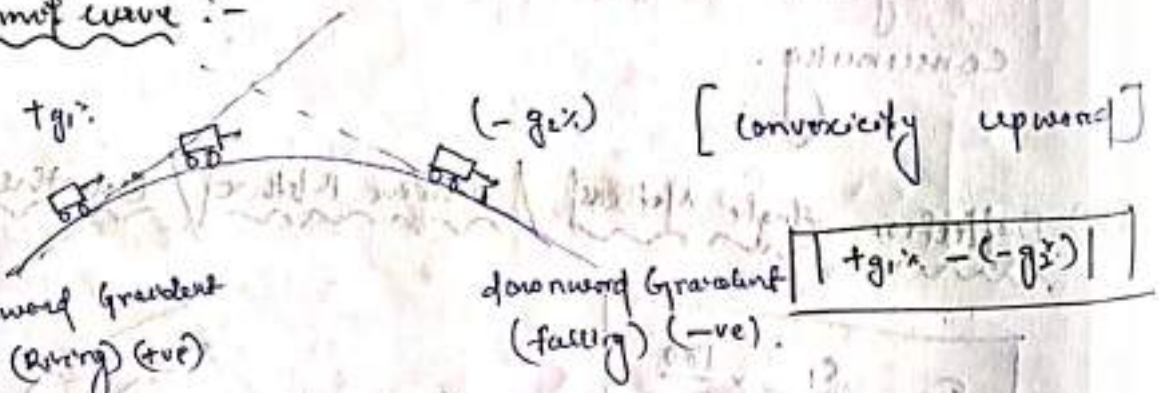


VERTICAL CURVES :-

→ These curves are provided when there is change in slope or/ Gradient. In highways & Railways.

types of curve

(1) Summit curve :-



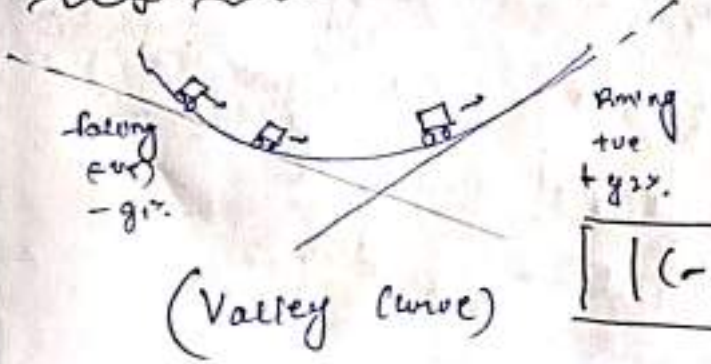
Summit curve

- when Rising Gradient meet falling gradients.

Slope = $\tan\theta = \frac{1}{10} = \frac{1}{n}$ i.e. 1 in n

$\frac{1}{10} \times 100 = 10\%$

(2) Valley Gradient :-



- when falling gradient meet a rising gradient.

Change in Gradient = $|(g_1\%) - (g_2\%)|$

2

Length of Vertical Curve :-

V.imp

Length of curve = $\frac{\text{Total change of Grade}}{\text{permissable rate of change of Grade}}$

Numerical

Q. A gradient +1.2% meets another gradient of −0.8%. Calculate the length of curve if rate of change of gradient is 0.1% per 30 m. chain.

Sol^n

Total change in Grade = $|+1.2 - (-0.8)|$

= 2 %

Rate of change in gradient = $\left(\frac{0.1\%}{30}\right)$

Length of curve = $\frac{\text{Total change in Gradient}}{\text{Rate of change in Gradient.}}$

= $\frac{2.0\%}{\left(\frac{0.1\%}{30}\right)} = \frac{2.0 \times 30 \times 10}{0.1\%}$

= 600 m. (In terms of length)

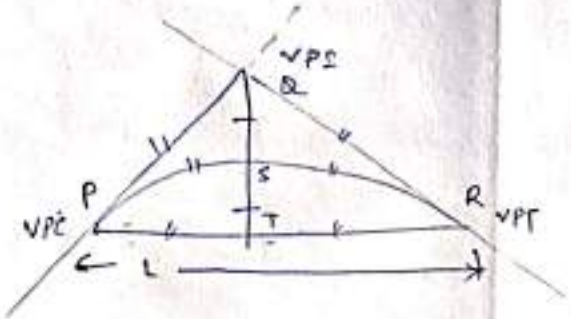
30

$\frac{600}{30}$ = 20 chains

ASSUMPTION WHILE DESIGNING VERTICAL CURVE :-

V.imp

- PT = TR
- PQ = PS = PT
- QS = ST



CH-9: AREA AND VOLUME :-

(i) If area is of regular shape (Triangle, Rectangle, Square etc) → Addition of all the area of geometric shape.

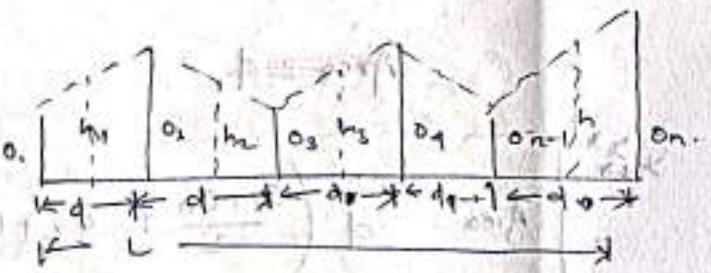
(ii) If plan is of irregular shape → Planimeter is used to find the area.

Calculation Of AREA:-

(1) MID ORDINATE RULE:-

$O_1, O_2, O_3 \dots O_n$ = Length of offset.

d: distance between two consecutive offset.



n = no. of offset.

no. of segement = $(n-1)$

$L = (n-1) \cdot d$

h → Mid ordinate = $\left(\frac{O_1 + O_2}{2}\right)$

Area: Base × Ht = $d \times h_1$, $d \times h_2$, $d \times h_3 \dots$

Total area = $h_1 \times d + h_2 \times d + h_3 \times d + \dots + (h_{n-1}) \times d$

Total area = $(h_1 + h_2 + h_3 + \dots + h_{n-1}) \times d$

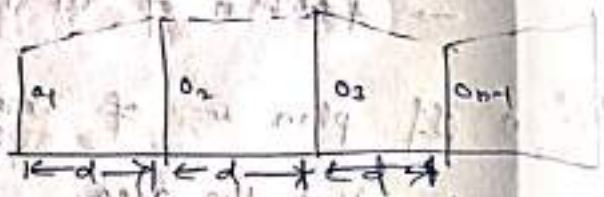
* Divide and Multiply by $(n-1)$ and n

$$\text{Total area} = \frac{(h_1 + h_2 + h_3 + \dots h_{n-1})}{n-1} \times (n-1)d$$

L = base length.

2. AVERAGE ORDINATE METHOD:—

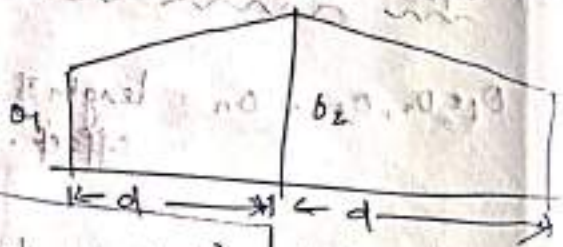
$$\text{total Area} = \frac{O_1 + O_2 + O_3 + \cdots + O_n}{n} \times L$$



n: total no of offset

L: length of Base = (n-1)d

3. TRAPEZODAL RULE:-



$$\text{Area} = d\left(\frac{O_1 + O_n}{2} + O_2 + O_3 + O_3 + O_4 \cdots O_{n-1}\right)$$

d: distance between two consecutive offsets.

$O_1, O_2, O_3 \cdots O_n$ respective length of offset.

Note: Method is prefered when Boundary b/w two consecutive offset is straight (Area irregular)

4. SIMSON 1/3rd RULE / PRISMOIDAL FORMULA:-

⇒ when boundries between two consecutive offset is assumed to be curve then method is prefered.

Total Area: $\frac{d}{3}\left[(O_1+O_n) + 4(O_2+O_4+O_6+\cdots) + 2(O_3+O_5+\cdots)\right]$

Total Area: $\frac{d}{3}$ [(1st offset + Last offset) + 4 (sum of even offset) + 2 (sum of odd offset)]

Example Numerical

(1) Calculate area ordinate (offset) 40m, 60m, 80m, 20m. Using trapezoidal formula. d = 30m.

Step Simson 1/3 rule

Total Area: $\frac{d}{3}$ [(1st + nth) + 4 (even) + 2 (odd)]

$= \frac{10}{3}$ [(40+20) + 4×60 + 2×30]

$= 10$ [60 + 240 + 60]

$= 3600\ m^2$ (Ans)

Not used because of even no. of offset

Trapezoidal

Total Area = $d\left[\frac{1st + last}{2} + O_2 + O_3 \cdots + O_{n-1}\right]$

$= 30\left[\frac{40+20}{2} + 60 + 80\right]$

$= 30\ [30 + 140]$

$= 30 \times [170]$

$= 5100\ m^2$ (Ans)

Note:-

→ Precomodial formula is used when no. of offset are odd.

