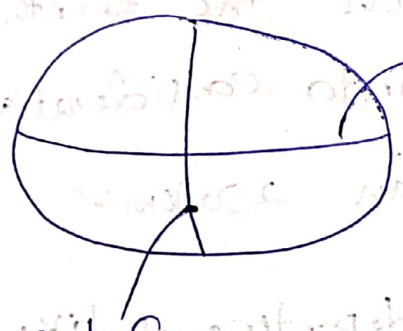
# Surveying

Surveying is the art of determining the relative position of points on or below the surface of the Earth by considering linear and Angular measurements.

→ Shape of Earth

a) oblate spheroid

b) oblate Ellipsoid



Equitorial Axis

EA > PA (By 42.95 km)

polar Axis

[Radius of Earth (R) = 6370 km]

Geoid → Zero elevation surface.

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Types of Surveys

a) on the Basis of Accuracy

i) plane surveying:

a) The surveying in which the spheroidal shape of Earth is not considered and Assumed as a flat surface

b) plane surveying is carried out over an Area less than 250 km²

c) plane surveying is carried out by the state government departments like Irrigation, P&B etc.

d) Degree of Accuracy obtained is low

2) Geodetic surveying:

a) The survey in which the Earth's curvature is taken into consideration

b) Area greather than 250 km²

c) central government departments like ies survey of india department

d) Degree of Accuracy obtained is high.

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b) On the basis of place :—

a) land survey
b) Hydrographic survey
c) underground survey
d) Aerial survey

e) Astronomical survey

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c) on the Basis of instrument -

⇒ chain survey
⇒ Compass survey
⇒ Theodolite survey
⇒ Levelling
⇒ plane Table survey
⇒ Tacheometry
⇒ Total station
⇒ E.D.M

d) on the Basis of purpose :

⇒ Topographic survey
↓
deals Topographical Features of earth
ie, rivers, hills, valleys, mountaines, etc

⇒ Engineering survey
↓
Detailed Quantity with drawing

⇒ Cadastral survey

⇓

To fix the Boundaries of land & This survey is carried by "Revenue Engineer"

⇒ Geological survey

⇓

deals with Minerals, Fold, Fault etc.

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Note:

① under plane survey, two plumb lines are parallel

② under geodetic survey, two plumb lines are intersect at center of earth

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principles of surveying =

1) To work from whole to part

2) To locate a New station by at-least 2 References

## scale

Representation fraction (RF) = $\frac{\text{Map distance}}{\text{ground distance}}$.

→ large scale
→ small scale

which one is larger

a) 1 : 1000 (larger)  b) 1 : 10,000 (smaller)

## Types of scale :

1) plain scale → used to represent two consecutive units (2D)

2) Diagonal scale → used to represent three consecutive units (3D)

3) Vernier scale → used for Exact Measurement

Type

i) Direct Vernier

→ calibration is same direction as main scale

→ one division str length slightly smaller than Main scale

$V < S$

v → vernier reading
s → Main scale

→ L.S ⇒ Least count (L.C)

L C ⇒ $\frac{S}{n}$ , n ⇒ no. of divisions

ii) Retrograde vernier

→ Calibration opposite direction

→ V > S

→ L.C ⇒ $\frac{S}{n}$

iii) Double Vernier

→ Vernier is provided in both direction

→ Main scale also calibrated in both directions.

iv) Extended Vernier ;

n → division in vernier equal to (2n-1) division in main scale

Shrunk scale :

"Shrunk scale = shrinkage factor x original scale"

suppose shrunk scale is

1cm = 10m

So Area scale will be

$(1cm)^2 = (10m)^2$

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1) CHAIN SURVEYING

→ chain surveying is limited only to "linear Measurements"

→ suitable for small ground area

→ Fit for flat ground

principle → "Triangulation"

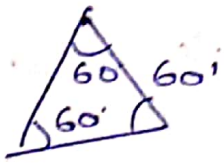
a) well conditioned Triangle → $\theta = 30° - 120°$

↳ not less than 30° and not more than 120°

b) ill Conditioned Triangle

angle should less than 30° and more than 120°

**Ideal Triangle** → Angles in $\Delta^{le}$ are 60° only




## Types of chain

1. Metric chain
   - 20m (100 links)
   - 30m (150 links)
2. Engineers chain → 100ft (100 links)
3. Gunter's chain → 66 fts (100 links)
4. Revenue chain → 33 fts (16 links)

## Lines

a) Main line → Joins Main Stations

b) Base line → Biggest Central line

c) Checklines / proof lines → To check the accuracy of work

d) Tie line → To locate the interior details on Main line.

