2018-19 Onwards (MR-18)	MALLA REDDY ENGINEERING COLLEGE (Autonomous)	B.Tech. III Semester		
Code: 80104	SURVEYING & GEOMATICS	L	T	P
Credits: 3		3	-	-

Pre Requisites: NIL

Course Objective: Student will be able to learn and understand the various basic concept and principles used in surveying like Chain Surveying, Compass Surveying, Plane Table Surveying, the field applications and concepts of leveling survey

MODULE-I: **[09 Periods]**

INTRODUCTION BASIC CONCEPTS: Introduction, Objectives, classifications and Principles of surveying, Scales, Shrinkage of maps, conventional symbols and code of signals, Surveying Accessories, phases of surveying.

MEASUREMENT OF DISTANCES AND DIRECTIONS:

Linear distances: Approximate methods, Direct methods-chains – tapes, ranging-tape corrections, Indirect methods- optical methods –E.D.M methods.

Prismatic Compass: Bearings, Included Angles, Local Attraction, Magnetic Declination and Dip.

MODULE-II: LEVELING AND CONTOURING: **[09 Periods]**

Leveling: Basic definitions, types of levels and leveling staves,Temporary and permanent adjustments- method of leveling. Booking and determination of levels-HI method – Rise and fall method, effect of curvature if earth and refraction

Contouring: Characteristics and Uses of contours, Direct and indirect methods of contour surveying, interpolation and sketching of Contours.

MODULE-III **[10 Periods]**

A. **COMPUTATION OF AREAS AND VOLUMES:** **Areas:**Area from field notes, computation of areas along irregular boundaries and area consisting of regular boundaries, Planimeter. **Volumes:**Embankments and cutting for a level section and two level sections with and without transverse slopes, determination of the capacity of reservoir, volume of barrow pits.
B. **THEODOLITE SURVEYING:** Types of Theodolite, description, uses and adjustments – temporary and permanent, measurement of horizontal and vertical angles. Principles of Electronic Theodolite. Trigonometrical leveling when the base is accessible and in accessible

MODULE-IV **[10 Periods]**

TRAVERSING: Methods of traversing traverse computation and adjustments , gale's traverse table, omitted measurements

TACHEOMETRIC SURVEYING: Principles of tacheometry, Stadia and tangential methods of Tacheometry.

MODULE-V **[10 Periods]**

CURVES: Types of curves, design and setting out – simple and compound curves.

INTRODUCTION TO MODERN SURVEYING METHODS: Total Station, Global positioning system and Geographic information system (GIS)

GEOMATICS: Basic Concepts of Photogrammetry – Scale, Flying Height.

TEST BOOKS:

1. B.C.Punmia Ashok Kumar Jain and Arun Kumar Jain "**Surveying**" (Vol – 1, 2 & 3), Laxmi Publications (P) ltd., 14th Edition, 2014.
2. Duggal S K, "**Surveying**" (Vol – 1 & 2), Tata Mc.Graw Hill Publishing Co. Ltd. 4th Edition, 2004.

REFERENCES:

1. Arora K R "**Surveying Vol 1, 2 & 3**", Standard Book House, Delhi, 15th Edition, 2015
2. Chandra A M, "**Plane Surveying**", New age International Pvt. Ltd., Publishers, New Delhi, 3rd Edition 2015.
3. Chandra A M, "**Higher Surveying**", New age International Pvt. Ltd., Publishers, New Delhi, 3rd Edition 2015.

E RESOURCES:

1. HYCOS/Surface Waters/Levelling_and_surveying.pdf
2. http://v5.books.elsevier.com/bookscat/samples/9780750669498/9780750669498.PDF
3. http://www.whycos.org/fck_editor/upload/File/Pacific
4. http://nptel.ac.in/courses/105107122/
5. https://www.youtube.com/watch?v=chhuq_t40rY

Course Outcomes:

At the end of the course, students will be able to

1. Apply basic geometry to detect difference in plane and arc distance over "spherical" earth surface for typical length survey projects.
2. Identify the importance of the compass survey and its practical applications
3. Apply basic methods and applications of plane Table survey
4. Identify the field applications and concepts of leveling survey
5. Identify the different methods of calculation of area, contouring and measurement of volumes.

CO- PO –PSO Mapping
(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

COS	Programme Outcomes(POs)												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	3	1	3	3	1		2	1	2		3	
CO2	3	3	3	3	3	2	2		2	3		3		3	
CO3	3	2	3	3	1	2	3		3	3		3		3	
CO4	3	3	3	3	2	2	3	2	3	3	3	3		3	
CO5	3	3	3	3	3	3	3	2	3	3	3	3		3	

MODULE - I

INTRODUCTION TO BASIC CONCEPTS.

1' = 0.3048 m

Surveying:

Surveying is the art of determining the relative positions of points. on, above or beneath the surface of the earth by means of direct or indirect measurements of distance, direction and elevation. It also includes the art of establishing points by pre-determined angular and linear measuremen[t]. The application of surveying requires skill as well as knowledge of mathematics, physics and to some extent astronomy.

Units of measurements:

Basic units of length:

British units	Metric Units
12" Inches = 1' foot	10 mm = 1 cm
3 feet = 1 yard	10 cm = 1 decimeter
5½ yards = 1 rod, Pole (or) perch	10 decimeter = 1 m
4 poles = 1 chain (66')	10 m = 1 decameter
10 chains = 1 furlong	10 decameter = 1 hectometer
8 furlongs = 1 mile	10 hectometer = 1 kilometer
100 links = 1 chain = 66'	1852 m = 1 nautical mile (International)
6 feet = 1 fathom	
120 fathoms = 1 cable length	
6080' = 1 nautical mile	

BRITISH UNITS | METRIC UNITS

6080' = 1 nautical mile

1' = 0.3048 m

1" = 2.54 cm

1" = 25.4 mm

1 ton = 1000 kg

1 quinton = 100 kg

11/07/19

Basic units of area:

Metric units

10 sq mm = 1 sq cm

100 sq cm = 1 sq decimeter

100 sq decimetre = 1 sq m

100 sq m = 1 sq decametre / 1 are

~~100 sq decam/ares = 1 sq km~~

100 ares = 1 hectare / 1 sq hectometre.

100 hectares = 1 sq km

British units:

144 sq inches = 1 sq foot

9 sq feet = 1 sq yard

Basic units of volume :

Metric units :

1000 cu.mm = 1 cu cm

1000 cu.cm = 1 cu ~~dm~~ deci m

1000 cu.deci m = 1 cu.m

British units :

~~1 cu foot~~

1728 cu.inches = ~~1728~~ 1 cu foot

27 cu.feet = 1 cu.yard

1 m = 100 cm = 3.28' feet

$\frac{100}{30.48} = 3.28$ feet

1 Sq m = 3.28' x 3.28' = 10.76 sq ft

$\boxed{1 \text{ Sqm} = 10.76 \text{ sq ft}}$

Basic units of angular measurements :

In this there are three systems :

1) Sexagesimal system
2) centesimal system
3) Hours system

1) Sexagesimal system:

1 circumference = 360°

$1^\circ = 60'$ min

1 min = 60 sec / $60''$

2) centesimal system:

1 circumference = 400^g. (g - grads)

1 grad = 100 centi grad / 100^c

1 centigrad = 100^{cc} (centi centi grads)

3) Hours system:

1 circumference = 24^h

1 h = 60 min / 60^m

1 min = 60^s

Note:

1) 1 cu m = 1000 litres of water

1 gallon = 0.00455 cu m

= 0.00455×1000 l

= 4.55 l

Objectives of surveying:

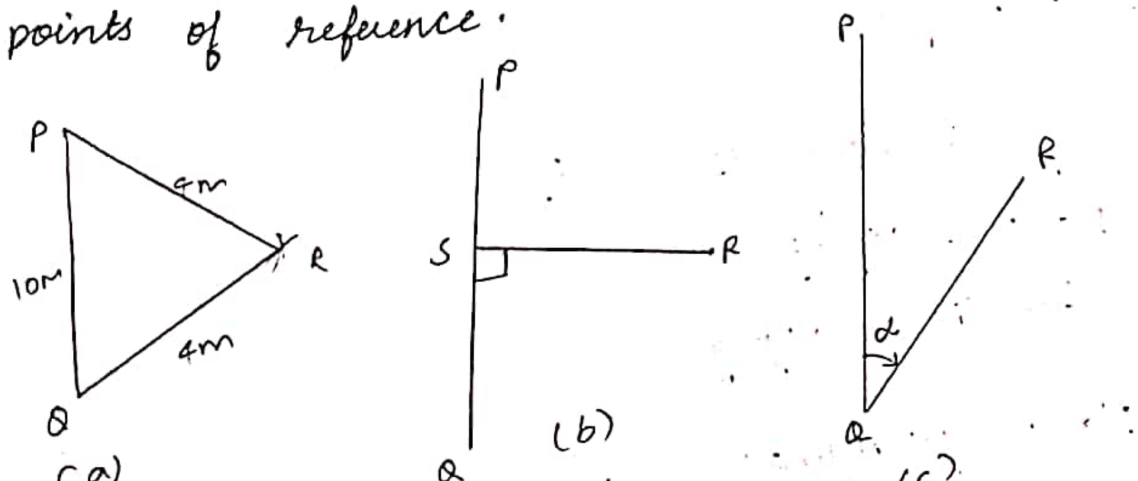
1) To determine dimensions and contours at any part of the earth surface. To prepare a plan or a map.
2) To establish boundaries of the land.
3) To select a suitable ~~sue~~ site for an engineering project.
4) To measure areas and volumes.

12/7/19.

* Principles of surveying:

1) Location of a point by measurement from two points of reference.
2) working from whole to part.

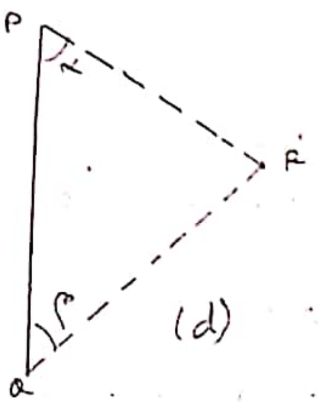
1. Location of a point by measurement from two points of reference.



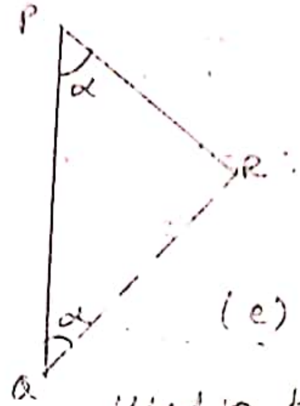
(a) used in chain surveying

(b) used for defining details

(c) used in traversing



used in triangulation & used in very extensive work



used in traversing is of minor utility

2) working from whole to part:

The idea of working in this way i.e from whole to part is to prevent the accumulation of errors and to control and localize minor errors which, otherwise, would expand to greater magnitude if the ~~rivers crosses i.e~~ reverse process i.e part to whole, thus making the work uncontrollable at the end.

Primary divisions of survey:

1) Plane surveying
2) Geodetic surveying.

1) plane surveying:

It is the type of surveying in which the mean surface of the earth is considered as a plane and the spheroidal shape is neglected.

2) Geodetic surveying:

In this type of surveying the shape of the earth is taken into account.

All lines lying on the surface curved lines and triangles are spherical triangles. Therefore, it involves spherical trignometry. All geodetic surveys include work of larger magnitude and high degree of precision.

15/07/19.

Classification of surveying:

1) Surveying can be classified based up on nature of field to be surveyed. In that

i a) Land surveying:

Land surveying is divided as 3-types

a) Topographical survey (Natural - rivers, streams, lakes
(Artificial - Roads, Railway tracks etc)

b) ~~ped~~ Cadastral survey (fixing of boundaries, calculation of land area, transfer of land property from one owner to another etc).

c) city survey.
(construction of streets, water supply systems, sewers and other works)

ii) Marine surveying:

iii) Astronomical surveying.

Marine Surveying: used for navigation, harbour works, determinging Mean sea level (MSL), tide's fluctuations, taking soundings to determine the depth of water.

Astronomical Surveying:

observations to heavenly bodies like sun or any fixed star.

2) Based on object of surveying:

a) Engineering survey:

To find out quantities - Design of roads, reservoirs, water supply and sewage supply lines.

b) Military Survey:

To determine the points of strategic importance.

c) Mine surveying:

To ~~expro~~ explore mineral wealth.

d) Geological surveying:

To determine different stratas in earth's crust.

e) Archaeological survey:

unearthing relics of antiquity.

3) Based on instruments used:

a) Chain surveying
b) Compass surveying
c) plane table surveying
d) ~~Leveling~~ Dumpy level - leveling
e) Theodolite surveying
f) Tacheometric surveying
g) Traversing surveying
h) Triangulation surveying
i) photogrammetric surveying
j) ~~Aer~~ Aerial surveying.