Eg-2 No. of offset 90m, 60m, 30m, d=60m use prismoidal formula

Sol^n

$$\text{Area} = \frac{d}{3}\left[(O_1 + O_n) + 4(\text{even}) + 2(\text{odd})\right]$$

$$= \frac{60}{3}\left[90+30 + 4\times 60\right]$$

$$= 20\left[\underline{70} + \underline{240}\right]$$

$$= 20 \times 310$$

$$= 6200\ m^2$$

CALCULATION OF VOLUME:-

Volume = Area × Length

① Trapizodial formula:-

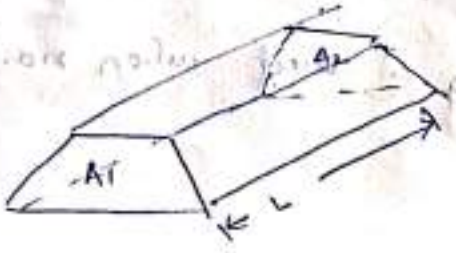
$$\text{Volume}(m^3) = d\left[\left(\frac{A_1 + A_n}{2}\right) + A_2 + A_3 + \cdots A_{n-1}\right]$$

② Simpson Rule:-

$$\text{Volume}(m^3) = \frac{d}{3}\left[(A_1 + A_n) + 4(A_2 + A_4 \cdots) + 2(A_3 + A_4 \cdots)\right]$$

× ~~irregular~~ ~~lot~~

③ MID SECTION FORMULA:-



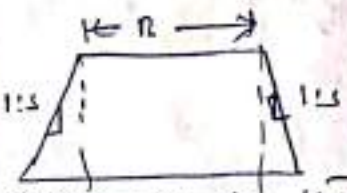
Case-1

$A_1 = A_2$

$I_V = SH$

$dV = Sdq\ H$

$\frac{1}{d} = \frac{S}{x}$ $\boxed{x = Sq}$



$\boxed{A_1 = A_2}$

Area = 2 (Area of triangle) + (Area of Rectangle)

$= 2 \times \left[\frac{1}{2}(S \cdot q) \cdot q\right] + B \cdot d$

$\boxed{\text{Area} = Bd + Sd^2}$ SSC JE

↳ Mid sec formula

$\boxed{\text{Volume} = \text{Area} \times L}$

where

B = width of embankment

S = ~~steps~~ side slope

q = depth of embankment

Case-2 ($A_1 \neq A_2$)

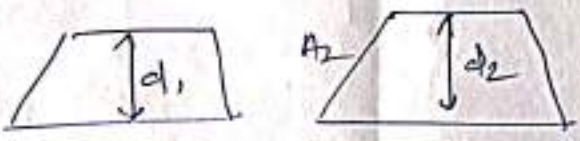
by using mean depth

$\boxed{d_m = \frac{d_1 + d_2}{2}}$ ①

$\boxed{\text{Area} = Bd_m + Sd_m^2}$ ②

$\boxed{\text{Volume} = \text{Area} \times L}$ ③

$\{d_m$ = mean depth$\}$



by using Arr. mean Area

$\boxed{A_1 = A_2 = B \cdot Bd + Sq^2}$

$\boxed{A_m = \frac{A_1 + A_2}{2}}$

$\boxed{\text{Volume} = A_m \times L}$

$\{\because A_m$ = mean Area$\}$

Note Q

(H) In mid section formula :- _____ :.

(a) The mean depth is the average of two consecutive section.

(b) The area of mid section is calculated by using depth.

(c) The volume of earthwork is calculed by multiplying the mid section area between the two.

(d) All of the above. (Ans)

CH-10: PLAIN TABLE SURVEY :-

→ In Plain table survey instrument used for surveying in which sighting/field work and plotting are done simultaneously.

→ Suitable for small and medium scale mapping. i.e. 1:10000 to 1:50,000 where high accuracy is not required.

→ No Great skill required, less costly as compare to theodolite survey.

* LIMITATION :—

→ Absence of measurement cause inconvenience.

→ Difficult to handle due to its weight.

→ It can not be done in rainy season.

→ It can not be done in dansel & heavy forest.

ACCESSORIES OF PLANE TABLE SURVEY :—

1. Plane Table Board :—

Wooden drawing board made of well seasoned wood & the upper surface kept smoth (attached it with tripod).

** Johnson Table :— Drawing board of size.

45cm x 60cm or 60cm x 75cm.

2. Tripod :-

Used to place plane table over it.

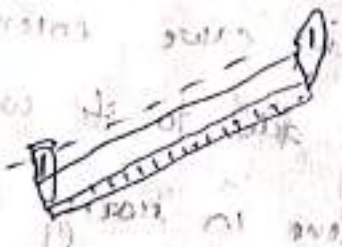
3. Alidade :-

(a) Plain Alidade :-

→ Used for sighting object and drawing line.

→ Graduation/scale are marked on one side which is beveled/termed as fiducial Edge.

→ Vanes are used for sighting the object & it is essential that perpendicular to surface of sheet.



(b) Telescopic Alidade :-

→ It is used when it is required to take inclined line of sight.

→ It consist of small telescope with level tube and graduated arc/circle mounted on horizontal axis.

→ Horizontal distance measurement can be done by tacheometric relation by taking reading on staff.

4. Compass :—

→ Trough Compass is used for establishing the magnetic meridian → direction of north & south.

→ When needle of compass align itself along magnetic meridian, reading of compass correspond to zero.

5. Spirit Level :—

→ Two level tube are at right angle to each other are placed over the plane table to level the plane table.

→ Spirit level is used ascertain that plain table is levelled or not.

6. Plumbing fork :—

→ Plumbing fork is a U-shape metal frame.

* Plumbing fork is used for following purpose :-

→ Centering plane table over station occupied by it which is already plotted on drawing sheet.

→ Transferring ground point on drawing sheet.

TEMPORARY ADJUSTMENT OF PLAIN TABLE.

1. fixing the table on tripod → Setting of measurement
2. Levelling → Spirit level.
3. Centering
4. Orientation

1. FIXING THE TABLE ON TRIPOD :-

2. LEVELLING :-

The process of bringing plane table in horizontal plane done with spirit level by placing the level on the board in two position in right angle.

3. CENTRING :-

It the process of bringing plotted point on table exactly over ground station done with plumbing fork.

4. Orientation :-

It is the process of putting the plain table in a same fixed direction so that line represent certain direction on plan is parallel to direction of ground.

This is essential condition to be fullfild when More than one instrument station on ground.

METHOD OF ORIENTATIONS

This can be done by 2 Method.

1. By Trough Compass
2. By Back sighting.

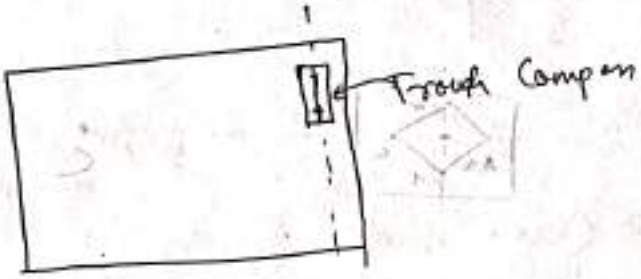
1. By Trough Compass :-

→ Trough Compass is placed on top right side corner of plane table in such way reading on trough compass = 0.

→ This is less accurate due to local attraction but more rapid orientation can be done with trough compass.

→ Shift instrument to next station and place along NS direction

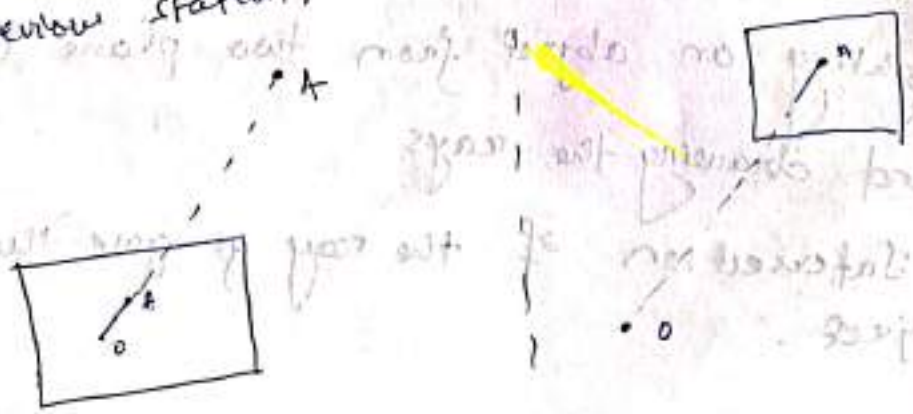
→ Rotate table till magnetic need. needle coincide with N.



2. By Back Sighting :-

→ The most accurate method of orientation.

→ In this method the plane table is set on need station and alidade is placed against the line joining the new station with previous station and the table is rotate until I.O.S. bisect the previous station.

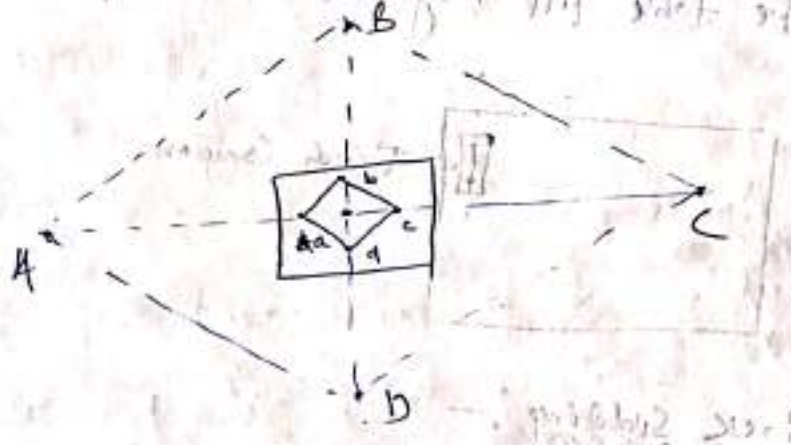


METHOD OF PLANE TABLE :-

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

1. RADIATION :-

Method is suitable when area to be surveyed is small and all required station to be plotted are clearly visible and accessible from instrument station.



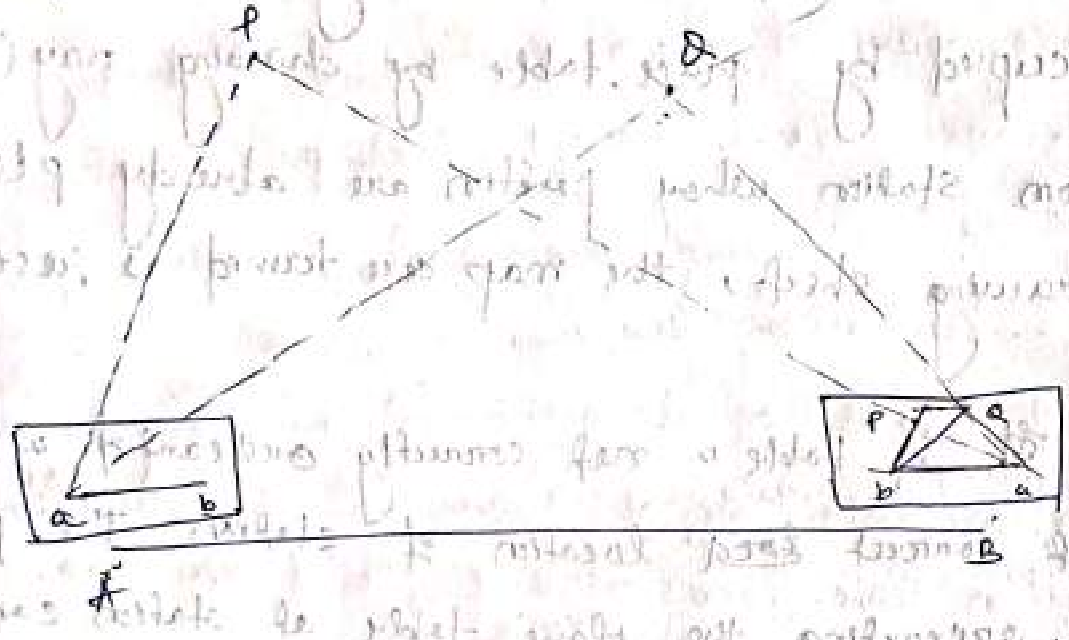
2. INTERSECTION METHOD :-

→ This Method is preferred when distance between point & instrument station is either too long or cannot be measured accurately due to some field conditions.