clinometer — to determine slope of ground

optical square :—

— a) used to set out 90°

— b) Two mirrors one is horiz mirror and another index mirror

— c) Based on the principle of "Double Reflection"

Correction of in Chain surveying —

(1) Due to standardisation —

$$\text{True length} = \frac{\text{Incorrect length}}{\text{correct length}} \times \text{Measured length}$$

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

$l' > l$, Corr$^n$ → +ve

$l' < l$, corr$^n$ → −ve

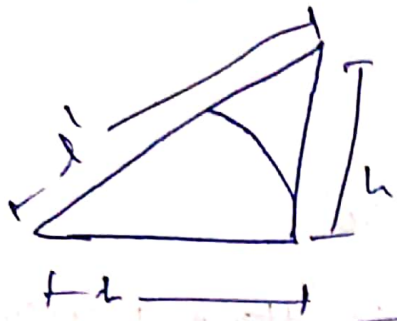
→ Area Measurement —

$$A \Rightarrow \left(\frac{l'}{l}\right)^2 \times A'$$

→ Volume Measurement

$$V \Rightarrow \left(\frac{l'}{l}\right)^3 \times v', \quad v' \Rightarrow \text{Measured volume.}$$

② Due to slope :—



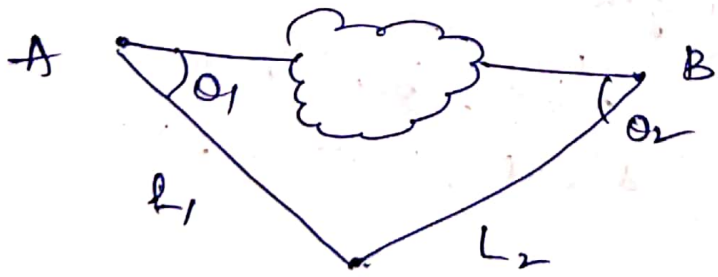

$C_{slope} = l' - l$

$$C_{slope} = l' - \sqrt{l^2 - h^2}$$

$$C_{slope} = \frac{h^2}{2L}$$ ← Approx formula

∴ slope correction is always "Negative" in Nature

③ Due to mis-alignment :—




$$C_{Mis} = L_1 + L_2 - (L_1 \cos\theta_1 + L_2 \cos\theta_2)$$

∴ Correction due to mis-alignment is also "Negative" in Nature

④ Due to Temperature :—

$C_{Temp} = l \alpha (T_m - T_o)$ where

$l \Rightarrow$ length of chain

$\alpha =$ coefficient of thermal Expansion

$T_m \Rightarrow$ Temp at a Time of Measure

$T_o \Rightarrow$ standard Temperature.

→ $T_m > T_o$, $C_{Temp} \Rightarrow +ve$

$T_m < T_o$, $C_{Temp} = -ve$

⑤ correction due to pull :—

$$C_{pull} = \frac{(P_m - P_o) l}{A E}$$ where

$P_m =$ pull at the Time of Measurement

$P_o \Rightarrow$ standard pull

$l \Rightarrow$ length of chain

$A \Rightarrow$ Area of cross-section

$E \Rightarrow$ youngs modulus of chain

→ $P_m > P_o$, $C_{pull} \Rightarrow +ve$

$P_m < P_o$, $C_{pull} \Rightarrow -ve$

(6) Correction due to sag :-

$$C_{sag} = \frac{w^2 l^3}{24 P_m^2}$$

$w$ = wt of chain per 'm' length

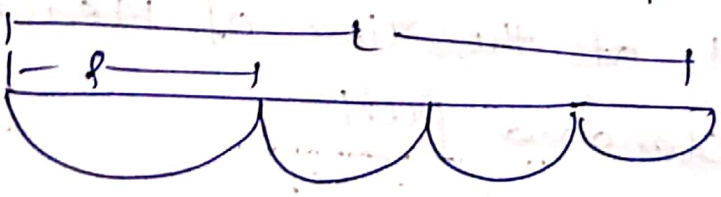
$l$ ⇒ length of chain

$P_m$ ⇒ pull at the Time of Measurement

∴ Note : sag correction is always Negative in Nature

→ Note, $$C_{sag} = \frac{w^2 L^3}{24 P_m^2 \cdot n^2}$$

$L$ ⇒ Total length of line and it is suspended in $n$ equal parts




$$n = \frac{L}{l}$$

$$n = \frac{L}{l}$$

Normal Tension :

+ve pull correction = −ve sag correction

$$\frac{(P_m - P_0)\,l}{AE} = \frac{w^2 l^3}{24 P_m^2}$$

$P_m \rightarrow$ Normal Tension.