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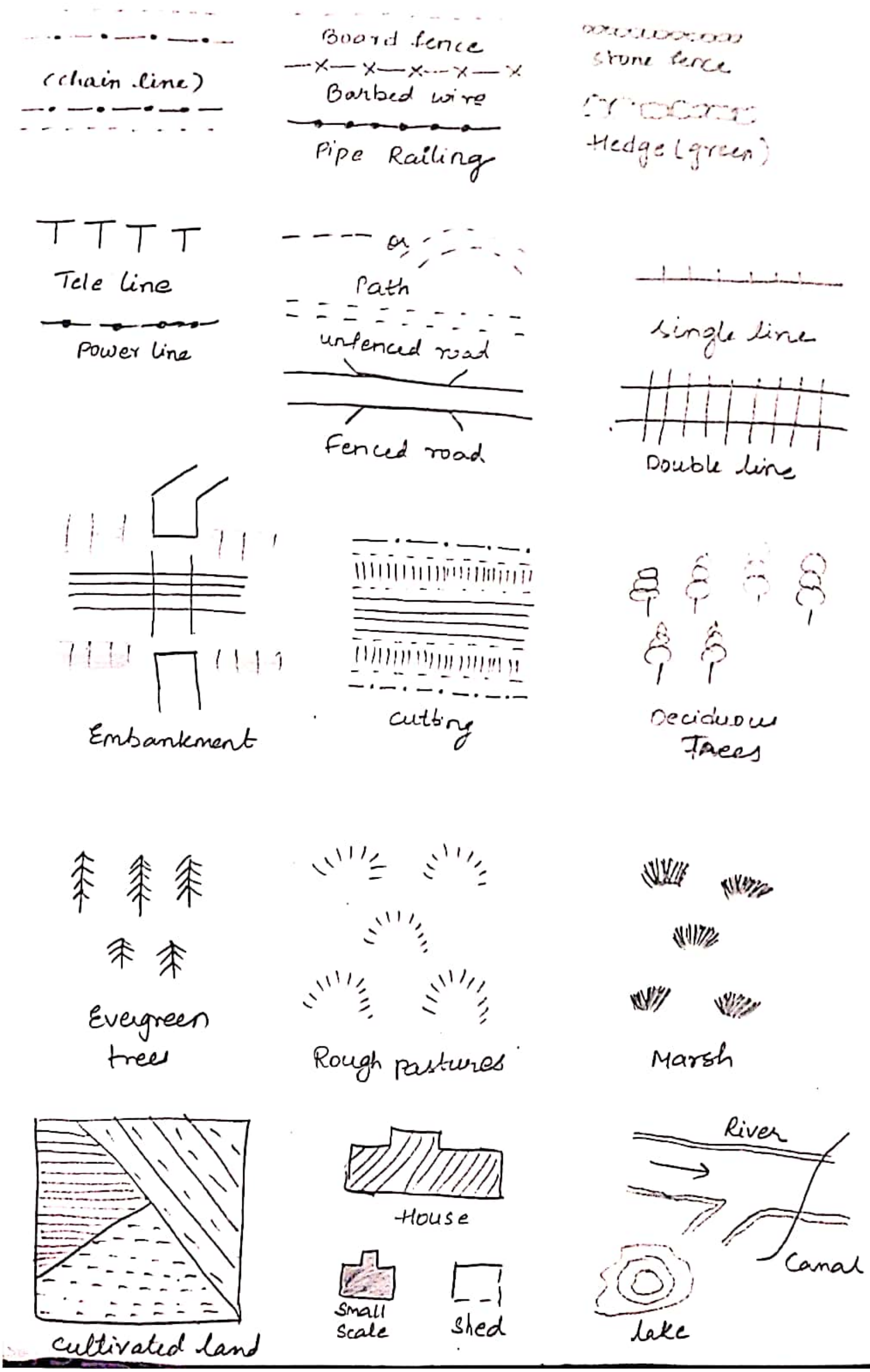
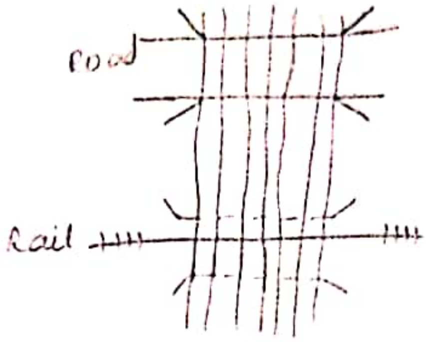
Conventional symbols:



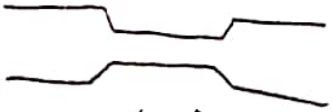
Stream line



Bridges

Ferry

Tunnel



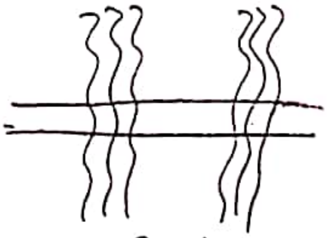
(or)

canal lock.

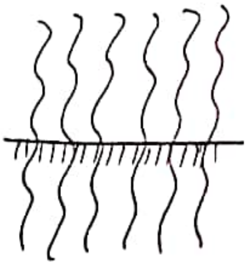
Triangulation

Traverse stations

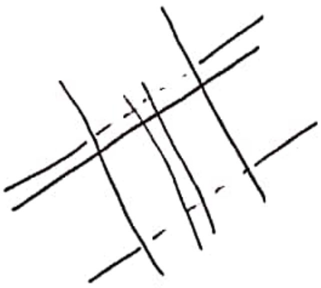
water-fall



ford



Dam



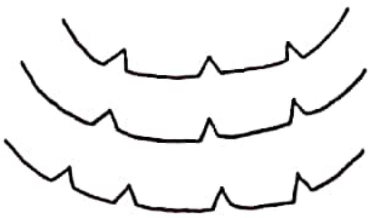
Level crossing.

pine tree

church

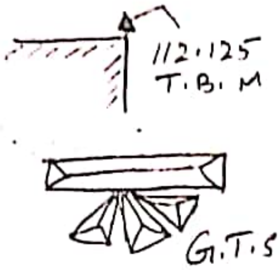
North

Refuse Heap



Rocks.

Sand pit



Bench Marks

Plans and maps:

Plans and maps are graphical representations.

Plan:

It is a graphical representation to some scale of the features on near or below the surface of the earth as projected on a horizontal plane.

Map:

If the graphical projection on a horizontal plane is small, the plan is called a map.

Map	Plan
1) we can study a part or whole of the earth with the help of a map.	1) plan is a detailed of drawing of small areas.
2) It contains lot of information.	2) The details are given in the form of symbols.
3) It shows very important features of the area only.	3) plan shows length and breadth

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Scale :

It is the basic requirement for preparation of lands or maps.

→ The proportion or ratio between dimensions adopted for the drawing and corresponding dimensions of object.

→ A scale may be represented numerically by engineer's scale or representative fraction (R.F)

→ Engineer's scale is represented by 1cm = 40cm.

→ For a scale of 1cm = 1Km, the R.F is

$$1\,cm = 1\,km$$

$$1\,cm = 1{,}00{,}000\,cm$$

$$R.F = \frac{1}{1{,}00{,}000} \Rightarrow 1:1{,}00{,}000$$

→ One should be familiar with the units of measurement in order to calculate R.F.

Units of measurement :

1 cm = 10 mm

1m = 100 cm

1Km = 1000 m

1' = 0.3048m

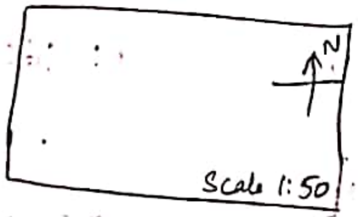
1 hectare = 10000 m^2

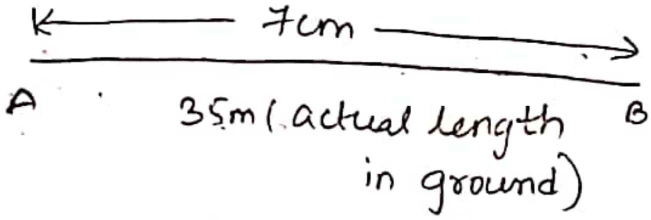
→ The representative fractions and scales recommended for various types of maps are as follows.

Type of map	Scale	R.F
Geographical map	1 cm = 160 km	1 : 1,60,00000
Topographical map	1cm = 2.5km	$\frac{1}{2,50000}$
Location map	1 cm = 5m to 25m	$\frac{1}{500}$, to $\frac{1}{2500}$
Forest map	1cm = 0.25km	$\frac{1}{25,000}$
Cadastral map	1 cm = 10m to 50m	$\frac{1}{1000}$ to $\frac{1}{5000}$
Town planning	1cm = 50 to 100m	$\frac{1}{5000}$ to $\frac{1}{10000}$
Buildings	1 cm = 10m	$\frac{1}{1000}$
Mines	1cm = 10m to 25m	$\frac{1}{1000}$ to $\frac{1}{2500}$
Priliminary survey of ~~planes~~ rails & roads	1 cm = 10 to 60m	$\frac{1}{1000}$ to $\frac{1}{6000}$

Shrinkage of scale :

We usually represent the scale of a map at the bottom of the drawing sheet as shown below. which is known as graphical scale.





Scale : $\boxed{1\text{cm} = 5\text{m}}$

→ when a map shrinks or expands, the scale line also shrinks or expands with it and thus: the measurements made from the map are not affected.

Shrinkage ratio (S.R) (or) shrinkage factor (S.F) :—

The ratio of the shrunk length to the actual length is known as shrinkage ratio or shrinkage factor.

① $$S.R / S.F = \frac{\text{shrunk length}}{\text{actual length or original length}}$$

$$= \frac{\text{Shrunk scale}}{\text{original scale}} = \frac{\text{Shrunk RF}}{\text{original RF}}.$$

(2) correct distance = $\frac{\text{Measured distance}}{S.F}$

(3) correct area = $\frac{\text{Measured area}}{(SF)^2}$

problem:
The area of the plan of an old survey plotted to a scale of 1cm = 10m which measures now by a planimeter as measured area as 100.20 sq. cm. The plan is found to have shrunk so that a line originally 10cm long now measures 9.7cm only. Find (a) shrunk scale (b) True area of the survey in m^2.

Sol!:- original length = 10cm
shrunk length = 9.7cm

shrinkage ratio = $\frac{\text{shrunk length}}{\text{original length}}$

$$S.R = \frac{9.7}{10} = 0.97$$

shrunk scale = S.R × original scale

$$= 0.97 \times \frac{1}{1000}$$

$$= 0.00097 = \frac{1}{1030.93}$$

Measured area = $100.2\ cm^2$

True area = $\frac{\text{Measured area}}{(SF)^2}$

$$= \frac{100.20}{(0.97)^2} = 106.49\ cm^2$$

$$= \cancel{103.29}\ 106.49 \times 10^{-4}\ m^2$$

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Wrong scale:

If a wrong measuring scale is used to measure the length of a line already drawn on a plan or a map, the measured length will be erroneous.

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

In the same way,

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

Problem:

A surveyor measured the distance between 2 points on the plan drawn to a scale of 1cm = 40m. The result was 468m. Later we discovered that he has used a scale of 1cm = 20m. Find the true distance between the points.

Sol:- ~~R.F original scale~~

Measured length = 468 m.

when 1 cm = 20 m.

$$\text{RF of wrong scale} = \frac{1}{20\times100} = \frac{1}{2000}$$

$$\text{R.F of correct Scale} = \frac{1}{4000}$$

$$\therefore \text{correct length} = \frac{\text{R F of wrong scale}}{\text{RF of correct scale}} \times \text{Measured length}$$

$$= \frac{\frac{1}{\cancel{2000}}}{\frac{1}{\cancel{4}000}} \times 468$$

$$= 2 \times 468$$

$$= 936 m$$

Q) The plan of an area has shrunk such that a line originally 10cm long now measures 9.5cm. If original scale of the plan was 1 cm = 50m. Determine a) shrinkage factor b) shrunk scale c) correct distance corresponding to a measured dist of 980m d) correct area corresponding to a measured area of 10000 m^2.

sol:- original length = 10cm,

Shrunk length = 9.5 cm

$$\text{Shrunk factor} = \frac{\text{shrunk length}}{\text{original length}}$$

$$S.F = \frac{9.5}{10} = 0.95$$

original scale = 1 cm = 50m.

$$\text{original scale RF} = \frac{1}{5000}$$

$$\text{Shrink Scale} = S.F \times \text{original scale}$$

$$= 0.95 \times \frac{1}{5000}$$

$$= 1.9 \times 10^{-4} = 0.00019$$

$$= \frac{1}{5263.15}$$

Measured distance = 980m

$$\text{correct distance} = \frac{\text{Measured dist}}{SF}$$

$$= \frac{980}{0.95} = 1031.57\,m$$

Measured area = $10000\,m^2$.

$$\text{correct area} = \frac{\text{Measured area}}{(SF)^2}$$

$$= \frac{10,000}{(0.95)^2} = 11080.33\,m^2$$

Phases of surveying:

The work of a surveyor is divided into 3 parts:

1) Field work.
2) Office work
3) Care & adjustment of instruments.

Field work:

It consists of measurement of angles and distances and keeping a record in the form of field notes.

→ In field notes we have to enter numerical values, sketches and explanatory notes.

Office work:
It consist of a) drafting.
b) Computing
c) Designing.

Care and adjustment of instruments:
The equipment used in field i.e dumpy level, theodolite, compass etc are very delicate instruments so they must be handled with a great care.

Surveying Accesories:
1) Chain surveying:
Ranging rods, cross staff, chains, Arrows.

2) Compass surveying:
Prismatic compass, surveyor's compass, Arrows, Ranging rods, tripod.

3) Theodolite Surveying:
Theodolite, tripod, arrows, Ranging rods etc., plumb bob

4) Traverse surveying:
chain
compass
arrows
Ranging rods, plumb bob.