→ The location of an object is determined by sighting an object from two plane table station and drawing the rays.

→ Intersection of the rays gives the position of object.

→ It is very essential that two instrument station should be there



3. TRAVERSING METHOD :-

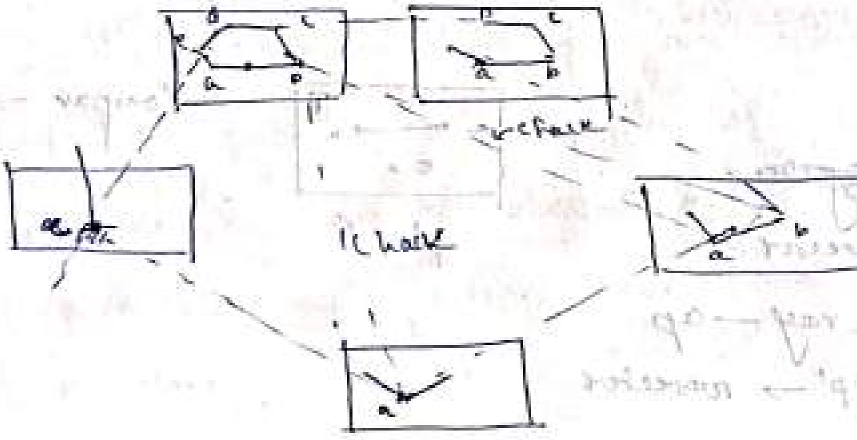
→ Method is similar to compass or theodolite traversing

- Method is used for traversing both open as well as close traverse.

- At each successive station table is fixed & foresight is taken on following station & its location is plotted by measuring distance between two stations.

- Orientation is done by back sighting.

- If n = total no. of station, plane table must be set (n-1) stations to known error of closure.



9. RESECTION METHOD :—

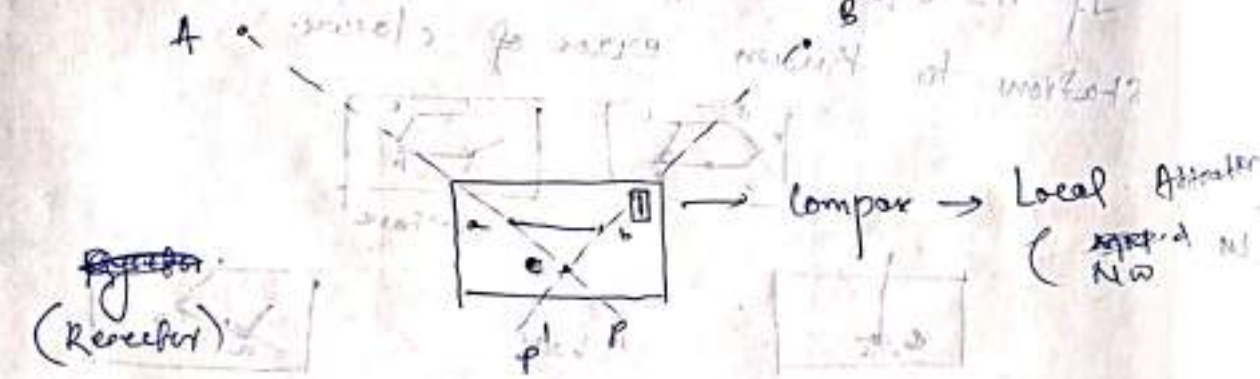
→ Is the process of locating instrument station occupied by plane table by drawing ray (resector) from station whose position are already plotted on drawing sheet, the map are termed as resection.

→ If table is not correctly orientated we cannot get correct location of station. The problem of orienting the plane table at station can be solved by different methods.

* The following methods are :-

1. Resection of orientation by Compass
2. Rection after orientation Back sighting.
3. Resection By two point problem.
4. Resection By three point problem.

1. RESECTION AFTER ORIENTATION BY COMPASS :-



Back ray — ap

pp' → resector

B. RESECTION AFTER ORIENTATION BY BACK SIGHTING :-

→ If B → ab → (short plot.)

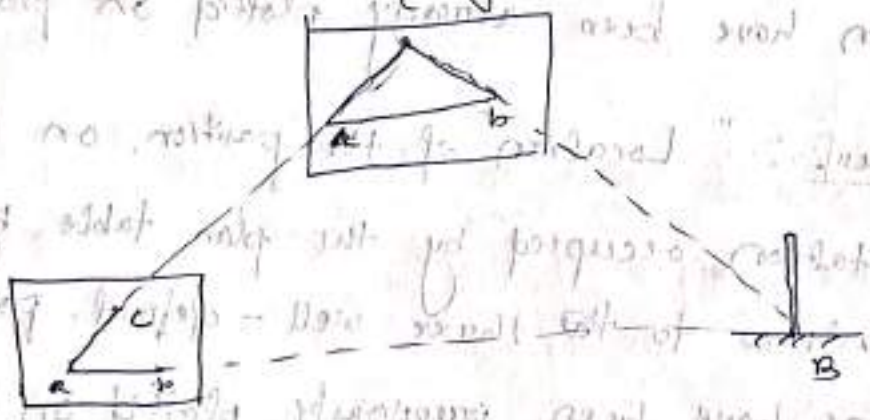
→ The Method can be used only if either station A or station B is accessible.

Step-1: A station → place plane table

Step-2: c → Assume → instrument position

Step-3:- Place plan table at c

Step-4:- from b → Back Ray → cut "c".



Note:-

→ Above two methods of resection first method is nearly used as it consist of error due to local attraction.

→ In second case it is necessary to set plan table on or one of the point is known.

C. RESECTION AFTER ORIENTATION BY TWO POINT PROBLEM:-

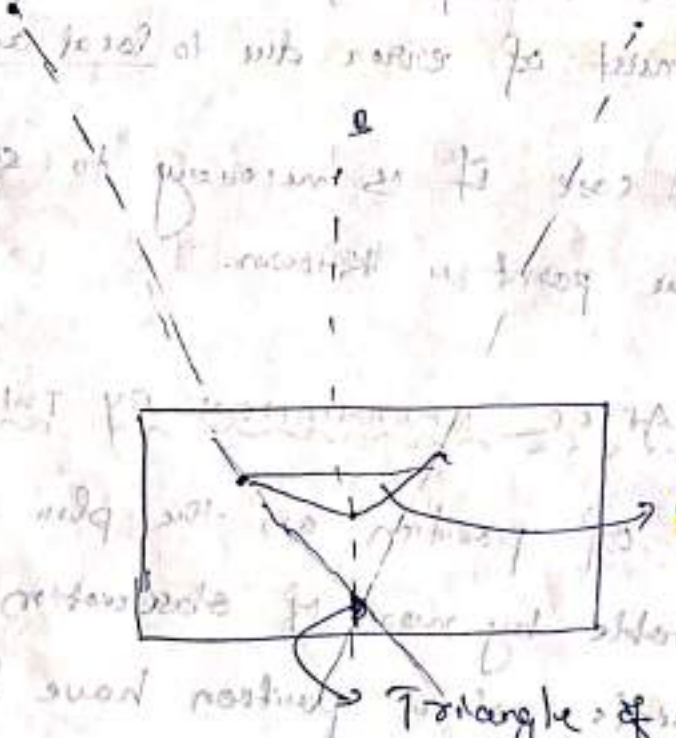
→ Location of position on the plan of station occupied by plane table by mean of observation to two well defined points whose position have been previously plotted on plan.

→ This Method consist of locating position of plane table station on plane drawing sheet by observation of two well defined points whose position have already been plotted.

D. THREE POINT PROBLEM :—

→ It consist of Locating the position of instrument station with help of three well defined points whose position have been already plotted on plan.

Statement :- " Location of the position, on the plan, of the station occupied by the plan table by mean of observations to the three well-defined points whose positions have been previously plotted on the plan.

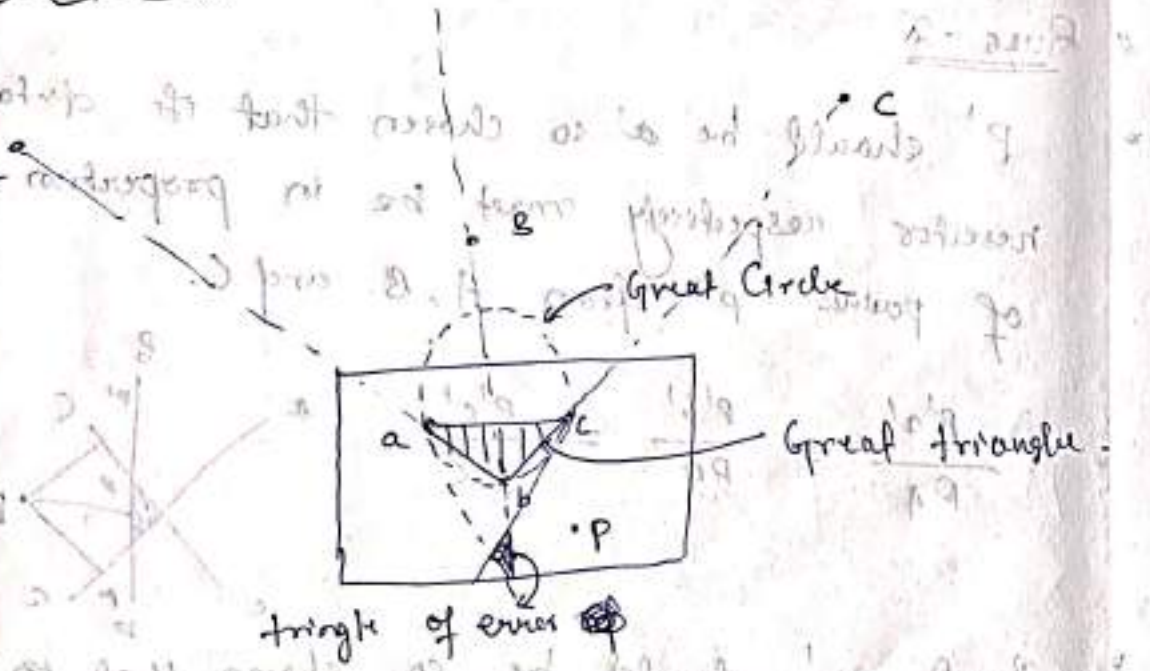


* It can be done by following Methods.