(7) Correction due to Reduction to MSL

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

$R$ = Radius of Earth

→ This correction is always Negative in Nature

Total Correction ⇒ Sum of all correction

$$C_{Total} \rightarrow \pm C_{standard} - C_{slope} - C_{MS} \pm C_{temp} \pm C_{pull} - C_{sag} - C_{MSL}$$

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## ⇒ Limiting length of offset

Case-01 Error only in laying direction


Error on paper ≠ 0.025cm (CC)

$\frac{1}{4}$ 0 cm

$$l = \frac{0.025}{\sin\theta}\ m$$

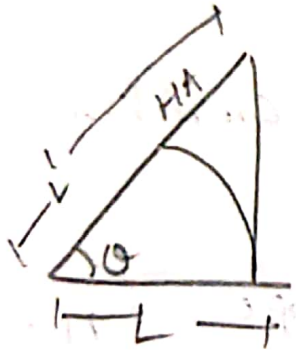
$$l \rightarrow \frac{0.025\ s}{\sin\theta}\ m$$

Case-02 :

Error in laying direction as well as in length Measurement

$$l = \frac{1}{\sin\theta}\sqrt{(0.0255)^2 - x^2}$$

Hypotenusal Allowance ; (HA) :=




$$HA \Rightarrow L' - L$$

$$HA \Rightarrow l(\sec\theta - 1)$$

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## 2) COMPass surveying

principle :- Traversing

Types OF Traverse

→ Open Traverse

→ closed Traverse

Meridian ; fixed Reference line:

Types ① True meridian
② magnetic meridian
③ Arbitary meridian
④ Grid meridian

Bearing : Angular Measurement from the fixed reference line

① True Bearing
② Magnetic Bearing
③ Arbitary Bearing
④ Grid Bearing

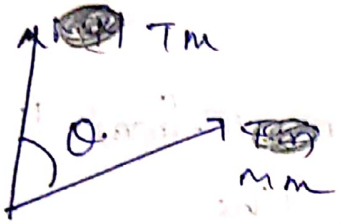
System OF Bearings :

1) WCB (whole circle Bearing)
→ Fixed direction ⇒ North
→ Movement ⇒ clockwise
→ Range ⇒ 0° to 360°
→ Instrument ⇒ prismatic compass

2) Reduced Bearing (RB) (or) QB
→ Fixed Direction → North / South
→ Movement → Clockwise / Anti-Clockwise
→ Range ⇒ 0° to 90°
→ Instrument → surveyor's Compass

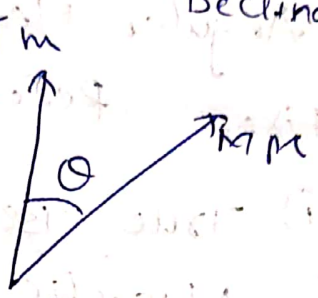
## → Magnetic Declination :—

Horizontal angle between the True meridian and magnetic meridian



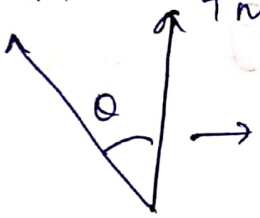

θ → magnetic Declination

a)




Declination East (positive)

b)




Declination west (Negative)

## True Bearing (TB) :—

TB = Magnetic Bearing ± Declination

Magnetic Bearing = TB ± Declination

Declination East → +ve

Declination West → −ve.

## Variation in Declination :

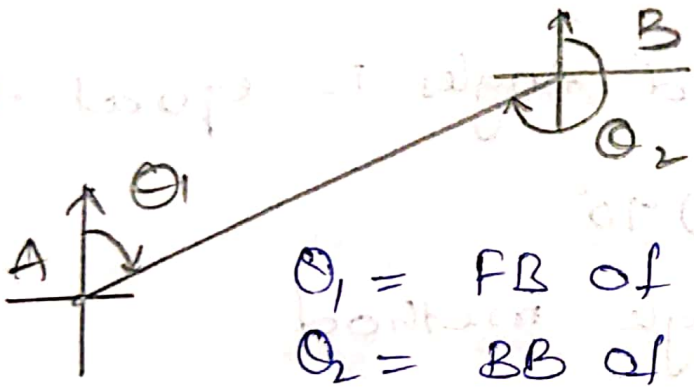
a) Diurnal / Daily variation

b) Annual / yearly variation

c) Irregular variation

d) Secular variation

## Fore and Back Bearing :




$\theta_1$ = FB of line AB

$\theta_2$ = BB of line AB

## Calculation of FB and BB

$$BB = FB \pm 180$$

(1) FB < 180°, then BB → FB + 180

(2) FB > 180°, then BB → FB − 180°

$$\therefore FB - BB = \pm 180°$$

## Local Attraction :-

Magnetic object that deflect magnetic needle from exact magnetic north & south pole.