5) Levelling:
level, & levelling staff, Tripod, Ranging rods, plumb bob

6) contouring:
Level, leving staff, Tripod, Ranging rods etc.

7) plane table surveying:

Plane table, tripod, Drawing sheets, Alidade, U-fork or plumbing fork, Trough compass, spirit level, stationary items.

Code of Signals for Ranging:

Sl.No	Signal by the surveyor	Action by Assit
1.	Rapid sweep with right hand	Move considerably to right.
2.	Slow sweep with right hand	Move slowly to the right.
3.	Right arm extended	continue to move to the right.
4.	Right arm up and moved to the right	plumb the rod to the right.
5.	Rapid sweep with left hand	move considerably to left.
6.	Slow sweep with left hand	Move slowly to the left.
7.	Left arm extended	continue to move to the left.
8.	Left arm up and moved to the left.	plumb the rod to the left.
9.	Both hands above head and then brought down	correct.
10.	Both arms extended forward horizontally and the hands depressed briskly.	Fix the rod.

Measurement of Distances & Directions.

Linear Distances:

Different methods:

1) Direct measurements
2) Measurement by optical means.
3) Electromagnetic methods.

1) Direct Measurements:

The various methods for direct measurements are as follows.

a) Pacing.
b) Measurement with passometer
c) Measurment with pedometer.
d) Measurement with Odometer and speedometer.
e) Chaining

a) pacing: It is a rough one and it can be done as quickly as possible. This method is used to check roughly the distance measured by other methods. The length of pace varies with individual and nature of ground also.

b) Measurement with passometer:

It is like a watch and is carried in Pocket or attatched to one leg. It automatically registers the no. of paces then the no. of paces is to be multiplied by average length of the pace.

c) Measurement with pedometer:

It is smilar to passometer except adjusted to the length of the pace of the person who carring it. It registers the total distance covered by any no of paces.

d) odometer and Speedometer:

Odometer is an instrument to count the no. of revolutions of a wheel. The well known Speedometer works on this principle.

e) Chaining:

It is done with the help of chain or a tape. It is the most accurate method for direct measurement.

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CHAINING:

It is the method of measuring the distance with a chain or a tape. Chaining is done for ordinary precision where as steel tape is used for works where great accuracy is required.

Instruments used for chain survey:

Instruments used for measuring distance.

1) Chain
2) Tape

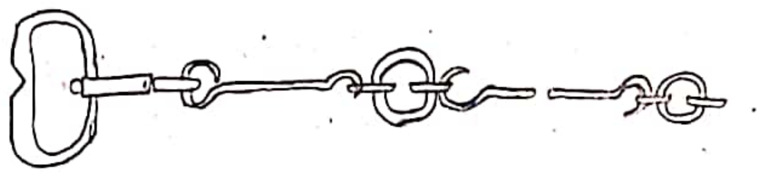
Instrument used for marking survey stations:

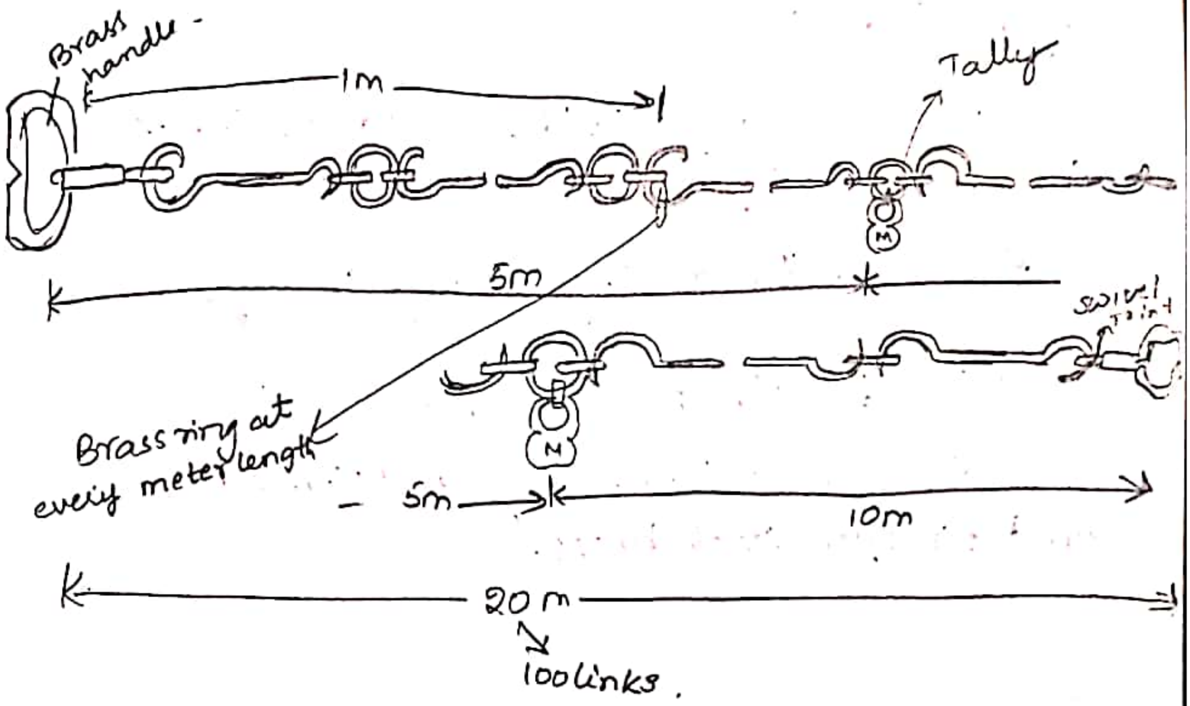
1) Ranging rods.
2) Cross-staff → ⊥lar offsets, Right angles.
3) Pegs
4) Arrows

other instruments:

1) plumb bob

Chain:





It is made up of 4mm dia Galvanized Iron.

Advantages of chain:

1) It is suitable for rough usage in the field.
2) It can be easily readable.

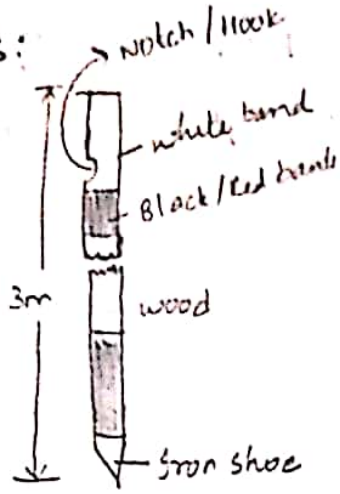
Types of chains:

1) Gunter's chain or Surveyor's chain

66' long
100 links will be there.
each link 0.66'

- It is convinenient to measure the distance in miles and ~~pof~~ ferlongs

Offset rods:



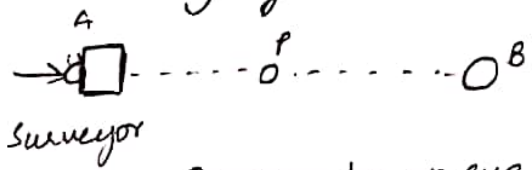
Plumb bob:

~~Plumb bob~~:

Ranging out survey lines:

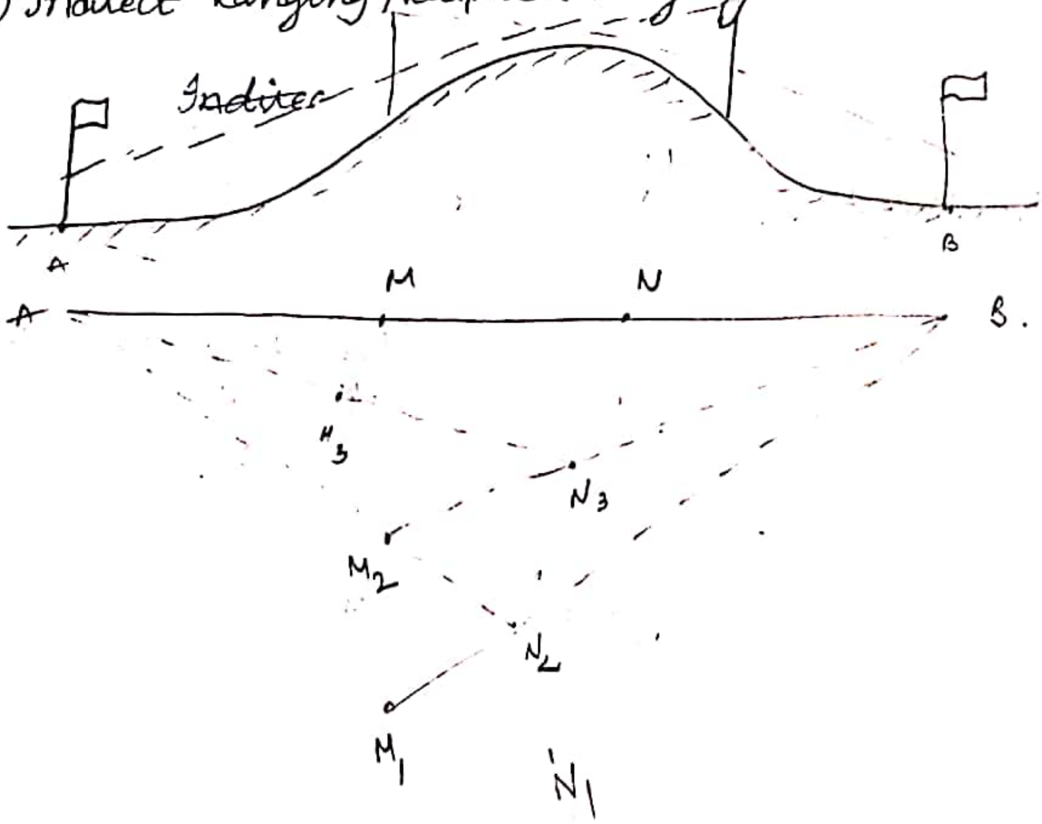
1). Direct Ranging
2) Indirect Ranging

1) Direct Ranging:



Ranging by an eye

2) Indirect Ranging / Reciprocal ranging:



Indirect a reciprocal ranging is used when both the ends of survey line are not intervisible either due to high level of ground or long distance between them in such case ranging is done indirectly by selecting 2 intermediate points M_1, N_1 very near to the chain length, in such a way that from M_1, both N_1 and B are to be visible and from N_1, both M_1, A are to be visible.

→ 2 surveyors are to be stationed at M_1 and N_1 with ranging rods. The person at M_1 directs N_1 to come in line M_1B to a new position N_2.

→ The person at N_2 directs M_1 to move to a new position M_2 in line width N_2A. Thus the two persons are now at M_2 and N_2. The process is repeated till the points M and N are located in such a way that the person at M, finds the person at N in line with MB. And the person at N finds the person at M in line with NA. After establishing of M and N, other points also can be fixed by direct ranging.

30/7/19

Error due to incorrect chain:

(i) Correction to measured length:

$$l = l' \times \left(\frac{L'}{L}\right)$$

where l = actual or true length of the line.

l' = Measured length of the line.

L' = Incorrect (or actual) length of the chain or tape used.

L = actual true or designated length of the tape or chain.

(ii) Correction to area :

$$A = A'\left(\frac{L'}{L}\right)^2$$

where A = actual (or) true area of the ground.
A' = measured area or computed area of the ground.
L' = Incorrect (or) actual length of chain or tape
L = True or designated length of chain or tape

(iii) Correction to Volume:

$$V = V'\left(\frac{L'}{L}\right)^3$$

V = actual or true ~~area~~ volume of the ground
V' = measured ~~area~~ volume or computed volume of
L' & L has the same meaning as above.

Problem :-

1) The length of a line measured with a 20m chain was found to be 250m. Calculate true length of the line if the chain was 10cm too long.

Sol:- True length of chain = 20m = L

l' = measured length = 250m

$$L' = 20\,m + \frac{10}{100}\,m$$

$$= 20.1\,m$$

$$l = l'\left(\frac{L'}{L}\right)$$

$$l = 250\left(\frac{20.1}{20}\right)$$

$$= 251.25\ m$$

2) The length of a survey line was measured with 20m chain and it was found to be equal to 1200m. As a check the length was again measured with 25m chain and found to be 1212m. On comparing the 20m chain with the test gauge it was found to be 1 decimeter too long then find the actual length of 25m length chain used.

sol:- Note :- $\boxed{1 \text{ decimeter} = 10cm}$

with 20m chain

$L = 20m$

$l' = 1200m$

$L' = 20+0.1 = 20.1\ m$

$$l = l'\left(\frac{L'}{L}\right)$$

$$l = 1200\left(\frac{20.1}{20}\right)$$

$$l = 1206\ m.$$

with 25^m chain,

$l' = 1212\ m.$

$l = 1206\ m$

$L' = 25+(x).$

$L = 25m$

$$l = l'\left(\frac{L'}{L}\right) \Rightarrow \frac{l}{l'} \times L = L'$$

$$L' = \frac{1206 \times 25}{1212} = 24.88$$

$$L' = 25 + x$$

$$24.88 = 25 + x$$

$$\cancel{25} \; 24.88 - 25 = x$$

$$x = -0.12$$

i.e $0.12m$ ~~reduced~~ too short.

Thus the 25m chain was 12cm too short.