1. Mechanical Method (Tracing paper Method)
2. Graphical Method (Bassel Method)
3. Lehman Method (Trial and error Method) / Triangle of error Method.

Imp:-

3. Lehman Method / Trial and error Method / Triangle of error Method :-



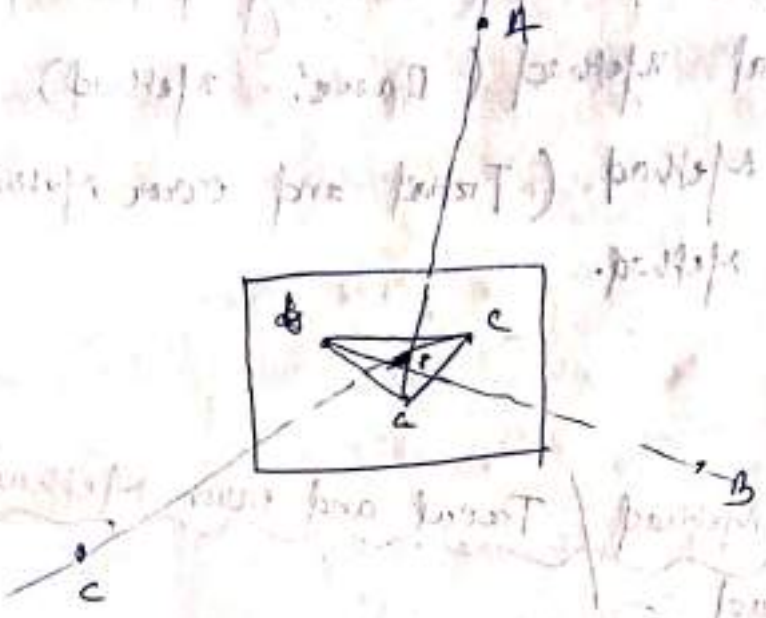
* Lehman's Rule :-

→ Rule-1 :-

(i) → If station P is outside the great triangle, the of error Δ also lies outside the great triangle hence point 'p' must also consider outside triangle of error.

(ii) → If station P is lies inside the great triangle, the triangle of error also lies inside the great triangle, hence p' must also be considered inside the triangle of

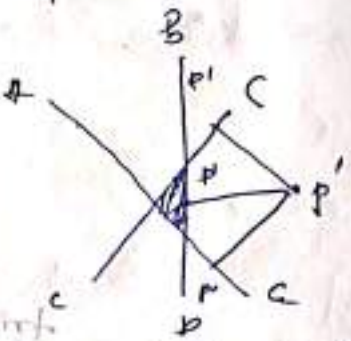
Case-ii



RULE-2

* P' should be so chosen that its distance from resector respectively must be in proportion to distan of point P' from A, B, and C.

$$\frac{P'a'}{PA} = \frac{P'b'}{PB} = \frac{P'c'}{PC}$$



* Point P' should be so chosen that all of b on same side (left or Right) of all the resector Aa, Bb Cc.

Note!-

→ The accuracy with which a plan table station can b located through three point problem is known as its fix.

→ The degree of accuracy of solution of the three point problem is designated as its strength i.e. if the accuracy is high, the fix is termed as strong and for Low accuracy fix termed as poor.

→ fix is Good when instrument station lies inside the great triangle and particularly when it is at the Ortho-Centre and the middle station is much nearer then the other-

CH-11: PHOTOGRAMMETRY :-

Intro

+ The branch of surveying in which maps are prepared from photo taken on ground.

→ It cover the large survey area in less time & we can reach the inaccessible area.

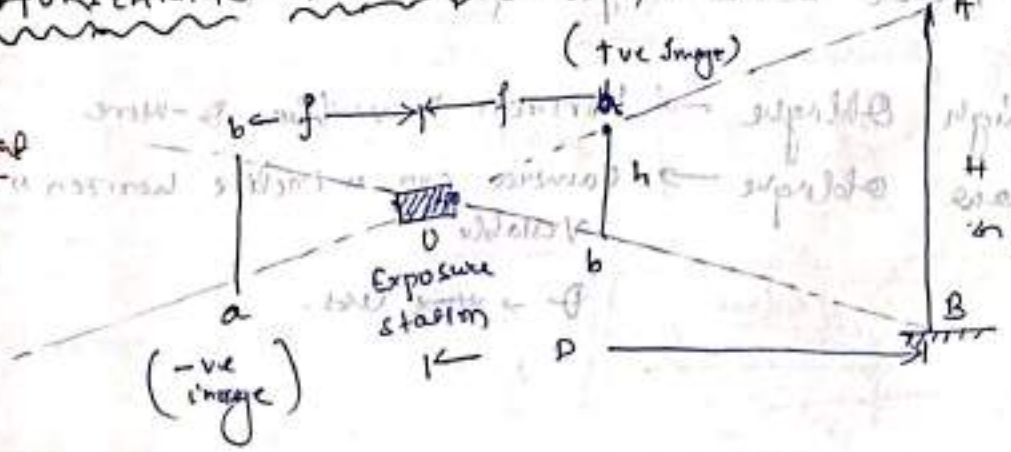
→ Cost + high
time → Less

TYPE Of PHOTOGRAMMETIC SURVEY :-

* Aerial
* Terrestrial.

AERIAL	TERRESTIAL
→ Camera is mount on aircraft	→ Camera is Mounted on CPhoto-theodolite) Ground.
→ Axis of camera is vertical	→ Axis of camera is horizontal.
→ With the help of this photograph we can prepare → Topographical Map (Natural & manmade)	→ Establish the features like Vertical Cliff.

#2.1 HORIZONTAL PHOTOGRAMMETRY (TERRESTIAL Photogrammetry) :-



$$\text{Scale} = \frac{\text{Distance on Photograph}}{\text{Distance on Ground}}$$

$$\text{Scale} = \frac{h}{H} = \frac{f}{D}$$

where

D = Distance b/w exposer station and object.

f = focal length of camera.

2. AREAL PHOTOGRAMMETRY :-

→ Photo are taken from camera mounted in an aircraft flying over an area.

TYPE OF PHOTOGRAPH :-

(i) Vertical Photograph :- It is taken with camera mounted on aircraft and lens axis is perpendicular to surface of earth.

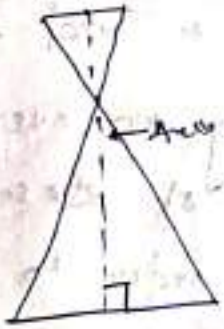
(ii) Tilted Photograph :- Vertical axis of camera unintentionally inclined by vertical by not more than 3 degree $[\theta \leq 3]$

(iii) Oblique Photograph :- Camera axis intentionally & make some angle from vertical axis.

angle 3°

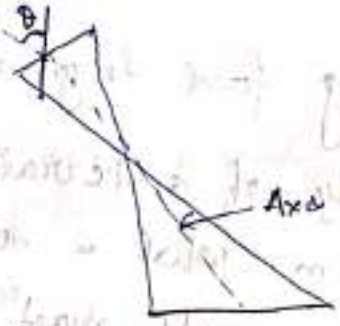
* High Oblique → horizon is visible, θ - more
* Low oblique → camera axis is incline horizon is not visible.

θ → less.



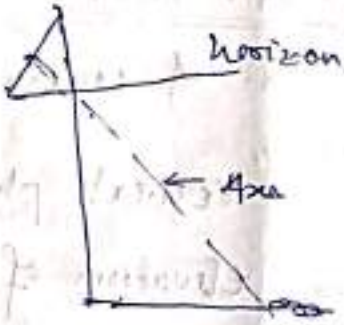
(Vertical photograph)

* Camera axis is ⊥r to earth surface.



(Low oblique photograph)

* Camera axis inclined
* horizon is not visible
* $\theta \rightarrow$ Less



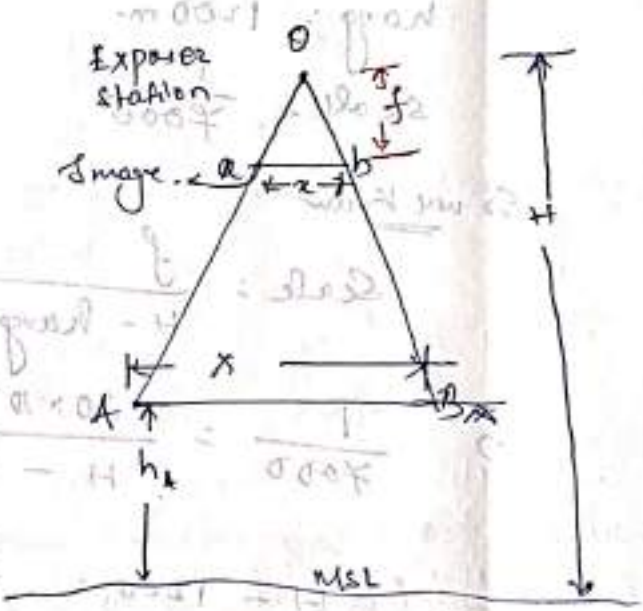
(High oblique photograph)

* horizon is visible
* Camera axis is inclined
* θ = More

SCALE Of PHOTOGRAPH :—

$$\text{Scale} = \frac{\text{distance on photograph}}{\text{distance on ground}}$$

$$\text{Scale} = \frac{x}{X} = \frac{f}{H - h_A}$$



f = focal length of camera

H = flying height.
(elevation of camera from MSL)

h_A = Elevation of point 'A' from MSL.

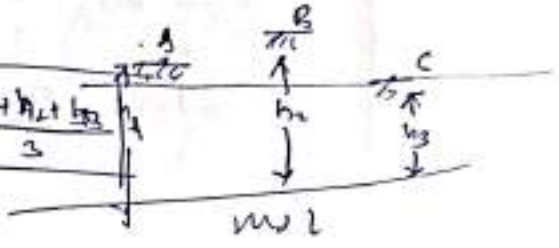
(i) **Datum Scale** $= \frac{f}{H}$ → Assume object is lie on MSL

$h_A = 0$

(ii) **Point scale / Scale** $= \frac{f}{H - h_A}$ → elevation of point 'A' is given.