$\therefore FB - BB \neq 180^\circ$

Methods to correct Bearing :

(a) Direct method

↓

Sum of included Angles is equal to

→ $(2n-4)\,90^\circ$

(b) Included Angle method

**Dip** :- Vertical angle between magnetic force direction and surface of Earth

at Equator → Angle of Dip = $0^\circ$ (min)

at poles → Angle of Dip = $90^\circ$ (max)

1) Isogonic line → Line with 'same Declination"

2) Agonic Line → Lines with zero declination.

In Agonic line, Both TM and MM Coincides with each other

3) Isoclinic line → Line with same Angle of Dip

4) Aclinic line → Zero Angle of Dip

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## Traverse surveying

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1) Chain Traversing :—

a) only linear Measurements

b) NO Angular Measurements

2) Compass Traversing :—

a) Linear + Angular Measurements

b) Bearing at every station by Compass

c) Also called loose-Needle method.

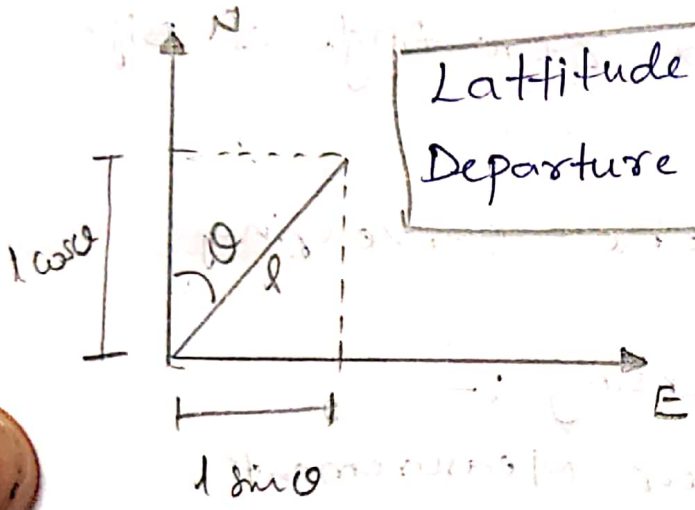
3) Theodolite Traversing :—

a) Also called "fast Needle method"

b) At every first station Bearing is measured by compass

c) At every station included angle is measured by "Theodolite"

## Latitude and Departure




Latitude → $l \cos\theta$

Departure = $l \sin\theta$

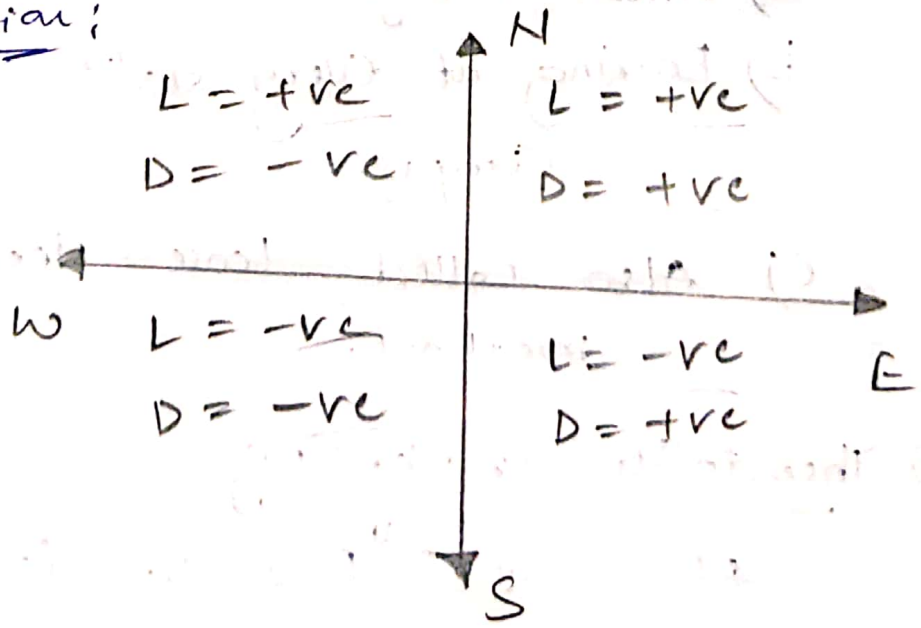
N – S – Latitude

E – W – Departure

For closed Traverse

$\Sigma$ Latitude = 0 & $\Sigma$ Departure = 0

Direction:



## Closing Error :

If $\Sigma L \neq 0$ & $\Sigma D \neq 0$

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

$$\theta = \tan^{-1}\left(\frac{\Sigma D}{\Sigma L}\right)$$ → Direction of closing error