3) A 20m chain was found to be 10cm too long after chaining a distance of 1500m. It was found to be 18cm too long at the end of day's work, after chaining a total distance of 2900 m. Find the true distance if the chain was correct before dhe commencement of the work.

Sol:- For 1^{st} 1500m :-

$$\text{average error } e = \frac{0+10}{2} = 5\,cm$$

$$L' = 20 + \frac{5}{100} = 20.05m$$

$$L = 20m.$$

$$l' = 1500m$$

$$l = l'\left(\frac{L'}{L}\right)$$

$$= 1500\left(\frac{20.05}{20}\right)$$

$$l_1 = 1503.75m.$$

For next 1400 m :-

$L' = ?$

$$\text{Avg error} = \frac{10+18}{2} = 14 \text{ cm}.$$

$$L' = 20+0.14$$
$$L' = 20.14 \text{ m}.$$
$$L = 20 \text{ m}$$
$$l_2 = l'\left(\frac{L'}{L}\right)$$
$$l_2 \Rightarrow 1400\left(\frac{20.14}{20}\right)$$
$$= 1409.8 \text{ m}$$

$$l = l_1 + l_2$$
$$= 1503.75 + 1409.80$$
$$= 2913.55 \text{ m}.$$

4) A surveyor measured the distance between 2 points on the plan drawn to a scale of 1 cm = 40 m and the result was 468 m. Later however he discovered that he used a scale of 1 cm = 20 m. Find the true distance between the two points.

Sol:-

Scale: 1 cm = 40 m

1 cm = 4000 cm

Distance between 2 points measured with a scale of 1 cm = 20 m is

? - 468 m

$$\frac{468}{20} = 23.4 \text{ cm}$$

Actual scale of plan is 1 cm = 40 m

True dist b/w $\frac{23.4 \times 40}{1}$

$= 936m.$

5) A 20m chain used for a survey was found to be 20.1 m at the begining and 20.3 m at the end of the days work. The area of the plan drawn to a scale of 1cm = 8m was measured with the help of Planimeter and was found to be 32.56 sq.cm. Find the true area of the field.

Sol:- $L = 20m$

$L' = \frac{20.10 + 20.30}{2} = 20.2m$

$1cm = 8m$

Area of plan $= 32.56 cm^2$.

Area of the ground $= 32.56 \times 8)^2 = 2083.84 m^2$.

$A = A'\left(\frac{L'}{L}\right)^2$

$A = 2083.84 \left(\frac{20.2}{20}\right)^2$

$A = 2125.725 m^2$

) The area of the plan of an old survey plotted to a scale of 1cm = 10m measures now as $100.2 cm^2$. The plan is found to have shrunk so that a line originally 10cm long now measures 9.7 cm only. There is a note on the plan that the 20m chain used was 8cm too short. Find the true area on the survey.

Sol :- present length of 9.7 cm = 10cm of original length.

∴ present area 'A' of $100.2 cm^2 = \left(\frac{10}{9.7}\right)^2 \times 100.2$

$= 106.49$ sq.cm .

= original area of plan .

scale of the plan ⇒ 1cm = 10m

∴ original area of survey $= (106.49)(10)^2$

$= 10649$ sq.m.

Faulty length of ~~length~~ chain used = 8 cm too long

$20 - 0.08$

$\Rightarrow \cancel{20.08}$ 19.92m

Correct area $= 10649\left(\frac{19.92}{20}\right)^2$

$= 10563.98 m^2$

31/7/19 .

Chaining on Uneven (or) sloping ground:

1) Direct Method

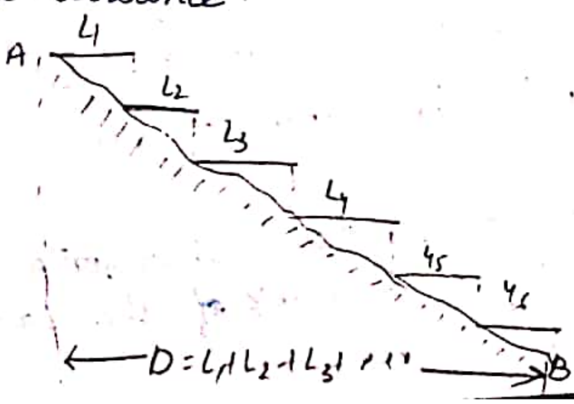
2) Indirect method .

a) Angle measured

b) Difference in level measured .

c) Hypotenusal Allowance .

1) Direct method:



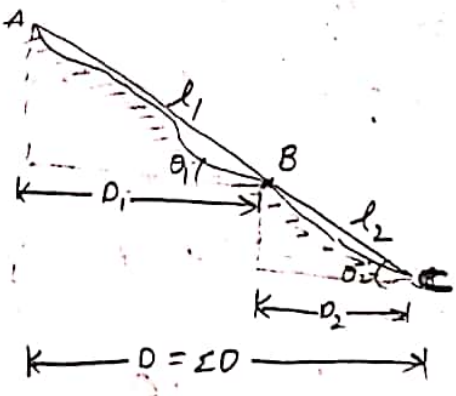
The direct method is also called as method of stepping.

$\therefore D = L_1 + L_2 + L_3 \ldots$

$D = \Sigma L.$

2) Indirect Method:

a) Angle measured:



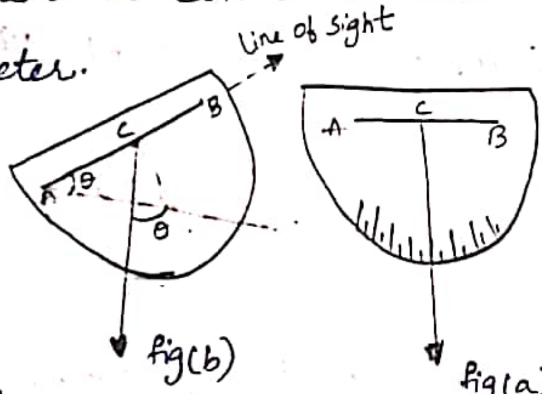
$\cos\theta_1 = \frac{D_1}{l_1}$

$D_1 = l_1 \cos\theta_1$

$D_2 = l_2 \cos\theta_2$

⋮

The slopes of the lines can be measured with the help of a clinometer.



A clinometer consists of 1) a line of sight

2) Graduated arc

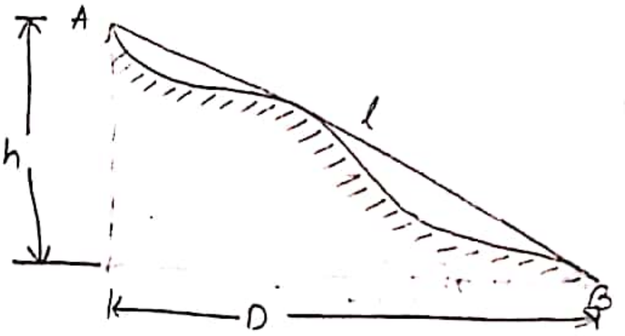
3) A light plumb bob with a long thread suspended at the centre.

→ fig(a) shows a semi-circular graduated arc with 2 pins at A and B forming the line of sight. A plumb bob is suspended from C, the central point.

→ when the clinometer is horizontal, the thread touches the zero mark of the calibrated circle.

→ To sight a point, the clinometer is tilted so that the line of sight AB may pass through the object. Since the thread still remains vertical, the reading against the thread gives the slope of the line of sight.

b) Difference in level measured:



$$l^2 = h^2 + D^2$$

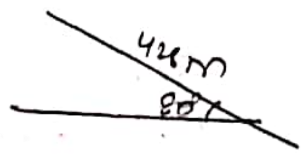
$$l^2 - h^2 = D^2$$

$$D = \sqrt{l^2 - h^2}$$

→ 3,4,5 method is nothing but making right angles using chain and tape using the measurements 3,4 & 5.

Problem:

The distance between ~~3 4 5 method~~ the points measured along a slope is 428m. Find the horizontal dist b/w them if



a) the angle of slope between the points is 8°

b) The difference in level is 62 m c) The slope is 1 in 4

sol:- $l = 428\,m$,

a) $\theta = 8^\circ$.

~~cos θ =~~ $\cos\theta = \frac{D}{l}$ $\cos 8 = \frac{D}{428}$

$D = 428 \cos 8^\circ$

$D = 423.83\,m$

b) $h = 62\,m$

$l = 428\,m$.

~~$l^2 = \sqrt{D^2}$~~ $D = \sqrt{l^2 - h^2}$

$$D = \sqrt{(428)^2 - (62)^2}$$

$$D = 423.48\,m$$

c) Slope is 1 in 4

$\tan\theta = 1/4$

$\theta = \tan^{-1}(1/4) = 14.03^\circ$

$\cos\theta = \frac{D}{l}$

$\cos(14.03) = \frac{D}{428}$

$$D = 428\cos(14.03)$$

$$D = 415.23\,m.$$

Errors in chaining:

Errors and mistakes are classified into 2 types. Cumulative error, compensating error.

1) Cumulative error:

which occurs in the same direction and tends to accumulate.

2) Compensating error:

It may occur in either direction and hence tends to compensate. Errors are regarded as +ve or -ve according to they make the result too great or too small.

→ Errors and mistakes arises from

1) Erroneous length of chain or tape.
2) Bad ranging.
3) Careless holding and marking.
4) Bad straightening
5) Non - horizontality.
6) Sag in chain.
7) variation in temperature.
8) variation in pull.
9) personal mistakes.

1) Erroneous length of chain or tape : (cumulative + or -)

If the length of chain is more, the measured distance will be less and hence error will be -ve. similarly if chain is too short, measured distance will be more and error will be +ve. Proper correction has to be applied.

2) Bad Ranging : (cumulative, +)

For each and every stretch of the chain, the error due to bad ranging will be cumulative and the effect will be too great.

3) Careless handling & Marking (compensating, + or -)

This causes a variable systematic error.

4) Bad straightening : (cumulative, +)

If the chain is not straight but is lying in an irregular horizontal curve, the measured distance will always be too great.

5) Non - horizontality (cumulative ,+)

If the chain is not horizontal especially in the case of sloping or irregular ground, the measured distance will always be more.

6) Sag in chain (cumulative ,+)

when the distance is measured by stepping or when the chain is stretched above the ground due to andulations , the chain gets sags.

7) Variation in temperature: (cumulative ,+)

When a chain or a tape used at temperature different from that at which it was calibrated, its length changes. Due to raise in temperature, the length of chain increases then the measured distance will be less and the error becomes -ve.

Due to fall in temp, the length of chain decreaes , the measured dist will be more and error becomes -ve. In either cases the error is cumulative.

8) variation in pull (compensating ±, cumulative ±):

If the pull applied in straightening the ~~to~~ chain or tape is not equal to that of standard pull at which it was calibrated. Therefore its length changes.

9) personal mistakes:

1) Displacement of arrows:
2) Miscounting the chain line.
3) Misreading
4) Erroneous booking

1/8/19.

Optical Methods:

In optical methods observations are taken through telescope and calculations are done for the distances such as in tacheometry ~~to~~ f or triangulation

EDM Methods: (Electro Magnetic Distance Measurements)

In this method, distances are measured with instruments that rely on propagation reflection and subsequent reception of either radiowaves, light waves or Infrared waves.

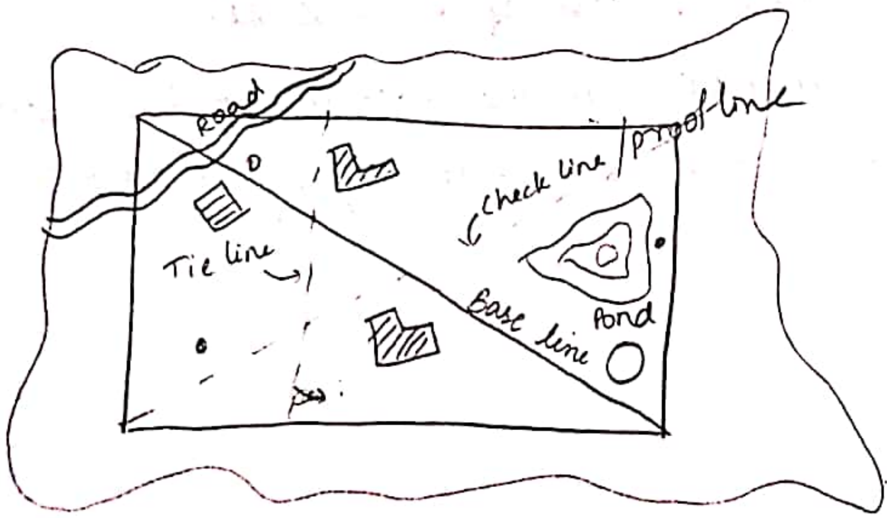
Well Conditioned Triangle:

A well conditioned Δle is a triangle in which no angle is less than 30° or greater than 120°. An equilateral Δle is the best conditioned or ideal Δle.

Ill conditioned triangle:

Ill conditioned Δles are those Δles in which atleast one angle is less than 30° or greater than 120°.

Base line, check line and Tie line:



Base line:

The lines joining main survey station are called main survey lines. The biggest of the main survey lines is called base line and various survey stations are plotted with reference to base line.

Check line:

These are proof lines, are the lines which are run in the field to check accuracy of the work.

A check line may be laid by joining apex of the Δle to any point on the opposite side or by joining 2 points on any 2 sides of a Δle.

Tie line:

It is a line which joins subsidiary stations or tie stations on the main line. The object of tie line is to take the details of near by objects but it also serves a purpose of a check line.