(iii) **Average Scale** $= \frac{f}{H - h_{avg}}$

$h_{avg} = \frac{h_1 + h_2 + h_3}{3}$



Example Problems

Q. A camera having focal length of 30 cm is used to take vertical photography of a terrain having an average elevation of 1200 m. What is the height of the sea level above which the air craft must fly in order to get a scale of 1:7000?

Soln:

Given

$f = 30\text{cm} = 30 \times 10^{-2}$

$h_{avg} = 1200\text{ m}$

$\text{scale} = \frac{1}{7000}$

So we know

$$\text{Scale} = \frac{f}{H - h_{avg}}$$

$$\frac{1}{7000} = \frac{30 \times 10^{-2}}{H - 1200}$$

$$H - 1200 = \frac{30 \times 10^{-2} \times 7000}{1}$$

$$H - 1200 = 2100$$

$$H = 2100 + 1200$$

$$H = 3300$$

Hence

IMPORTENT TERMS :-

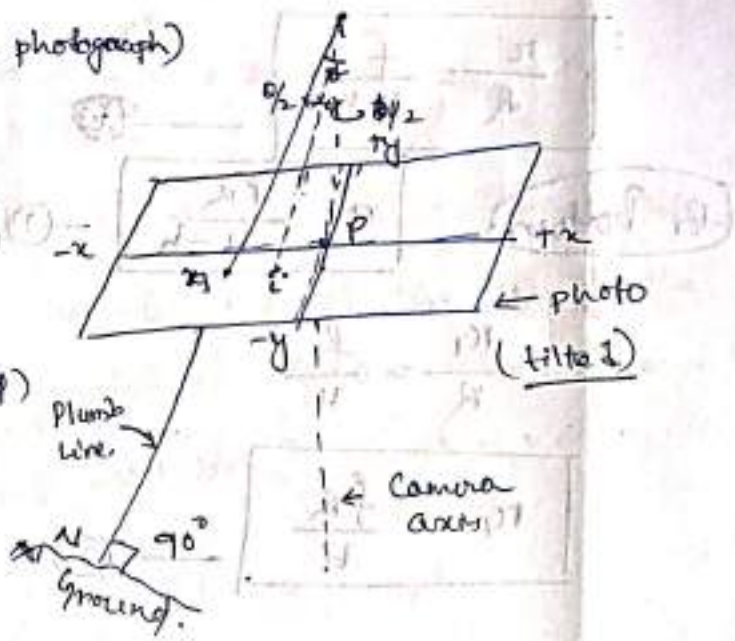
P: Principle point (center of photograph)

ϕ: tilt angle

n:- photo nadir point
(Plumb line meet photo)

N:- Ground nadir point.
(Plumb line → meet Ground)

i:- Isocenter
(line which devides tilted angle into two parts → meet on photograph)

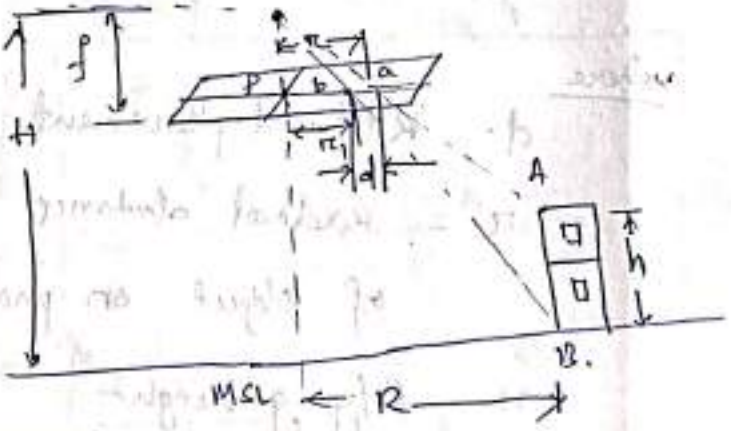


Note

If photograph is vertical photo nadir point, isocenter and principle point co-inside each other.

RILIEF DISPLACEMENT :-

Rilief displacement is radial distance between where an object appear in an image to where it actually should be.



Rilief Displacement.

$$d = r - r_1$$

Where

d:- relief displacement

r:- radial distance from principle point to the top of the object on photograph.

r_1:- radial distance from the principle point to the bottom of the photograph.

Scale

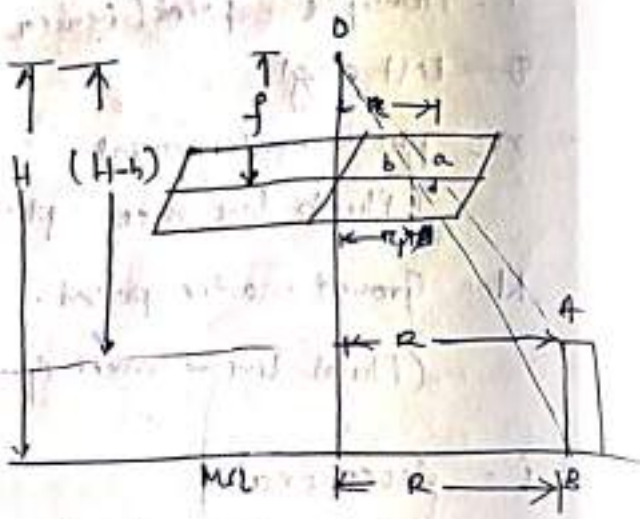
for top

Δ oab

$$\frac{r}{R} = \frac{f}{H-h} \quad \text{---} \otimes$$

for Bottom

$$r = \frac{fR}{H-h} \quad \text{---} (1)$$



$$\frac{r_1}{R} = \frac{f}{H}$$

$$r_1 = \frac{fR}{H} \quad \text{---} (2)$$

Relief displacement

$$d = r - r_1$$

2) $\frac{fR}{H-h} - \frac{fR}{H} \Rightarrow \frac{fRH - fRH + fRh}{H(H-h)}$

$$d = \frac{fRh}{(H-h)\cdot H}$$

from eqn (1)

$$d = \frac{rh}{H} \quad \text{[Object at MCL]}$$

where

d = Relief. displacement

r = Radial distance from principle point to top of object on photo

H = flying height

h = Height of the object.

* Object at h_A elevation from MSL

$$d = \frac{rh}{H - h_A}$$

Numerical Problem

An image on top of the hill is 96 mm from principal point of the photograph. the elevation of the top of the hill is 500 m and flying height is 4000 m above the datum. the relief displacement will be-?

Sol^n

Data Given

$r = 96$ mm.

$h = 500$ m.

$H = 4000$ m.

$$d = \frac{rh}{H} = \frac{96 \times 500}{4000} = 12 \text{ mm}$$

$d = 12$ mm. Ans

PHOTOCORINATE MEASUREMENTS :-

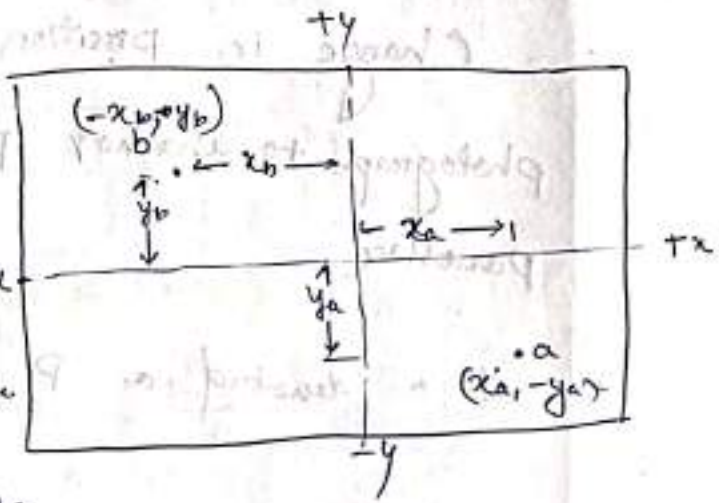
Given

$(+x_a, -y_a)$ → photo co-ordinate of point a

$(-x_b, +y_b)$ → photo coordinate of point b.

$(+X_A, -Y_A)$ → Ground coordinate (A)

$(-X_B, +Y_B)$ → Ground co-ordinate (B)



Scale - (f)

Distance photo → x_a
Actual dist → x_A

$$\frac{x_a}{x_A} = \frac{f}{H - h_A}$$

$$x_A = \frac{x_a}{f}(H - h_A)$$

Similarly

$$x_B = \frac{x_b}{f}(H - h_B)$$

$$y_A = \frac{y_a}{f}(H - h_a)$$

$$y_B = \frac{y_b}{f}(H - h_b)$$

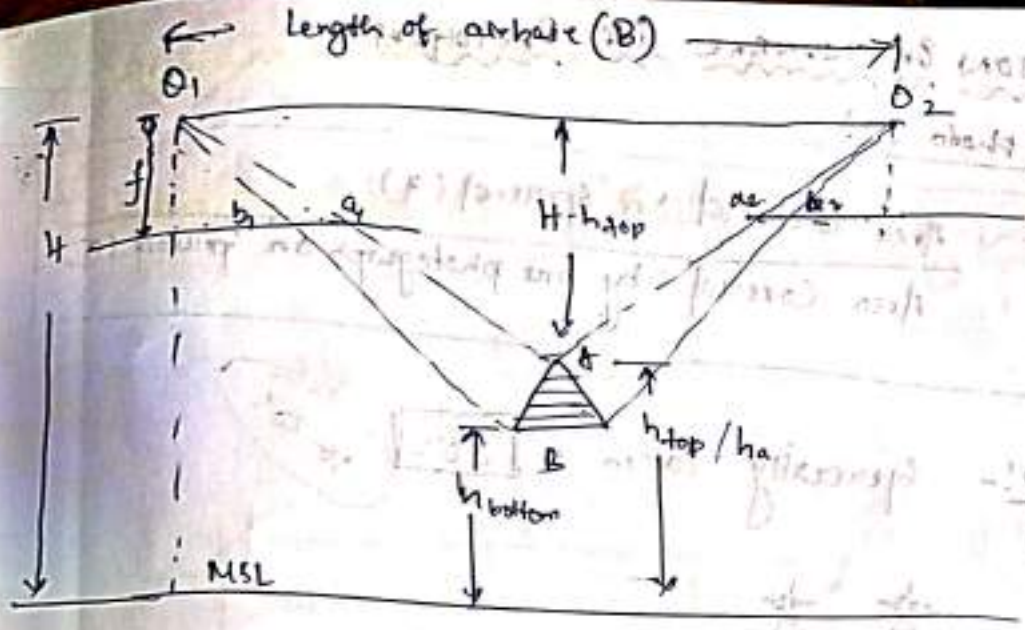
*** Distance between A & B on Ground.

$$D = \sqrt{(x_A - x_B)^2 + (y_A - y_B)^2}$$

PARALLAX / STEREOSCOPIC PARALLAX :-

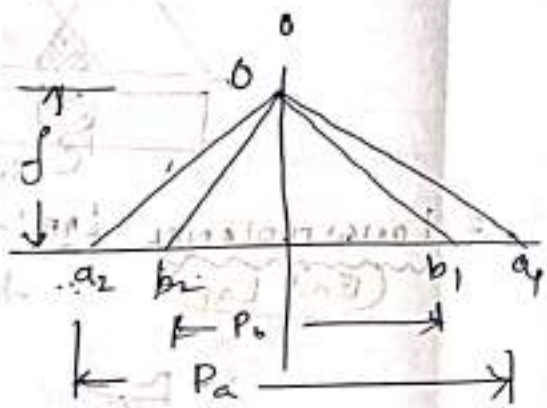
* Change in position of an image from one photograph to another photograph is termed as parallax.