## Methods for correction of Error :

1) Bowditch method
   → when angular and linear Measurements are taken with Equal degree of precision

Assumptions

a) Error in linear Measurements $\propto \sqrt{l}$

b) Error in Angular Measurements $\propto \frac{1}{\sqrt{l}}$

Correction :

→ Correction in Latitude

$$C_L = \frac{l_1}{P} \times \Sigma L$$

P → perimeter

→ Correction in departure :

$$C_D = \frac{l_1}{P} \times \Sigma D$$

2) Transit rule :

→ when Angular Measurements are more precisely than linear Measurements.

$$C_L \rightarrow \frac{L_1}{L_T} \times \Sigma L$$ where

$L_1$ = latitude of Line - 1

$L_T$ = summation of latitude without Considering the sign only Consider magnitude

$\Sigma L$ → summation of latitude with Considering sign.

$$C_D = \frac{D_1}{DT} \times \Sigma D$$

3) Axis method

4) Graphical method.

⇒ Adjustment of Bearing :-

Let 'e' be the closing error in bearing of last line of a closed

Traverse having "N" sides.

correction for 1st line $= \frac{e}{N}$

Correction for 2nd line $= \frac{2e}{N}$

Correction for 3rd line $= \frac{3e}{N}$

⋮

Correction for $N^{th}$ line $= \frac{Ne}{N} = e$

Q) In a closed Traverse with 5 sides, the Error found from fore bearing & Back Bearing of last line is $+2^c$. The Correction to 3rd line will be

Sol: Total Error is $= +2^c$

→ Correction for 1st line → $-\frac{2^c}{5}$

→ Correction for 2nd line $= -\frac{2 \times 2^c}{5}$

→ Correction for 3rd line

→ $-\frac{3 \times 2^c}{5}$

→ $-1^c 12' 0''$

# CONTOURING

**Contour :** An imaginary line on the ground joining the points of Equal Elevation

[Elevation = RL = Vertical Distance]

**Horizontal Equivalent :**

The horizontal distance between 2 Consecutive Contours

**Contour interval :**

The Vertical distance between 2 Consecutive Contours

**properties of contours :-**

1) Widely spaced Contour - Flat surface
2) closely spaced Contour - Steep slope
3) Equally spaced Contour - uniform slope
4) Approximately Concentric load contours with decreasing values towards center - "pond"

5) Concentric load contour with increasing values towards center - "hill"

6) V-shaped contours with convexity towards higher ground - "valley"

7) U-shaped contour with convexity towards lower ground - "Ridge"

8) If contour lines meet at a point - Existence OF CLIFF (or) cell

9) If Contour cross each other indicates the Existance of overhanging cliff (or) cave.

## USES OF CONTOUR MAPS :-

1) Preliminary selection of project works
2) Drawing the sections
3) Determination of Intervisibility
4) Location of Routes
5) Determining Catchment Area
6) Calculation of Reservoir capacity.

# LEVELLING

levelling : It is an Art of determining the relative heights of an object on or below the surface of the Earth.

(or).

It is the determination of Reduced levels of different points with respect to certain Datum (MSL)

Terminology

a) Reduced level (RL) :

The vertical distance of a point above or below the datum line is known as Elevation (or) Reduced level of that point.

RL is also known as Elevation

b) Datum : The imaginary level surface with reference to which vertical distances of different points are Measured. Called Datum surface

⇒ Datum as M.S.L

c) Mean sea level (MSL) :

This is the mean level of sea obtained by taking the average of all tide heights as measured at hourly interval over some specified period.

⇒ M.S.L is taken as standard datum surface

⇒ Duration of 19 years is for High precision.

d) level surface :

Any surface parallel to mean spheroidal surface of earth, is said to be level surface.

Ex: The water surface of a still lake is considered to be a level surface.

e) line of collimation :

It is an imaginary line joining the intersection of cross hairs at the Diaphragm to the optical center of objective and its continuation.

Line of collimation is also called as line of sight

(f) Bench mark : It is a fixed reference point of known elevation

i) Great Trigonometric survey BM (G.T.S)

⇒ Established by the survey of india department at an interval of about 100km all over the country.

ii) permanent Bench Mark

⇒ Established by different state government departments like R&B, Irrigation, P.W.B, Railways ..etc..

iii) Arbitary Bench mark

In this process, whole elevations are Arbitary assumed for small operations

iv) Temporary Bench Marks

BM's established temporarily

at the end of a day's work and from where levelling is continued in the Next day.