The accuracy in the location of the objects depend upon the accuracy in laying the tie line.

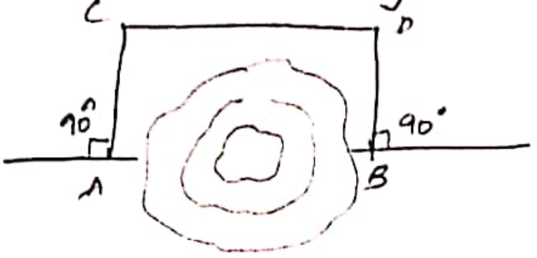
Obstacle in chaining :-

a) obstacle to ranging but not chaining

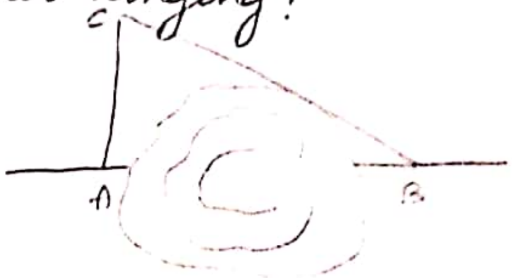
*b) obstacle to chaining but not ranging

c) obstacle to both chaining & ranging.

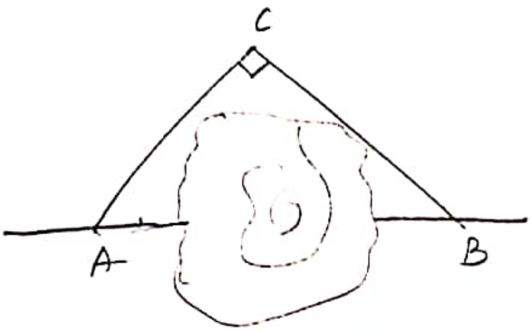
Obstacle to chaining but not ranging:



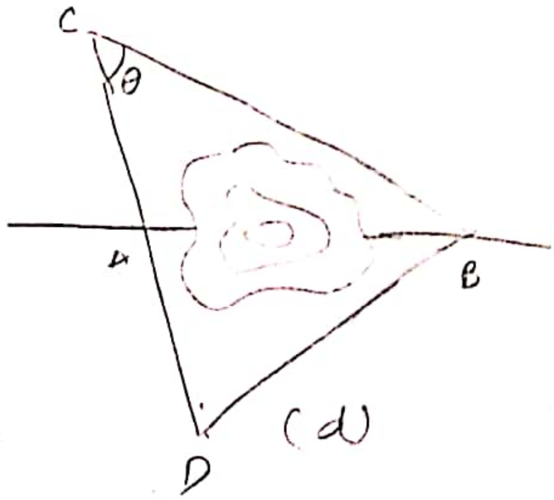
(a) $CD = AB$



(b) $AB = \sqrt{BC^2 - AC^2}$



(c) $AB = \sqrt{AC^2 + BC^2}$



(d)

For method (d)

Select 2 points C and D on both sides to A and these points should be in the same line.

Measure AC ~~and~~, ~~AD~~ BD, BC also AD let $\angle BCD = \theta$

From ΔBCD,

$$BD^2 = BC^2 + CD^2 - 2\,BC\,CD\cos\theta.$$

$$\cos\theta = -\left(\frac{BD^2 - BC^2 - CD^2}{2BC \cdot CD}\right)$$

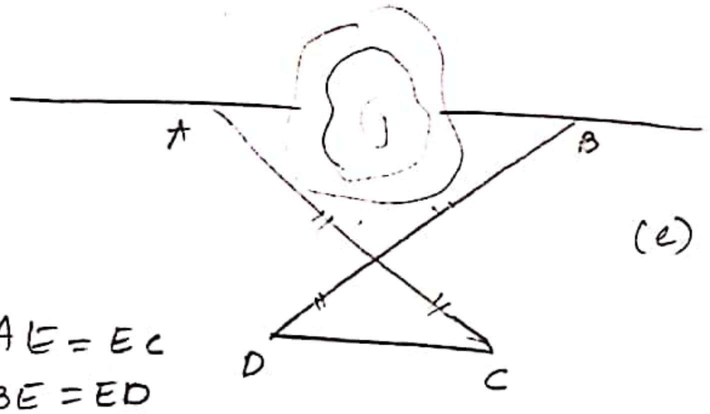
$$\cos\theta = \frac{BC^2 + CD^2 - BD^2}{2BC \cdot CD}.$$

similarly, ΔBCA, $AB^2 = BC^2 + AC^2 - 2BC\,AC\cos\theta$.

$$\cos\theta = \frac{BC^2 + AC^2 - AB^2}{2BC \cdot AC} \quad \text{(acc to cosine rule)}$$

$$\cancel{\frac{BC^2 + CD^2 - BD^2}{2BC\,CD} = \cos\theta = BC^2}$$

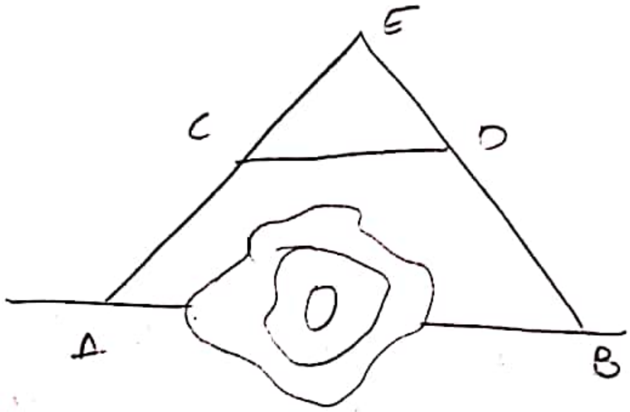
$$AB = \sqrt{BC^2 + AC^2 - 2BC\,AC\cos\theta}.$$



(e)

$AE = EC$
$BE = ED$

$AB = CD$.



(f)

Select any point E and measure AE and BE. Mark 'C' and 'D' on AE and BE such that $CE = \frac{AE}{n}$

$DE = \frac{BE}{n}$,

Measure CD. Then $\boxed{AB = n \cdot CD}$

Tape corrections:

1) correction for Absolute length

$$C_a = \frac{L \cdot C}{l}$$

2) corrections for Temperature

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

3) correction for pull (or) tension

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

4) correction for shape (or) Vertical alignment

$$C = \frac{h^2}{2L} \quad \text{(subtractive)}$$

5) Correction for horizontal alignment

(i) Bad ranging / Mis alignment

$$C_h = \frac{d^2}{2L}$$

6) Reduction to MSL

$$\text{correction } (C_{msl}) = L - D = \frac{Lh}{R} \quad \text{(subtractive)}$$

7) Correction to measurement in vertical plane

when $M = 0$

$$\delta = \frac{mgl^2}{2AE}$$

2/8/19

Compass Surveying:

Prismatic compass:

In some cases it becomes essential to use some type of instruments which gives angles or directions of the survey lines to be observed.

In engineering practice

a) surveyors compass
b) prismatic compass

are used for direct measurement of directions.

Traversing:

It is the type of survey in which the no. of connected survey lines form the frame work and directions and lengths of survey line are measured with an angle measuring instrument and a tape or chain respt.

Closed traverse:

When the lines a circuit which ends at the starting point, it is called as closed traverse.

Open traverse:

If the circuit ends else where it is called as open traverse.

Bearing:

Bearing of a line is its direction relative to a given meridian.

→ A meridian is any direction such as true meridian, magnetic meridian, Arbitrary meridian.

True Meridian :

True meridian through a point is the line in which a plane passing that point and north-south poles, intersects with the surface of the earth. Thus it passes through true north and true south.

True Bearing :

The bearing of a line is the horizontal angle which it makes with true meridian.

Magnetic Meridian:

Magnetic meridian through a point is the direction shown by a freely floating and balanced magnetic needle free from all other attractive forces. The direction of magnetic meridian can be established with the help of magnetic compass.

Magnetic bearing :

It is the horizontal angle which it makes off the line with magnetic meridian.

Arbitrary Meridian:

It is any convinient direction towards as permanent and prominent mark or signal such as a church spire or top of a chimney. Such meridians are used to determine the relative positions of lines in a small area.

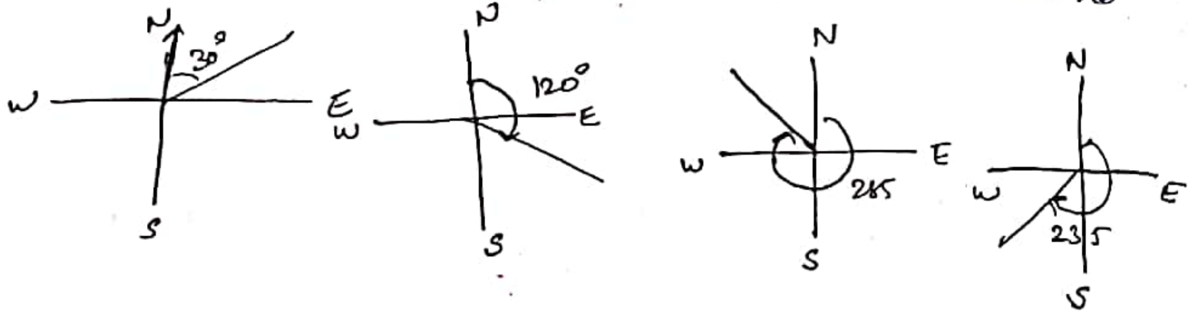
Arbitrary bearing :

It is the horizontal angle of line which it makes with any arbitrary meridian passing through one of the extremities. A theodolite or sextant used to measure the horizontal angle.

Designation of bearing :

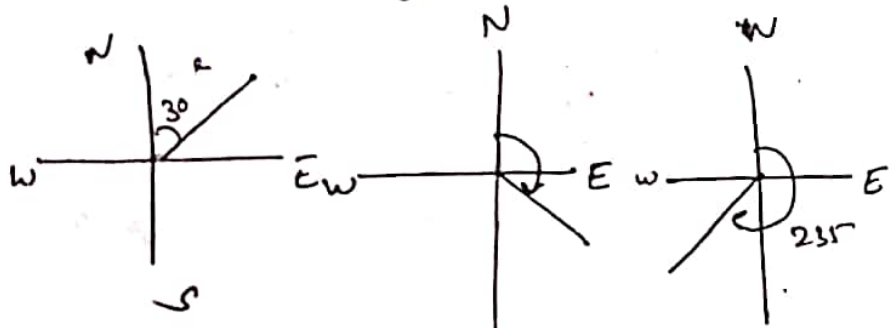
There are two types :

1) W.C.B → whole circle Bearings / Azimuth ~~bearing~~ system .



2) R.B/Q.B

Reduced Bearing or Quadrantal Bearing .



N 30° E

S 60° E

S 55° W.

1Q) Convert the following W.C.B to Q.B .

a) 22° 30′ b) 170° 12′ c) 211° 54′ d) 327° 24′

1Q) convert following Q B to WBC.

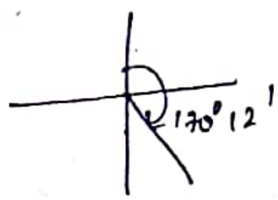
a) N 12° 24′ E b) S 31° 36′ E c) S 68° 6′ W d) N 5° 42′ W

1 Ans) a) WCB to QB

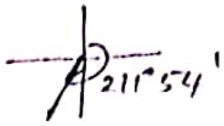
22° 30′ — N 22° 30′ E

b) 170° 12′ = QB = 180 − WCB

= S 9° 48′ E



c) $211°54'$



$\cancel{QB =} \quad \cancel{211°54'}$

$$180° + \alpha = 211°54'$$

$$QB \quad \alpha = 211°54' - 180°$$

$$QB = S\,31°54'\,W$$

d) $327°24'$

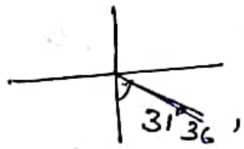
$$QB = 360° - 327°24'$$

$$QB = N\,32°36'\,W$$

2 Ans:- a) $N\ 12°24'\ E$

$$\Rightarrow \cancel{12°}\ WCB = 12°24'$$

b) $S\ 31°36'\ E$



$$WCB = 180° - QB$$

$$= 180° - 31°36'$$

$$WCB = 148°24'$$

c) $S\ 68°6'\ W$

$$WCB = 180 + QB$$

$$= 180° + 68°6'$$

$$WCB = 248°6'$$

d) $N\ 5°42'\ W$

$$WCB = 360 - QB$$

$$= 360° - 5°42'$$

$$WCB\ \cancel{QB} = 354°18'$$

5/7/19

1) WCB / Azimuthal system:

In this system the bearing of a line is measured with magnetic north or (with south) in clock wise direction.

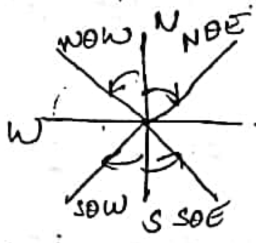
→ The value of the bearing varies from 0 to 360°.

→ prismatic compass is graduated with this system.

→ ~~In~~ ~~In~~ In India & UK, WCB is measured clockwise with magnetic north.

2) ~~QB~~ Quadrantal bearing system (Reduced Bearing):

In this system bearing of a line is measured east ward or west ward from north or south which ever is nearer.