→ It is denoted as P.



(Imp)

→ $\triangle O a_1 a_2$ & $\triangle O_2 O_1 A$ (Similar triangle)



$$\frac{P_a}{f} = \frac{B}{H - h_{top}/h_a}$$

XX

$$P_a = \frac{Bf}{H - h_a}$$

$$P_B = \frac{Bf}{H - h_b}$$

where

P_a = Parallax of station A
B = length of air base
H = flying height
h_a = Elevation of A from MSL.

Exam

- When object is on MSL

$$P = \frac{Bf}{H}$$

(Parallax)

$$B = \frac{PH}{f}$$

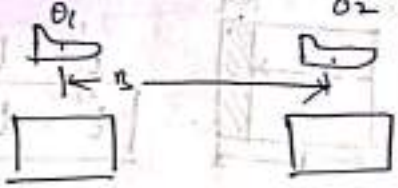
(Length of base)

Scale

$$\frac{b}{B} = \frac{f}{H}$$

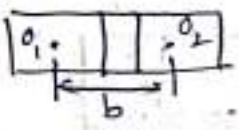
XX

$$b = \frac{Bf}{H}$$



where

b → photo base (length of airbase on photo)

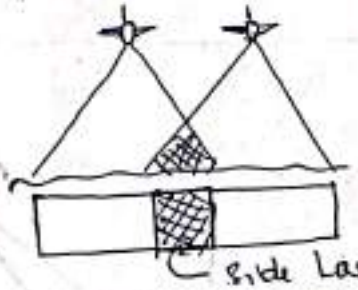


CALCULATION OF NUMBER OF PHOTOGRAPH

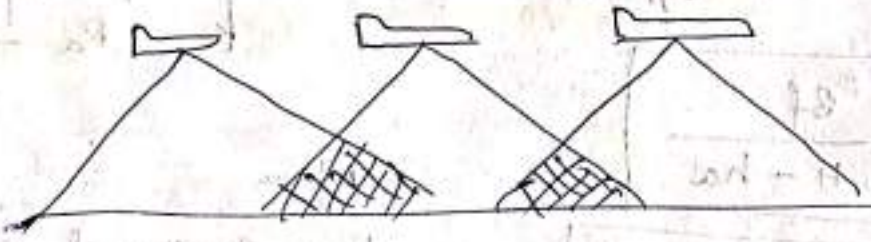
number of photo (N)

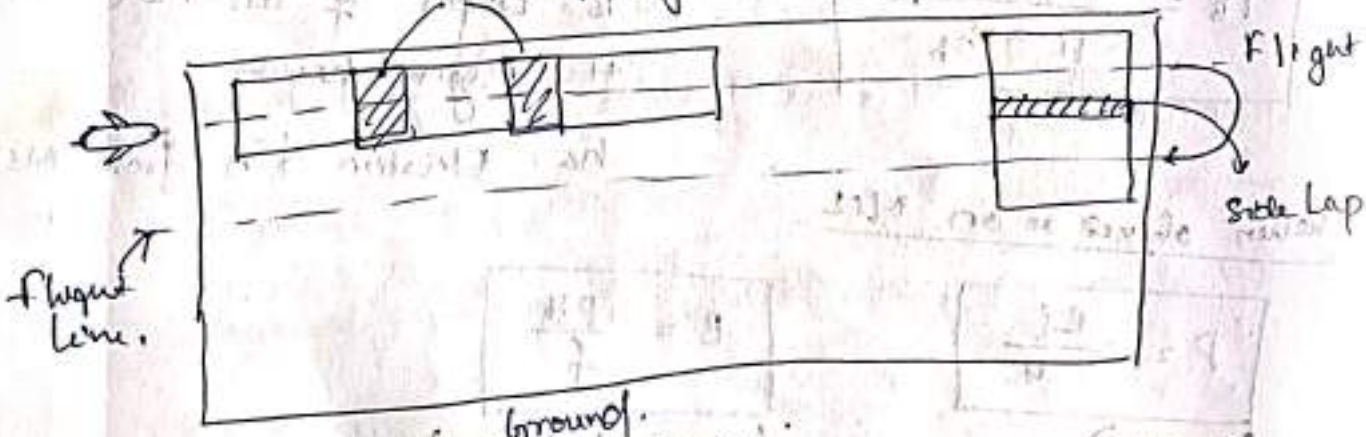
$$N = \frac{\text{Area to covered on Ground (A)}}{\text{Area Covered by one photograph on Ground (a)}}$$

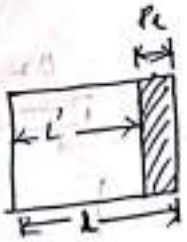
1# SIDE LAP :- (Ps) Generally taken as 30% (15–20%)



2. LONGITUDINAL LAP :- (End Lap) Also known as End Lap. Generally taken as 60% (Pl)





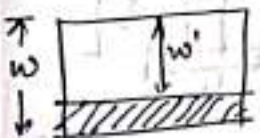


$$l' = L - (Pl)\cdot L$$

$$\boxed{l' = l\cdot(1 - P_l)}$$

Area of photo

$$\boxed{L(1-P_l) \times w(1-P_s)}$$



$$w' = w - (P_s)\,w = \boxed{w(1-P_s)}$$

Area covered by one photo on Ground = $\frac{l(1-P_l)}{s} \times \frac{w(1-P_c)}{s}$

So, Number of photograph required (N)

Stereoscopy

$$N = \frac{1}{\frac{l(1-P_l) \times w(1-P_c)}{s^2}}$$

$$N = \frac{As^2}{l(1-P_l) \cdot w(1-P_c)} \quad ***$$

Where

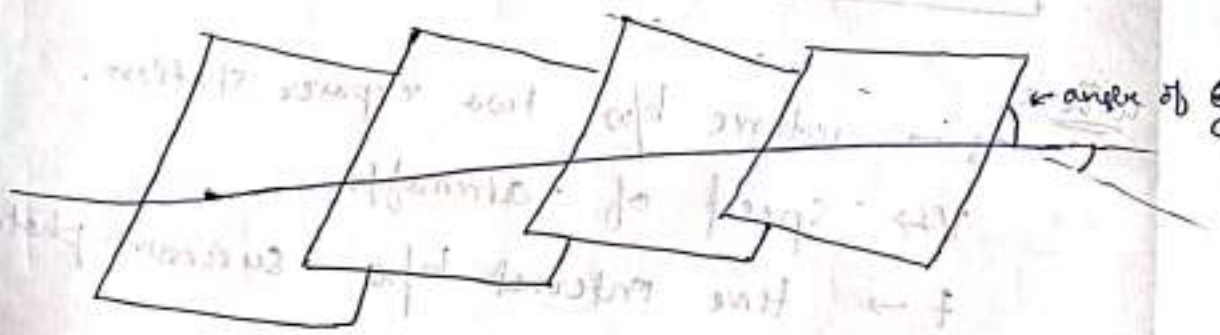
S: Scale
P_l: Longitudinal lap.
P_c: Side lap / End lap.

N = total number of photograph.

CRAB :-

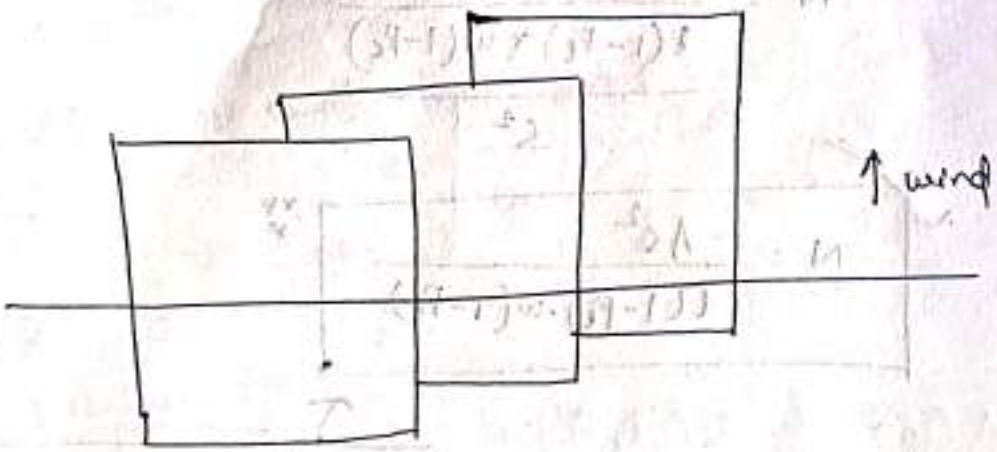
→ It is the angle formed by edge of the photograph with flight line

→ When camera is not square with direction of flight at the time of exposure an angle formed between flight line and edge of photograph. There angle is known as crab angle and effect is known as crab.



DRIFT

→ It is the lateral displacement of photographs & photo does not stay on its predetermined path due to effect of wind.



INTERVAL BETWEEN EXPOSURE :-

velocity = $\frac{\text{distance}}{\text{time}}$

$$\text{time (hr)} = \frac{\text{distance (km)}}{\text{velocity (km/hr)}}$$

$$t\,(\text{sec}) = \frac{3600\,B}{V}$$

where

B → distance b/w two exposer station.