(g) Back sight (B.S): First staff reading taken in any setup of instrument

(h) Intermediate sight (I.S):

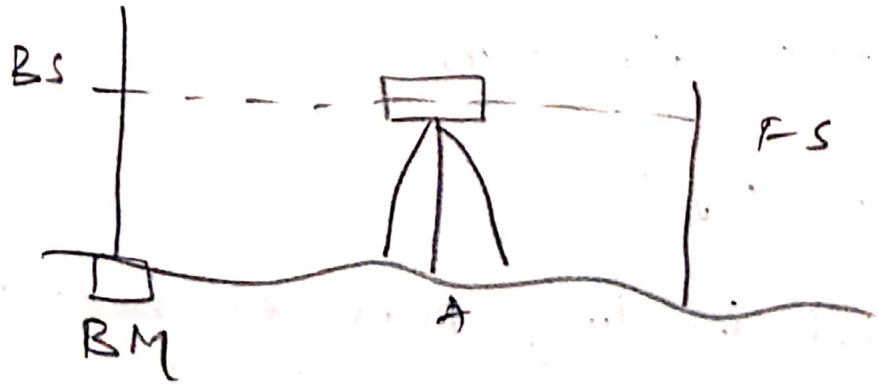
staff reading between the Back-sight and fore sight.

(i) Fore sight (F.S):

last staff reading taken from any setup of instrument.

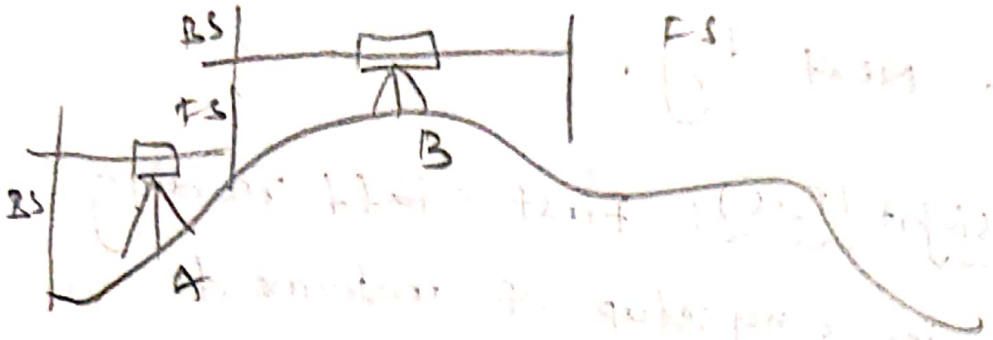
Types of Levelling:

1) simple levelling




→ No shifting of Instrument.

2) Differential levelling




→ shifting of instrument due to highly undulation in ground.

3) profile / longitudnal levelling :

→ Differential levelling done along center line of any alignment

4) cross levelling

→ levelling perform longitudnal as well as in cross-direction (or) Transverse direction

5) Fly levelling :

→ Differential levelling perform between km and starting point of any alignment

→ No need of any Intermediate sight

6) Check levelling;

→ checking Accuracy of work

→ Type of fly levelling

→ Joining start and end point by different path to check the accuracy of work.

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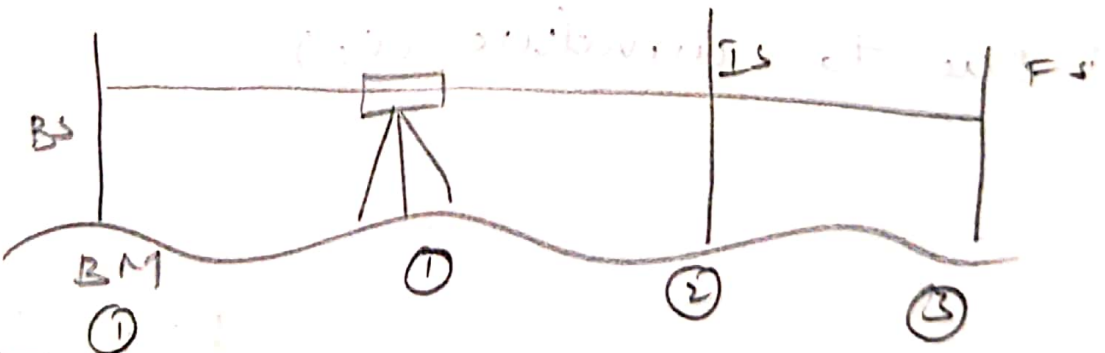
## Method of levelling