Thus both north and south are used as reference meridians and directions can be either clockwise or anti-clockwise depending up on the position of the line.

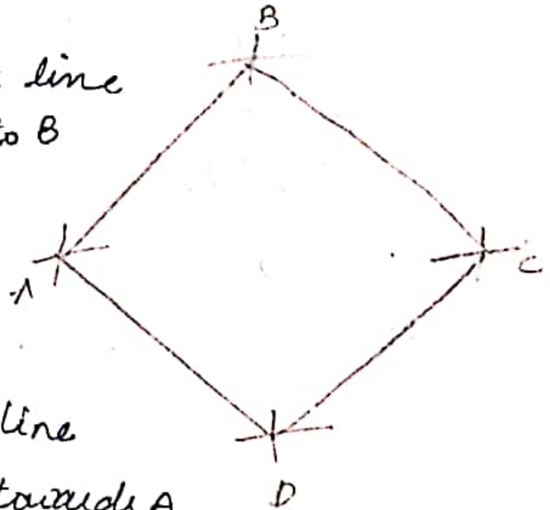
→ These bearings are observed by surveyor's compass. In this system, therefore the quadrant in which the line lies, has to be mentioned.

→ The QB of a line varies from 0 to 90°

→ The bearings of this system are known as reduced bearings (RB).

Fore/ Forward bearing (FB) and Back bearing (BB) :

~~Fore/ Forward Bearing :~~



If the bearing of a line AB is measured from A to B it is known as forward bearing or fore bearing (FB).

If the bearing of the line AB is measured from B towards A, it is known as backward bearing (or) Back bearing (BB), because it is measured in backward direction.

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

→ use '+' sign, $BB = FB + 180^\circ$ when FB is less than 180°.

→ use '−' sign when $BB = FB - 180^\circ$ when FB is more than 180°.

Problem :

The following are fore bearings of lines. Find out their back bearings.

(i) AB $12^\circ 24'$

$BB = FB + 180^\circ$

$= 192^\circ 24'$

(ii) BC $119^\circ 48'$

$BB = FB + 180^\circ$

$= 119^\circ 48' + 180^\circ$

$= 299^\circ 48'$

(iii) CD $266^\circ 30'$

$BB = FB - 180^\circ$

$= 266^\circ 30' - 180^\circ$

$= 86^\circ 30'$

(iv) DE $354^\circ 18'$

$BB = FB - 180^\circ$

$= 354^\circ 18' - 180^\circ$

$= 174^\circ 18'$

(iv) PQ N 18°0'E

WCB = 18°

BB = 180 + FB

= 180 + 18°

= ~~180~~ 198°

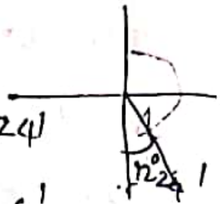
RB = 198 − 180

= S18°W.

vi) QR S 12°24' E

WCB = 180 − 12°24'

= 167°36'



BB = 180 + 167°36'

= 347°36'

QB = 12°24'

= N 12°24' W.

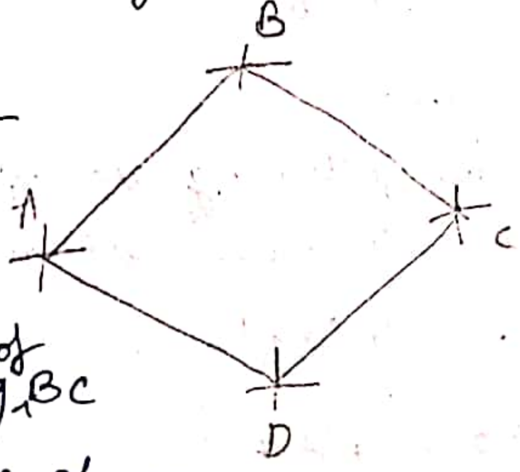
vii) RS S 59°18' W

N 59°18' E

(viii) ST N 86°12' W

S 86°12' E

Calculation of Angles from Bearings:



∠A = Bering of previous line − Bearing of next line

= Bearing of (AD − AB.)

∠B = Bearing of BA − Bearing of BC

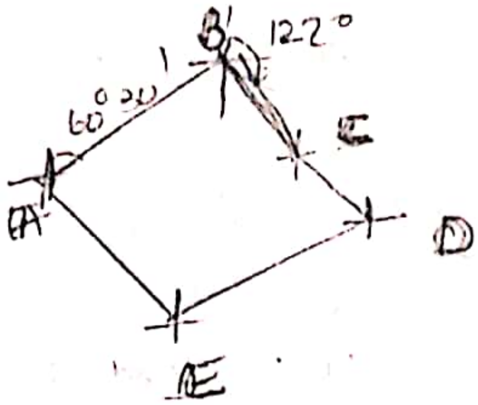
∠C = Bearing of CB − Bearing of CD

∠D = Bearing of DC − Bearing of DA

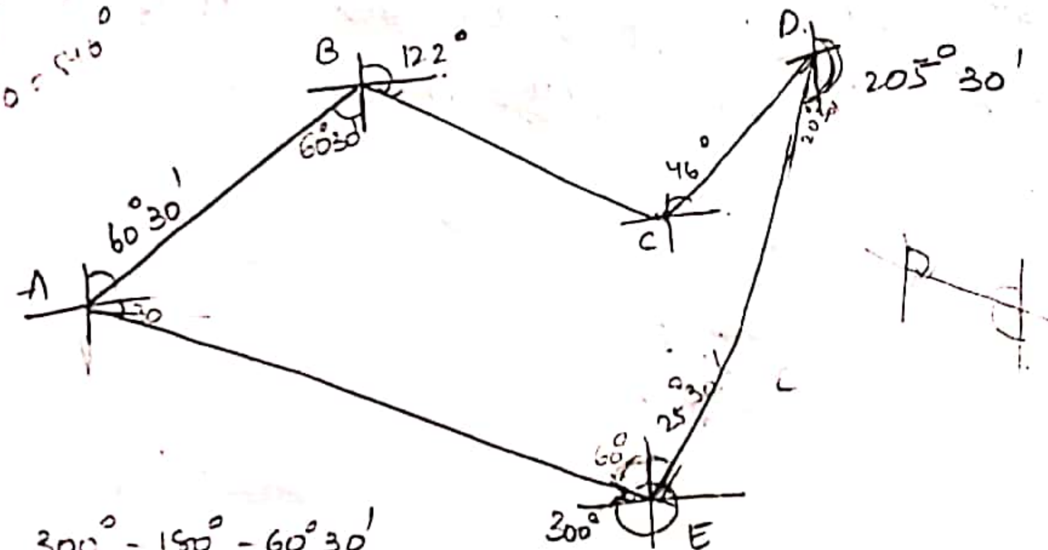
= 360° − (−Bearing of DC + Bearing of DA)

1) The following bearings were observed with a compass. Calculate interior angles.

Line	FB
AB	$60^\circ 30'$
BC	122°
CD	46°
DE	$205^\circ 30'$
EA	300°



BB = 180-146
2 2 6



$\angle A = 300^\circ - 180^\circ - 60^\circ 30'$
$= 59^\circ 30'$

$\angle B = 60^\circ 30' + 180^\circ - 122^\circ = 118^\circ 30'$

$\angle C = 122^\circ + 180^\circ - 46^\circ = 256^\circ$

$\angle D = 46^\circ + 180^\circ - 205^\circ 30' = 20^\circ 30'$

$\angle E = 60^\circ + 25^\circ 30' = 85^\circ 30'$

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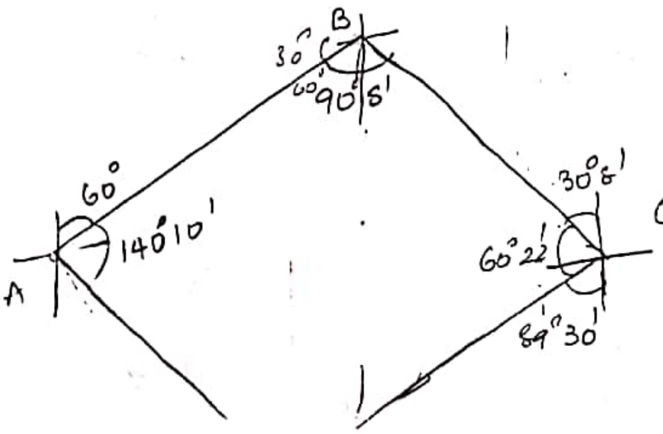
Calculation of Bearings from Angles:

Add the measured clockwise angles to the bearing of previous line if sum is more than 180° deduct 180°, if sum is less than 180° add 180°.

problem:

The following interior angles were measured with a sextant. in a closed traverse. The bearing of line AB was measured as 60° with prismatic compass. Calculate the bearings of all other lines if ∠A = 140° 10', ∠B = 90° 8', ∠C = 60° 22' ∠D = 69° 20'.



Bearing of AB = 60°

Bearing of AD = (180 + 60°) + 140° 10' = 200° 10' ~~- 180° = 20° 10'~~

-180° = 200° 10'

Bearing of BA = 180° + 60° = 240°

Bearing of BC = ~~90 +~~ ~~90° +~~ (180° - 90° 8' = 89° 52'
- 30°
= 59° 52')

→ 90° + 59° 52' = 149° 52'

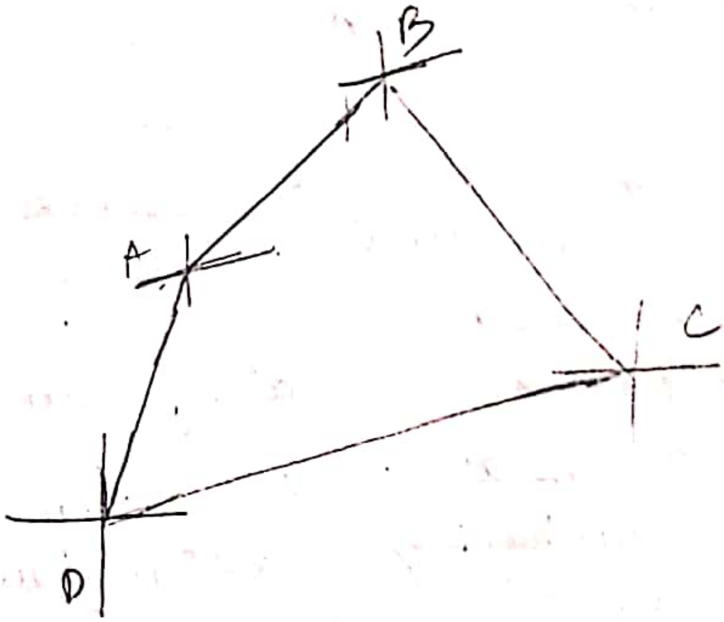
Bearing of CB = ~~(90~~. $360° - 30°8' = 329°52'$

Bearing of CD = ~~180°4~~ $360° - (60°20' + 30°8')$

$= 269°30'$

Bearing of DC = $89°30'$

Bearing of DA = $360° - 69°20' = 290°40'$



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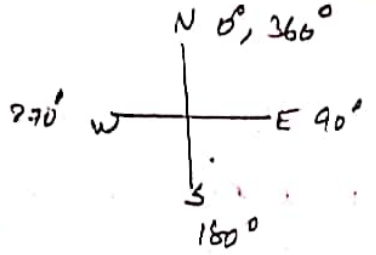
Dip:

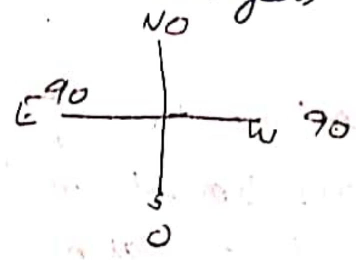
The ~~horizont~~ lines of forces of earth magnetic field runs from south to north, near equator they are parallel to earth surface. The horizontal projections of the lines of forces define the magnetic meridian, the angle which these lines of force, makes with the surface of the earth is called angle of dip (or) dip of the needle.

Adjustments of prismatic compass:

1. Centering
2. levelling
3) focussing the prism.

Prismatic compass	Surveyor's compass
1. The needle is broad needle type. It does not act as index.	1. The needle is edge bar type. Needle acts as index.
2. The grduated card ring attatched with needle. Ring doesnot rotate along with line of sight.	2. Graduated card is attatches to the box and not to the needle. The card rotates along with the line of sight.
3. The graduations are in WCB system. having 0° at south, 90° at west, 180° at north, 270 at east.	3. Graduations are in QB system having 0° at N&S. and 90° at W&E (E&W are interchanged)
4. The graduations are engraved inverted	4. The graduations are engraved erect.
5. object vane consists of metal vane with a vertical head. Eye vane consists of small metal vane with slit.	5. Object vane consists of metal vane with vertical head. Eye vane consists of metal vane with a fine slit.
6. Reading is taken with the help of prism provided at eye slit.	6. Reading is taken by directly seeing through top of the ~~box~~ glass



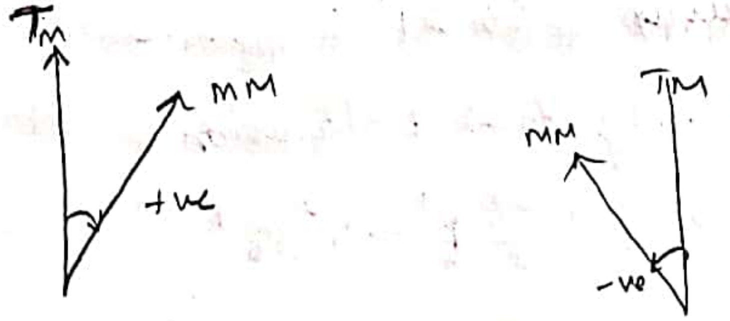


7. Sighting and reading can be done simultaneously from one position of the observer.	7. Sighting and reading cannot be done simultaneously from one position of the observer.
8. Tripod may or may not be provided. Instrument can be used even by holding suitably in hand.	8. Instrument cannot be used without a tripod.