V → speed of aircraft.

t → time interval b/w successive photograph.

Numericals

① In a aerial photogramatric Survey, if the exposure interval 20 sec to cover a ground distance of 100 m b/w exposer. what would be Ground speed of aircraft.

m/sec → Kmph

Soln Data Given

t = 20 sec

d = 700 m.

velocity = $\frac{\text{distance}}{\text{time}} = \frac{700\text{m}}{20\text{sec}} = 35 \times \frac{18}{5} = 180$ Kmph.

CH-12 MISCELLANEOUS TOPIC.

Theory of Error
Laws of Weights
Triangulation.
Advance Surveying Equipments.

1. THEORY OF ERROR:-

1. Human Error / Personal Error: (due to human error while reading / writing)

2. Instrumental Error: Due to faulty Instrument.
   Eg → Increase in length of chain / tape.

3. Natural Error:— Due to natural reason. E.g. Local Attraction, Tamperature Variation.

Note

Smallest length of line that can be drawn on map = 0.25 mm.

following type of error are observed in measurement.

1. Mistake: Inexperience or Carelessness.

2. Systematic / Cumulative error:— These error follows some patterne (i.e. magnitude & nature remain same for same cnd). Can be computed very easyly & suitable Correction can applied. $E \propto L$

3. Random / Accidental / Compensating Error :—

→ Occur due to ~~lack~~ of lack of perfection.

→ Tend to compensate each other when large in number.

$$e \propto \sqrt{L}$$

3. RANDOM / ACCIDENTAL / COMPENSATING ERROR :—

True Value → Exact value of quantity

Most probable Value → Value which is closer to true value.

↓ Most probable Value :—

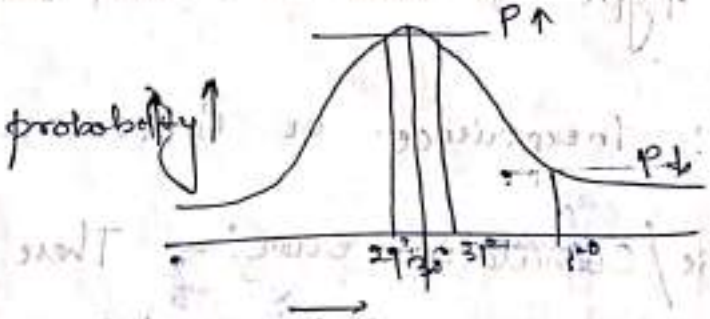
It is the value closer to the true value.

Error = Measured Value − Most probable value.

$$E = MV - MPV$$

→ Accidental error follows probability and statistics.

→ Accidental error also known as probable error.



Note → Accidental Error follows Normal Distribution Curve / Gaussian Distribution Curve.

→ Small error occur more frequently than Large Error.

→ Probability of positive and negative same magnitude of error is equall.

RULE OF WEIGHTAGE :—

→ Weightage of Quantity signifies relative precision.

→ Weightage always is expressed as number, higher is weightage is higher in precision lower the weightage lower in precisions.

→ Weatage are allocated to observation according to different rules.

(i) Weitage is inversly proportional to variance. (How far any value for MPV).

$$w \propto \frac{1}{\text{Variance}}$$

MPV = 30°

$\angle A = 29°$ (diff - 1°) ← Variance

$\angle A = 10°$ (diff - 20°)

(ii) Weitage of Quantity measured in similar conditions is directly proportional to no. of time Quantity is being measured (n).

$$w \propto n$$

$\angle A = 30°$ (6 times)

$\angle B = 28°$ (3 times).

(vii) Weightage also assign on the basis of experience.

(iv) Weightage of level length $\propto \frac{1}{\text{Length of length}}$.

CASE-I

DIRECT OBSERVATION OF EQUAL WEIGHTS :-

Eg:

$\angle A = 40^\circ$ $\quad w_1 = 1$

$\angle B = 30^\circ$ $\quad w_2 = 1$ } equall.

$\angle C = 50^\circ$ $\quad w_3 = 1$

$$\text{MPV} = \frac{\angle A + \angle B + \angle C}{3}$$

* Standard Deviation

Gen formula

$$\sigma = \sqrt{\frac{\Sigma v^2}{n-1}}$$

V = Variable. x_1, x_2, x_3

$$\bar{x} = \frac{x_1 + x_2 + x_3}{3}$$

$$\left.\begin{aligned} v_1 &= x_1 - \bar{x} \\ v_2 &= x_2 - \bar{x} \\ v_3 &= x_3 - \bar{x} \end{aligned}\right\}$$

n = number of observation.

I. Probable error of Single Observation / Standard deviation.

$$(\sigma_s) \quad E_s = \pm 0.6745 \sqrt{\frac{\Sigma v^2}{n-1}}$$

2. Probable error of average :-

imp → $E_{avg} = \pm \frac{E_s}{\sqrt{n}}$

n = total no. of observation.
E_s = probable error of single observation.

for table examination

Eg :-
Given $E_s = \pm 0.04$ m.
$E_{avg} = \pm 0.01$ m.

Soln
total no. of observation = ?

$$E_{avg} = \pm \frac{E_s}{\sqrt{n}}$$

$$\sqrt{n} = \pm \frac{E_s}{E_{avg}} \Rightarrow n = \left(\pm \frac{E_s}{E_{avg}}\right)^2$$

$$n = \left(\frac{0.04}{0.01}\right)^2 = (4)^2 = 16$$

CASE-2

DIRECT OBSERVATION OF UNEQUAL WEIGHT :-

Eg

			average	wt
$\angle A = 90^\circ$	wt = 2		I (x_1)	2
$\angle B = 80^\circ$	wt = 3		2 (x_2)	3
$\angle C = 10^\circ$	wt = 2.		3 (x_3)	2

$$MPV = \frac{w_1 x_1 + w_2 x_2 + w_3 x_3}{w_1 + w_2 + w_3}$$

(weighted avg).

(1) Probable Error of Single Observation :—

$$E_s = \pm 0.6745 \sqrt{\frac{\omega v^2}{n-1}}$$

(2) Probable Error of observation having weight 'w' :—

$$E_\omega = \frac{E_s}{\sqrt{w}}$$

Newton concept

Question

(1) Calculate Probable Error of area of circle of radius of circle = $12.25 \pm \underline{0.3\ m.}$ ↓ Random error.

Soln

Area of circle $= \pi r^2$

Step → $A = \pi r^2$

$$\frac{\partial A}{\partial r} = \pi \cdot 2r$$

$$\partial A = 2\pi r\, \partial r$$

$$= 2\pi (12.25)(0.3)$$

$$\partial A = 23.09\ m^2$$

↓ Random error in Area

Question

Radius of circle = 21 m with probable error ±0.21. Calculate probable error of circumference.

Soln

$$C = 2\pi r$$

$$\frac{\partial C}{\partial r} = 2\pi$$

$$\partial C = 2\pi \cdot \partial r$$

$$= 2\pi \times 0.21$$

$$\partial C = \pm 1.319\ m$$

PRECISION & ACCURACY

* PRECISION :— Degree of fineness of care with which any physical measurement is done.

* ACCURACY :— Degree of Perfection.

→ A value is accurate when it is claimed to true value.

→ Precise value represents set of observation that are clowed by, Grouped & have small deviation from true value.

→ Accurate
→ precise.

→ not accurate.
→ Precise.

→ not accurate
→ not precise.

B # LAWS OF WEIGHTAGE (V. Imp)

(I) The weightage of algebric sum or substraction of two or more observation is equal to reciprocal of summation of reciprocal of their individual weight.

Example

$\angle A = 30^\circ$ wt = 3.
$\angle B = 40^\circ$ wt = 2.

$\angle A + \angle B = 30^\circ + 40^\circ = 70^\circ$ wt $= \frac{1}{\frac{1}{3}+\frac{1}{2}} = \frac{6}{5}$

$\angle A = w_1$, $\angle B = w_2$

$$\angle A \pm \angle B \;/\; \angle A - \angle A = \frac{1}{\frac{1}{w_1} + \frac{1}{w_2}}$$

(2) If quantity of given weight is multipled by a factor the weight of reasult obtain by dividing its given weight by square of the ~~factor~~ factor.

Example

$\angle A = 90°$ $\quad wt = 3$

$4 \times \angle A = 160° \rightarrow wt = \frac{3}{(4)^2}$

Generally

$\angle A \Rightarrow wt = w_1$

$x \cdot \angle A \Rightarrow \boxed{wt = \frac{w_1}{(x)^2}}$

(3) If quantity of given weight is devided by factor the weight of reasult is obtain by multiplying its given weight by square of that factor.

Example

$\angle A = 100° \quad wt = 3$

$\frac{\angle A}{5} = 20° \Rightarrow wt = 3 \times (5)^2$

$\angle A \Rightarrow wt = w_1$

$\frac{\angle A}{x} \Rightarrow \boxed{wt = w_1 \times x^2}$

(4) Weight of arithmic mean of number of observation of unit weight is equall to no of observation.

Example

$\angle A = 30° \quad wt = 1$

$\angle B = 20° \quad wt = 1$

$\angle C = 10° \quad wt = 1$

$\frac{\angle A + \angle B + \angle C}{3} = 20° \Rightarrow \boxed{wt = 3}$

(5) Weight of weighted mean arithmetic mean is equal to sum of individual wt.

Example

$\angle A = 20^\circ$ wt = 2

$\angle B = 10^\circ$ wt = 1

$\angle C = 30^\circ$ wt = 3

Weighted Average = $\frac{20\times2 + 10\times1 + 30\times3}{2+1+3}$ = 3

wt = (2+1+3) = 6

(6) If an equation is multiplied by its own weight. that weight of resulting eqn is equal to reciprocal of weight of weight of equation.

Example

$\angle A + \angle B + \angle C = 10^\circ$ ⊗ wt = 4

$4(\angle A + \angle B + \angle C) = 40^\circ$

$\boxed{wt = \frac{1}{4}}$

$\angle A + \angle B$ = wt = w_1

$w_1 (A+B) \longrightarrow$ weight = $\frac{1}{w_1}$

(7) The weightage of an equation remain same if all sign of equation are changed

Example

$\angle A + \angle B = 30^\circ$ wt = 3

$-\angle A - \angle B = -30$ $\boxed{wt \rightarrow 3}$

(8). Weight of equation remain unchanged of equation is added to or subtracted from a constant.