1.) Height of Instrument Method




$$HI = RL_{BM} + BS$$

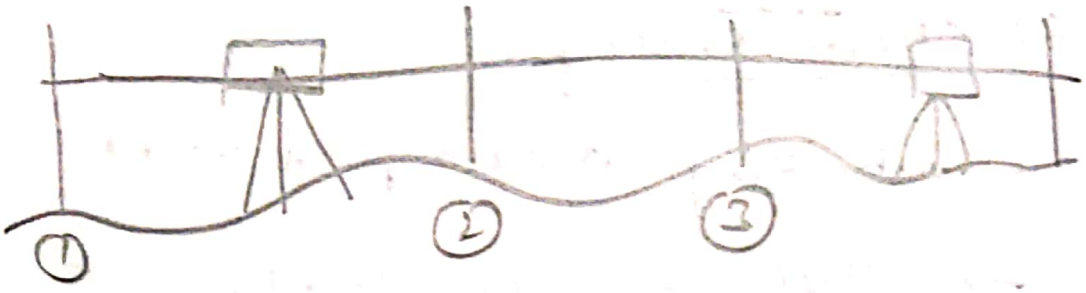
$$RL_2 = HI - IS$$

$$RL_3 = HI - FS$$

Check

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

2.) Rise and fall method:




RL of BM + Rise = RL of Next point

RL of BM − fall = RL of Next point

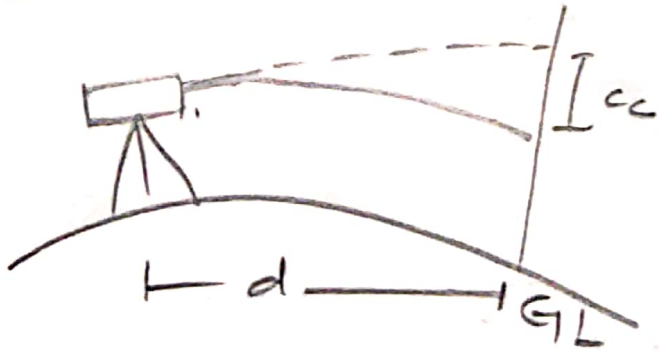
check

$\Sigma BS - \Sigma FS$ = Last RL − First RL =

$\Sigma Rise - \Sigma Fall.$

## Corrections in levelling.

(1) Due to curvature ($C_c$)




R = 6370 km

$C_c = \frac{d^2}{2R}$, R = Radius of Earth

d - Km

$C_c$ - m

$C_c = 0.0785 d^2 = 0.07850 d^2 = C_c$

This correction is always Negative in Nature

$$C_c = -0.0785 d^2$$

(2) Due to Refractive ($C_R$)

$$C_R = \frac{1}{7}(C_c), \quad C_R = \frac{1}{7}\left(\frac{d^2}{2R}\right)$$

$$C_R = \frac{1}{7} \times 0.0785 d^2$$

$$C_R = 0.0112 d^2$$

d — km

$C_R$ — m

This correction is Always +ve in Nature

(3) Due to Combined Correction

$$C = C_c + C_R \qquad \begin{pmatrix} d \to km \\ C - m \end{pmatrix}$$

$$C \to -0.0785 d^2 + 0.0112 d^2$$

$$C = 0.06373 d^2 = 0.0673 d^2 = C$$

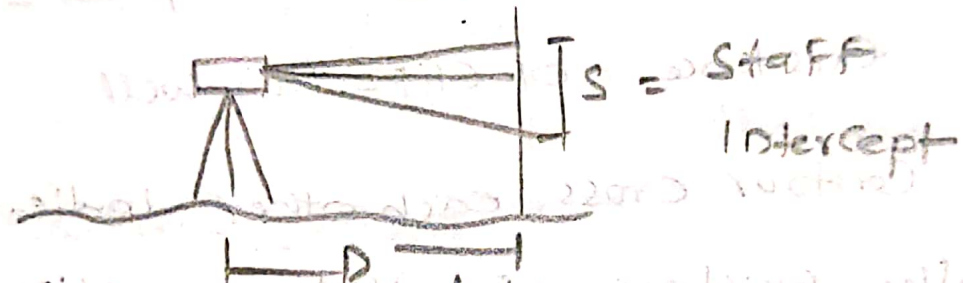
Combined Carvection $\to$ $-0.0673 d^2$

∴ combined Correction is always 'Negative' in Nature

# TACHEOMETRY

→ Special theodolite consists of Stadia Diaphargm

→ Distance and Elevation can be determined.