Magnetic declination:

Magnetic declanation at a place is the horizontal angle between true meridian and magnetic meridian shown by the needle at the time of observation. If the magnetic meridian is to the right side or to the eastern side of true meridian, the declination is said to be eastern or positive.

It is to the left side or western side of true meridian the declination is said to be western.



* Mariners called declination by the name "Variation"

Determination of True Bearing:

All imp surveys are plotted with reference to the true meridian, since the direction of magnetic meridian at a place changes with the time. Therefore true bearing = Magnetic bearing ± Declination.

Use + sign when declination is towards east and use − sign when declination is towards west.

The above rule is valid for WCB bearings only.

→ If a reduced bearing has been observed it is advisable to draw the diagram and calculate bearing.

Problem:

The magnetic bearing of a line is $48°24'$. Calculate true bearing if magnetic declination is $5°38'$ east.

Sol:- Declination. $5°38'$ E

Mag bearing $48°24'$.

$$TB = Mg\ B + \text{Declination}$$

$$TB = 48°24' + 5°38'$$

$$= 54°2'$$

Local Attraction:

It is a term used to denote any influence ~~such as~~ which prevents the needle from pointing to the magnetic north in a given locality.

Some of the sources of local attraction are.
Magnetite in the ground, wires carrying electric current, steel structures, rails, under-ground level pipes, keys, steel bowed spectacles, metal buttons, axes, chains, steel tapes etc. which may be lying on the ground nearby.

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Elimination of local attraction:

There are 2 methods to eliminate local attraction.

Method 1:

In this method, the bearings of the lines are calculated on the basis of bearing of that line which has a difference of 180° in its fore and back bearings.

Method-II.

This is a more general method and it is based on the fact that though the bearings measured at a station may be incorrect due to local attraction, ~~at~~ the included angle calculated from bearings will be correct since the amount of error is same for all bearings measured at the station.

The included angle between the lines are calculated at all the stations. If the traverse is closed traverse the sum of interior or internal included angles must be equal to $(2n-4)90°$

Problem:-

1) The following bearings were observed while traversing with a compass.

Line	FB	BB	
AB	45°45'	226°10'	BA
BC	96°55'	277°05'	CB
CD	29°45'	209°10'	DC
DE	324°48'	144°48'	ED

Sol:-

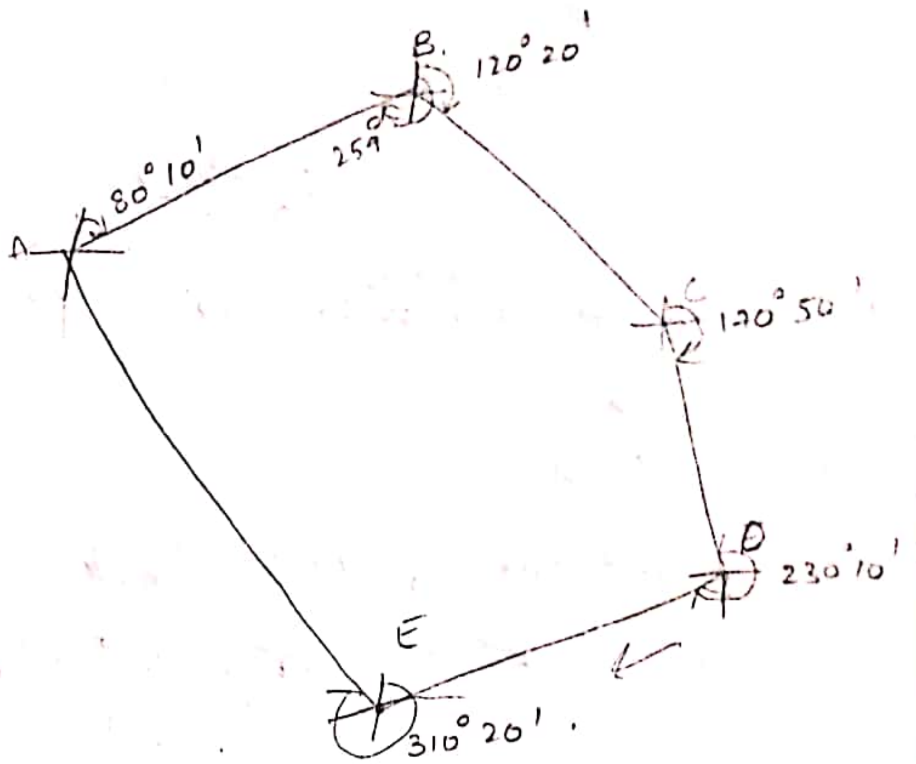
Line	Observed Bearing	Correction	Corrected Bearing	Remarks
AB	45° 45'	0° at A	45°45'	
BA	226°10'	−25' at B	225°45'	B & C
BC	96° 55'	−25' at B	96°30'	Stations are affected
CB	277°05'	−35' at C	276°30'	by L.A.
CD	29°45'	−35' at C	29°10'	A, D & E are free from
DC	209° 10'	0° at D	209°10'	local attraction
DE	324°48'	0° at D	324°48'	
ED	144°48'	0° at E	144°48'	

Method:

2) The following are bearings taken ~~by~~ on a closed compass traverse

Line	FB	BB	
AB	80°10'	259°	BA
BC	120°20'	301°50'	CB
CD	170°50'	350° 50'	DC ✓
DE	230°10'	49° 30'	ED
EA	310°20'	130°15'	AE

compute the interior angles and correct them for observational errors assuming the observed bearing of the line CD to be correct, and adjust the bearings of remaining sides.



$\angle A$ = Bearing of prev line − Bearing of next line.

$= \cancel{310°20' - 180°10'} =$

$= 130°15' - 80°10' = 50°5'$

$\angle B = 259° - 120°20' = 138°40'$

$\angle C = 301°50' - 170°50' = 131°$

$\angle D = 350°50' - 230°10' = 120°40'$

$\angle E = 49°30' - 310°20' + 360° = 99°10'$

error $= -25'$ correction $= +\frac{25'}{5} = 5'$

corrected included angles $= \angle A = 50°10'$, $\angle B = 138°45'$

$\angle C = 131°5'$, $\angle D = 120°45'$; $\angle E = 99°15'$

Bearing of DE

$\angle D$ = Bearing of DC − Bearing of DE

$120^\circ 45' = 350^\circ 50'$ − Bearing of DE

Bearing of DE $= 350^\circ 50' - 120^\circ 45'$

$= 230^\circ 5'$

Bearing of ~~EA~~ ED $= 230^\circ 05' - 180^\circ = 50^\circ 05'$

~~$\angle E$ = Bearing of ED~~ :

Bearing of EA :

$\angle E$ = Bearing of ED − Bearing of EA .

EA $=$ ~~$50^\circ 05'$~~ $99^\circ 15' - 50^\circ 05' + 360^\circ$

EA $=$ ~~$49^\circ 10'$~~ $310^\circ 50'$

Bearing of AE $=$ ~~$180^\circ + 49^\circ 10' = 229^\circ 10'$~~

$310^\circ 50' - 180^\circ = 130^\circ 50'$

Bearing of AB :

Bearing of AB = Bearing of AE − $\angle A$

$= 130^\circ 50' - 50^\circ 10'$

$= 80^\circ 40'$

Bearing of BA $= 80^\circ 40' + 180^\circ = 260^\circ 40'$

Bearing of BC = Bearing of BA − ∠B

$= 260°40' - 138°45'$

$= 121°55'$

Bearing of CB = $121°55' + 180° = 301°55'$.

Bearing of CD = Bearing of ~~DC~~ CB − ∠C

$= \cancel{350°50'}\ 301°55' - 131°05'$

$= \cancel{219°45'}\ 170°50'$

Bearing of DC = $170°50' + 180° = 350°50'$.

Errors in compass survey:

The errors classified as

a) Instrumental errors

b) personal errors

c) Errors due to natural causes.

a) Instrumental errors:

1) If Needle is not perfectly straight
2) pivot being bent
3) sluggish needle.
4) Blunt pivot point.
5) Improper balancing weight
6) plane of sight not being vertical.
7) Line of sight not passing through the centres.

b) personal error :

1) Inaccurate leveling of the compass box.

2) Inaccurate centering.

3) Inaccurate bisection of objects.

4) Carelessness in reading and recording.

c) Errors due to natural causes :

1) Variation in declination

2) local attraction due to proximity of local attraction forces.

3) Magnetic changes in the atmosphere due to clouds and storms.

4) Irregular variations due to magnetic storms etc.

MODULE - II

LEVELLING & CONTOURING

Leveling:

Leveling: Basic definitions, types of levels and ~~staves~~ leveling staves, Temporary and permanent adjustments - method of leveling. Booking and determination of level - HI method - Rise & fall method, effect of curvature if earth and refraction.

Contouring: characteristics and uses of contours, Direct and indirect methods of contouring, contour surveying, Interpolation and sketching of contours.

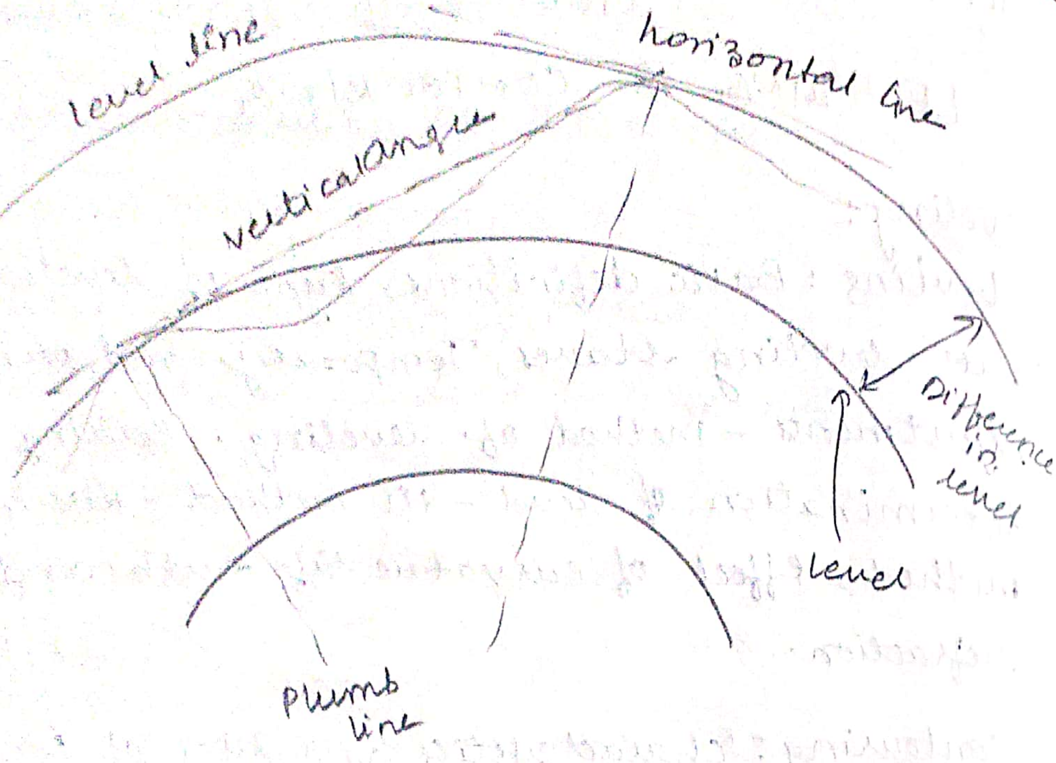
Leveling:

It is a branch of surveying. The object of which is: a) to find the elevations of given points wrt a given or assumed datum.

b) To establish points at a given elevation or at different elevations wrt to a given or assumed data.

→ First operation is required to enable the works to be designed and second operation is required in setting out of all kinds of engineering works.

→ Leveling deals with measurements in a vertical plane.



Level surface :

It is a curved surface which at each point is ⊥lar to the direction of gravity at that Point.

Eg: The surface of still water

Any surface ||el to the mean spheroidal surface of the earth is a level surface.

Level line:

It is a line lying on level surface.

Horizontal line:

It is a straight line tangential to the level line at a point. It is also ⊥lar to the plumb line vertical line:

It is normal to the level line at a point

Datum:

It is any surface to which elevations are reffered. MSL is a convient datum world over and elevations are commonly given as so much above or below MSL (mean sea level)

Bench Mark:

It is a relatively permanent point of reference whose elevation wrt some assumed datum is known.

Mean Sea level:

It is the average height of sea for all stages of the tides. At any particular place it is derived by averaging the hourly tides heights over a long period of 19 years.

13/08/19

Elevation:

The elevation of a point on or near the surface of the earth is its vertical distance above or below an arbitarily assumed level surface or datum.

Methods of leveling:

1) Barometric leveling
2) Trignometric or indirect leveling
3) Spirit leveling or direct leveling.