$(\angle A + \angle B) \Rightarrow$ wt = 5^{-1}

$15^{-0} + (\angle A + \angle B) \Rightarrow$ wt = 5^{-00}

$15^{-} - (\angle A + \angle B) \rightarrow$ wt = 5^{-0}

C # TRIANGULATION

→ In triangulation, entire area to be surveyed is covered with framework of triangles.

→ The main objectives of triangulation is to Locate the stations → Plain Survey
→ Geodetic Survey.

→ Suitable for hilly areas where traversing is not suitable.

→ If length & Direction of one side of the triangle are measured precisely length of the other two can be computed.

→ The length of the first line which is measured precisely is known as "BASE LINE".

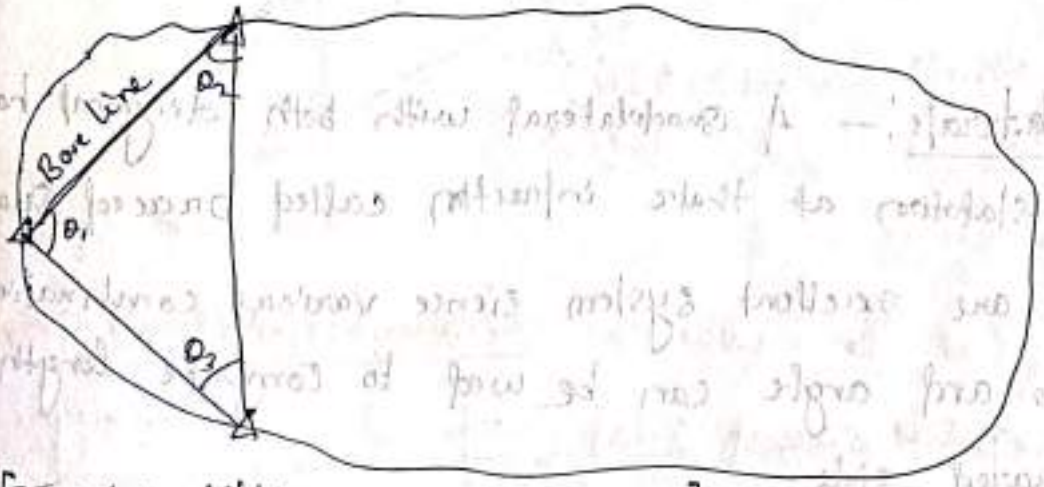
→ It is measured with invar tape or by EDM. (for more accuracy)

Applications :— Establishing accurately control point for plan and geodatic survey of large area.

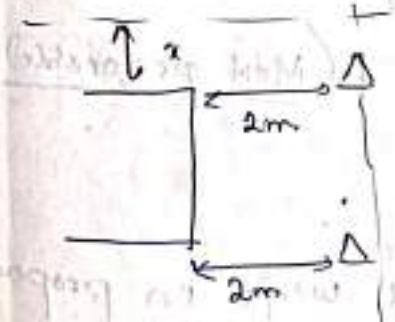
Control Points :— They are established on ground for reference during construction.

(1) Horizantal Control : (Horizantal plane)

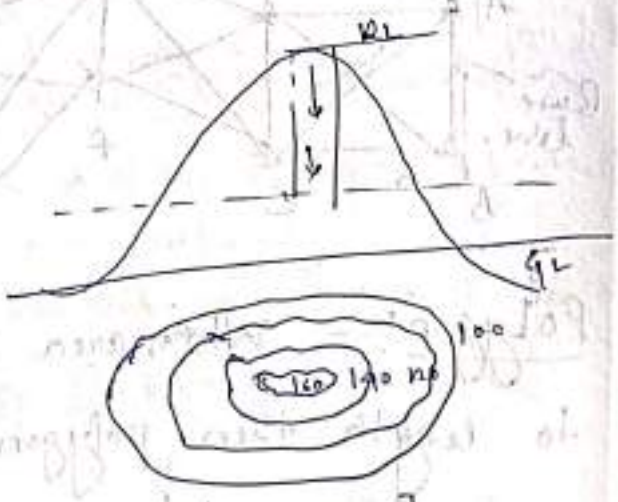
(2) Vertical Control (Vertical plane) : It consist of establishment of reference mark of known height relative to the some specified datum.



[Well condition triangle is used [30° - 120°]]



[Horizantal Control]

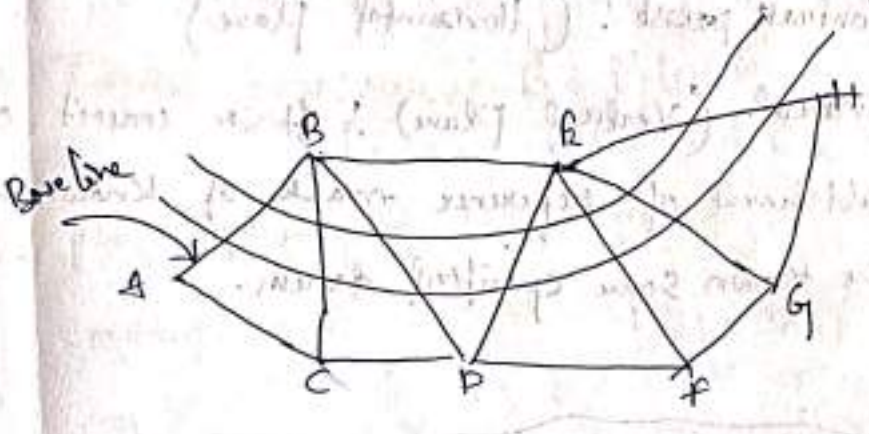


[Vertical Control]

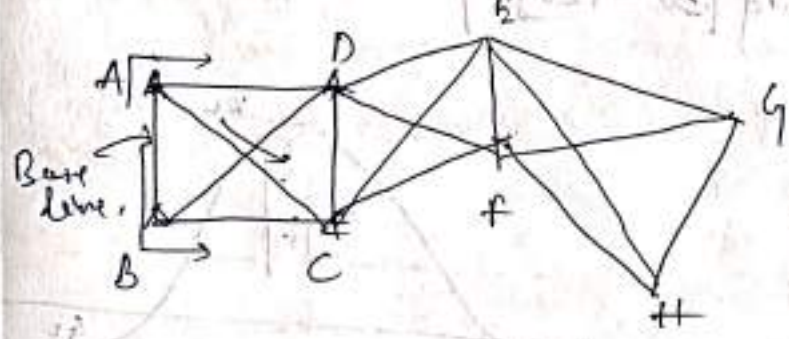
TRIANGULATION FIGURES

1. Triangle:- It is very rapid and economical when a narrow strip of terrian is to be surveyed.

Eg→ Highway, river, valley etc.

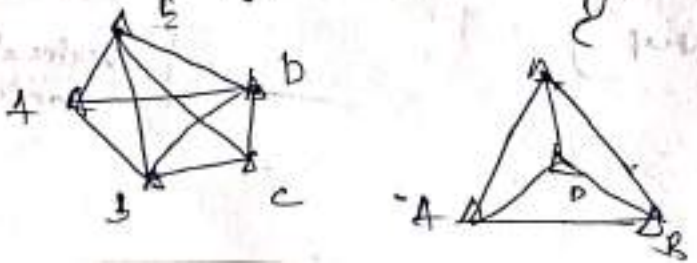


2. Quadrilaterals:- A quadrilateral with both diagonal having no station at their intersection called braced Quadrilateral. These are excellent system sience various combination of sides and angle can be used to compute length of required side.



(Most preferable)

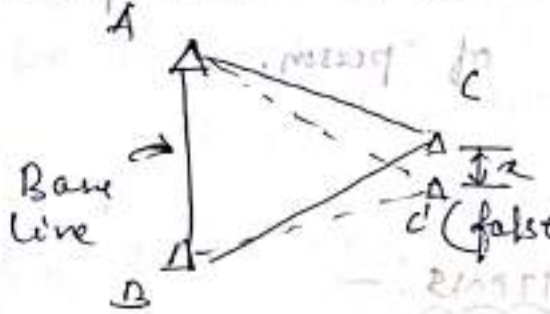
3. Polygon:- When area are more wide in proportion to length then polygon figure may be economical.



SATELLITE STATION :-

→ To have intervisibility of station and to achive well conditional triangle sometime high object like church spiare are selected as a triangulation station.

→ If it is impossible to set up instrument over such station, in such case we use nearby station called satellite station or false station.



Note
Important topics on triangulation

Triangulation → triangle → Control point → Construction
H V

→ Well conditional triangle.

→ Base line → Invertape / EDM ← measured by

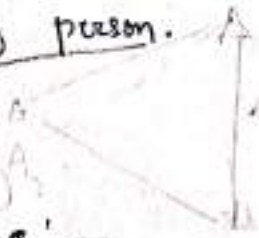
→ fig → triangle → Strip of terrain → Highway, River, Valley.
Quadilateral → Most preferable
Polygon → Area having very wider then length.

→ false station / satellite station.

D. ADVANCE SURVEYING INSTRUMENT :-

MINOR INSTRUMENTS

1. GHAT TRACER : To measure slope / Gradient.
2. CLENOMETER : To measure slope Angle.
3. THE PENTAGRAPH : Use for reproducing, enlarging or reducing map.
4. THE SEXTAND : Arrangement of mirror such that observer can see two different objects simultaneously. Use to measure horizontal & Vertical angle.
5. PASSOMETER/ PEDOMETER : Use to measure pace & each step of person.



IMPORTANT DEFINATIONS :-

* GREAT CIRCLE :- If a circle is drawn on sphere so that the radius of circle is same as radius of sphere is called great circle. It is a imaganary circle passing through Centre of earth.

Properties of Spherical Triangle

→ All three sides are arc not straight lines.

→ Three angle of spherical triangle are always grater then 180° and Less then 540°.

→ Infinite Great circle may pass through one point.

MODERN SURVEYING INSTRUMENT

DIGITAL LEVEL

Traditionally level used for measurement of elevation difference.

→ Dumpy Level
→ Tilting Level
→ Automatic Level

Digital Level :—

(microprocessor)

→ Digital level use electronic image processing to evaluate special bar code staff reading.

→ Bar code pattern (digital staff 4.05 m) is converted into evaluation and distance values using digital image matching process.

→ Staff reading can be seen on display of digital level in 4 sec.

DISTANCE MEASUREMENT :—

* Direct Distance Measurement : Chain/tape
* Optical distance Measurement : Tacheometry
* Electromagnetic Distance Measurement : EDM