$$D = KS + C$$

K ⇒ multiplying constant

C ⇒ Additive Constant

## Anallactic lens — Convex Lens

→ Special type of convex lens

→ k = multiplicative const = 100

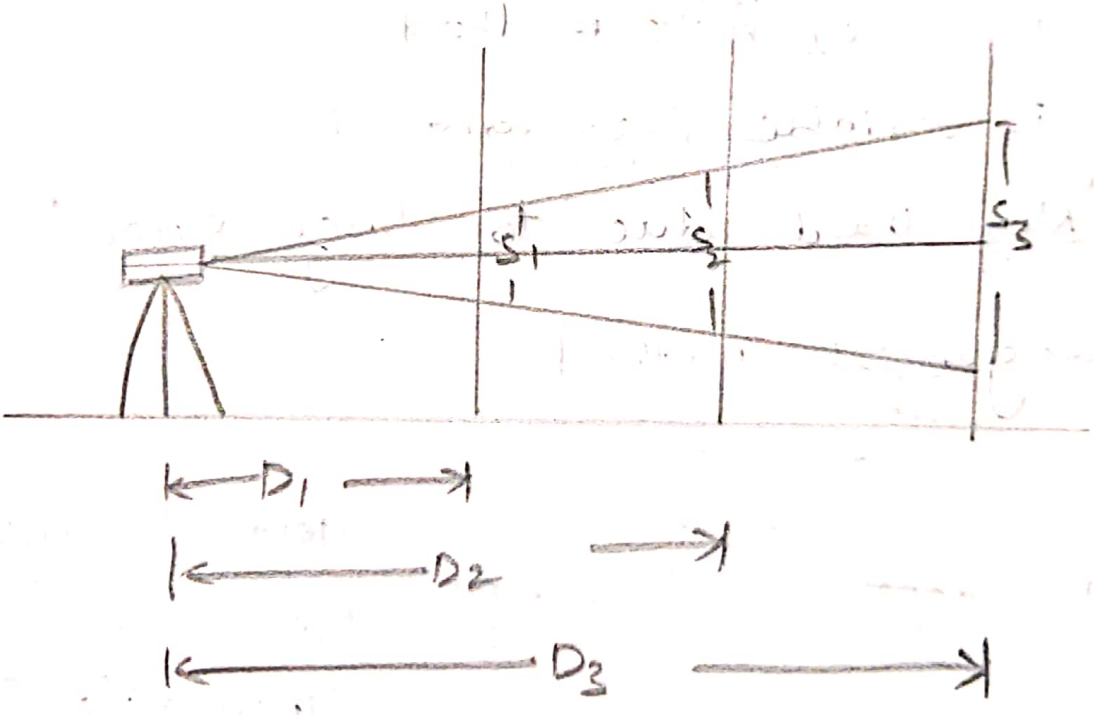
c = Additive Const = 0

K = 100, C = 0 , $D = 100S$

$K = \frac{f}{i} = \frac{\text{focal length}}{\text{Stadia intercept}}$

$C = f + d$, $d$ = distance of Vertical Axis of instrument from centre of lens.

principle of Tacheometry :




$D = Ks$ $(C=0)$

$$\frac{D_1}{S_1} = \frac{D_2}{S_2} = \frac{D_3}{S_3} = K$$

Tacheometry is Based on the principle of propefy of Isoceles Triangle

# Method of Tacheometry :

1.) Stadia hair Method

2.) Tangential Method

3.) Sub Tense bar method

## Stadia hair Method

→ fixed hair method

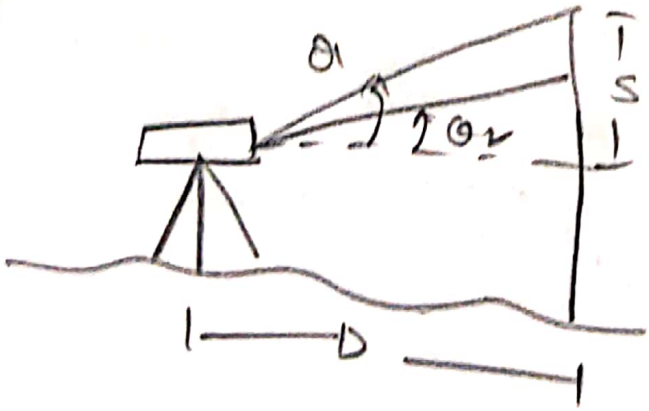
i = Constant , s = Variable

→ movable hair method

i = Variable , s = Constant

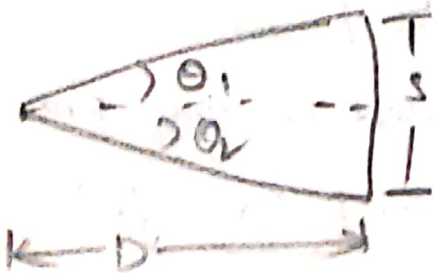
"Not used due to large error"

## Tangential method




Vertical Angle Measured by Theodolite

## subtense bar method




Horizontal Angle $\theta_1$ & $\theta_2$ measured by Theodolite