Types of levels & leveling staves:

The instruments commonly used in direct leveling are a) level

b) leveling staff

c) Tripod.

a) Level:

The purpose of a level is to provide a horizontal line of sight. It consists of 4 parts.

(i) Telescope - To provide line of sight.

(ii) Level tube - To make line of sight horizontal

(iii) A leveling head - Tribrach & Trivet stage.

(iv) Tripod - to support the Instrument.

Types of levels:

1) Dumpy level

2) Wye (Y) level

3) Reversible level

4) Tilting level

Diagram of dumpy level & its component parts.

1) Telescope

2) Eye-piece

3) Ray shade

4) objective end

5) longitudinal bubble

6) focusing screws

7) Foot screws

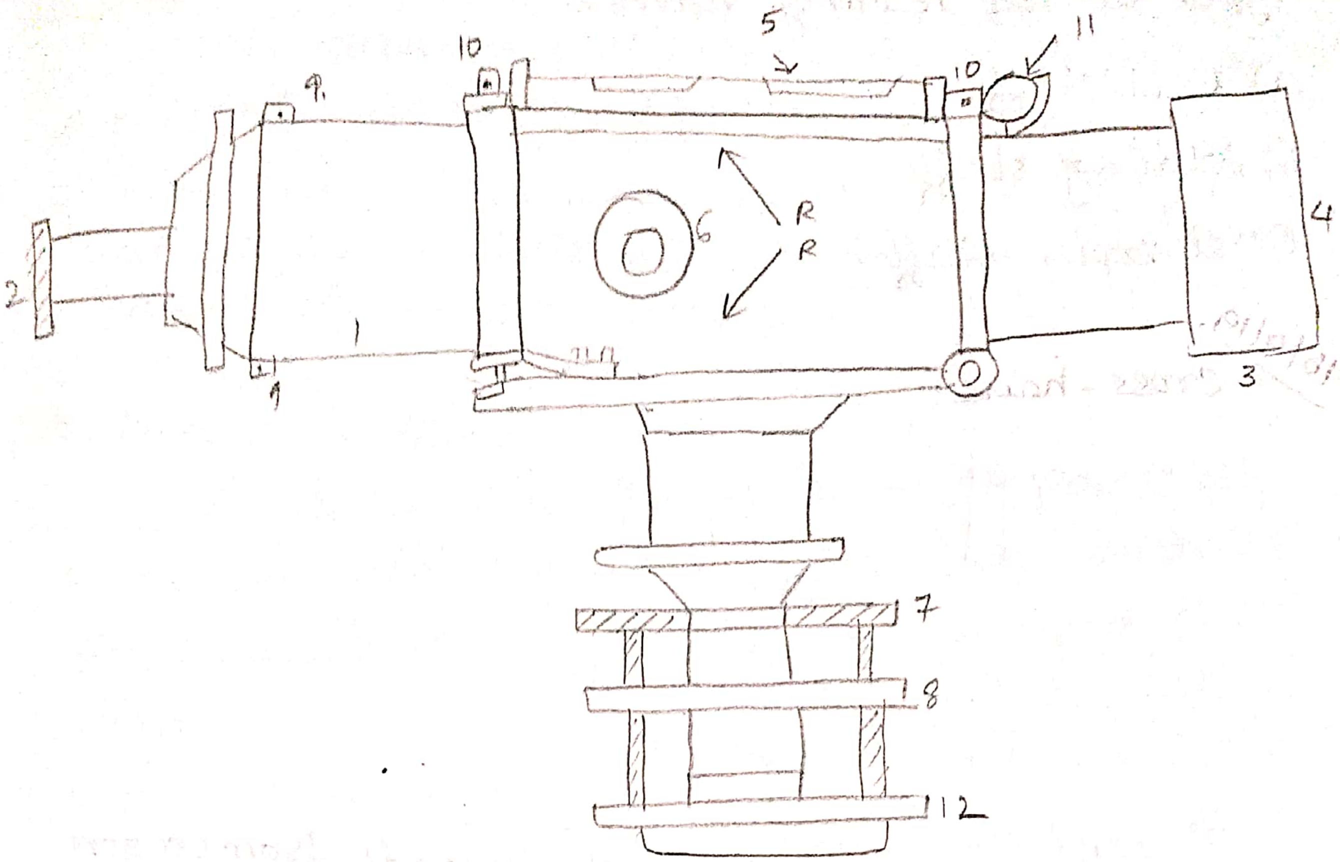
8) upper parallel plate

9) Diaphragm Adjusting screws

10) Bubble tube adjusting screws

11) Transverse bubble tube

12) Foot plate.



Types of leveling staves :

1) A leveling staff is a straight rectangular rod having graduations, the foot of the staff represents 'O' reading.

→ Purpose of leveling staff is to determine the amount by which the station i.e the foot of the staff above or below the line of sight.

1) Self reading staff
2) Target staff.

Self Reading staff :

It is the one which can be read directly by the instrument man through telescope.

Target staff :

It contains a moving target against which the reading is taken by staff man.

Types of self reading staves:

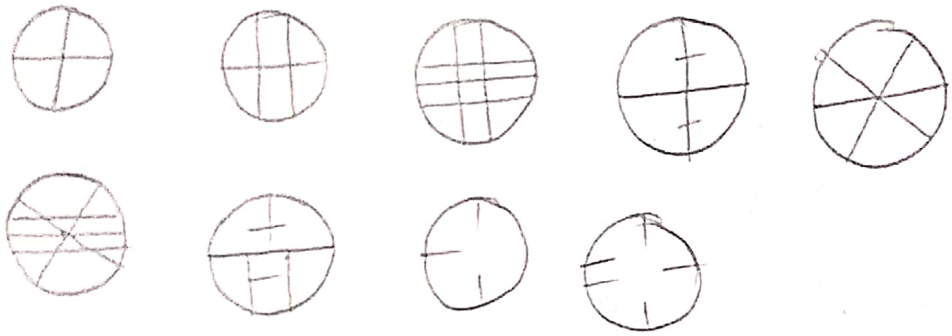
a) solid staff

b) folding staff

c) Telescopic staff.

16/9/19.

Cross-hairs:



These are made up of threads from cocoon of the brown spider but may be of very fine platinum wire of filaments of silk.

* Temporary (or) station Adjustments of a level:

It consists of .

1) Setting of the level

2) leveling up

3) Elimination of parallax.

   (i) focussing eye piece

   (ii) focussing objective

Special methods of direct leveling: (spirit leveling)

(1) Differential leveling / Fly leveling

(2) profile levelling

(3) Cross-sectioning

(4) Reciprocal leveling

(5) precised levelling

(1) Differential levelling:

To determine difference in elevation of two points is called differential leveling.

→ when the points are apart, it is necessary to set up the instrument no. of times. This type is called fly ~~ler type~~ levelling.

(2) Profile levelling:

To determine the elevation of points at measured intervals along a given line in order to obtain a profile of the surface along that line.

(3) Cross-sectioning:

It is also called as cross-levelling. It is the process of taking levels on each side of a main line at right angles to that line, inorder to determine a vertical cross-section of the surface of the ground or of underlying strata or of both.

(4) Reciprocal levelling:

The difference in elevation between two points is accurately determined by two sets of reciprocal observations when it is not possible to setup the level between the points.

(5) precised levelling:

It is the levelling in which the degree of precision required is too great to be attained by ordinary methods. Therefore special equipment or special precautions are required to eliminate sources of errors.

Terms & Abbreviations:

1) station: It is the point where the level rod is held but not where the level is set up.

2) Height of Instrument :

It is the elevation of line of sight wrt ~~the~~ th assumed datum. It does not mean that height of telescope above the ground.

3) Back ~~site~~ sight :

It is the sight taken on a rod at a point of known elevation, to ascertain the amount by which the line of sight is above that point so that we can obtain height of instrument.

Back sighting is equal to measuring up from the point of known elevation to line of sight. It is also known as '+' sight.

4) Fore Sight :

It is a sight taken on a rod held at a point of unknown elevation to ascertain the amount by which the point is below the line of sight, and thus to obtain the elevation of the station.

It is also known as minus sight ('-' sight) except in special case of tunnel survey.

5) Turning point or Change point :

T.P or C.P is a point on which both '-' sight and '+' sight are taken. The '-' sight is taken on the point in one set of instrument to ascertain the elevation of the point where as '+' sight is taken on the same point in other set of the instrument to establish new height of instrument.

b) Intermediate sight:

It is a point / these are the points intermediate between back sight and fore sight on which the minus sight is taken to determine the elevations of intermediate stations.

(i) $H.I = RL + BS$

(Elevation of bench mark + back sight)

(ii) Elevation of station point = $HI - IS/FS$

Hand signals during observations:

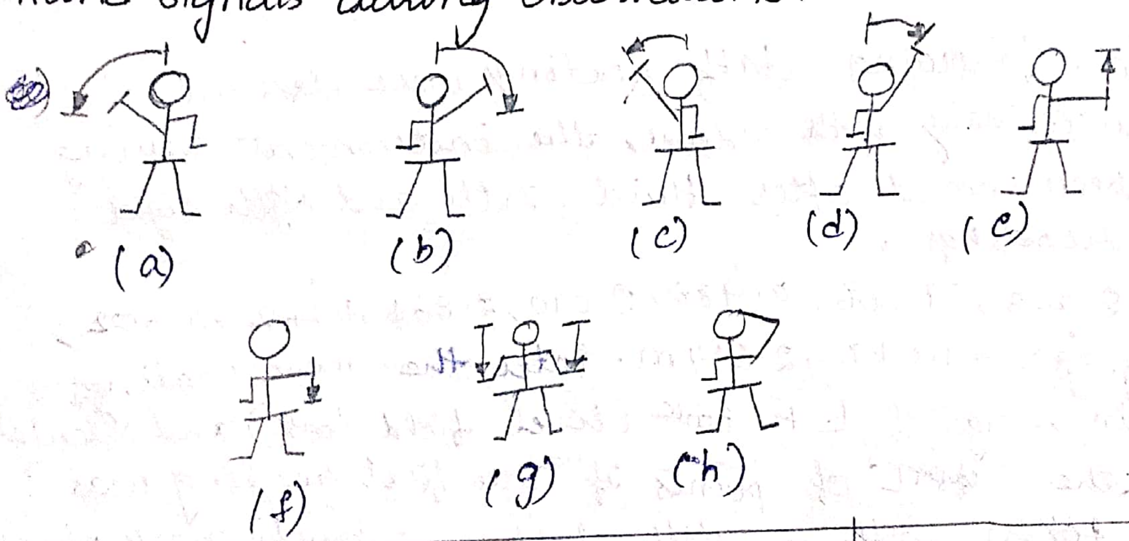


fig	Signal	Message
(a)	Movement of left arm over 90°	Move to my left
(b)	Movement of right arm over 90°	Move to my right
(c)	Movement of left arm over 30°	Move top off staff to my left
(d)	Movement of right arm over 30°	Move top off staff to my right
(e)	Extension of arm horizontally and moving hand up wards	Raise height peg or staff
(f)	Extension of arm horizontally and moving hand down wards	Reduce height of Peg or staff.

(g)	Extension of both arms and slightly thrusting downwards	Establish the position.
(h)	Extension of arms and placement of hand on top of head.	Return to me

Booking and Reducing levels:

There are 2 methods

(i) collimation or height of instrument method.

(ii) Rise and fall method.

Collimation or height of instrument method:

problem:

1) The following staff readings were observed succesively with a level, the instrument having been moved after third, sixth and ~~eigth~~ eight readings.

2.228, 1.606, 0.988, 2.090, 2.864, 1.262, 0.602, 1.982, 1.044, 2.684 m. Enter the above readings in a page of L.F. Book (level field book) and calculate the R.L of points if the first reading was taken with a staff held on a bench mark of 432.384 m

Sol:- method I - H.I method

or Collimation method.

Station	B.S	I.S	F.S	H.I	R.L	Remarks.
A	2.228			434.612	432.384	RL of BM
		1.606			433.006	
			~~0.988~~			
B	2.090		0.988	435.714	433.624	CP1
		2.864			432.85	
			~~1.262~~			
C	0.602		1.262	~~432.19~~ 435.054	~~431.588~~ 434.452	CP2
			~~1.982~~			
D	1.044		1.982	~~431.252~~ 434.116	~~430.208~~ 433.072	CP3.
		~~2.684~~	2.684		~~428.568~~ 431.432	

$\Sigma BS - \Sigma FS = L.RL - F.RL$

$5.964 - 6.916 = \cancel{428.568 - 432.384}$ $431.432 - 432.384$

$-0.952 = -0.952$

$\therefore$ There is a fall of 0.952 m.

Station	B.S	I.S	F.S	Rise	fall	R.L	Remarks
1.	2.228			0.622		432.384	RL of BM
2.		1.606		0.618		433.006	
3.	2.090		0.988		-0.774	433.624	C.P1
4.		2.864		1.602		432.85	
5.	0.602		1.262		1.38	434.452	CP2
						433.072	
6.	1.044		1.982		1.64	431.432	CP3
7.			2.684				

$\Sigma Rise - \Sigma Fall = I.R.L - F.RL$

$2.842 - 3.794 = 431.432 - 432.384$

$-0.952 = -0.952$

Comparision of H.I method & Rise & fall method:

H.I method is more rapid less tedious & simple. However since the check on calculations for intermediate sights is not available. The mistakes in their levels pass unnoticed.

→ The Rise & Fall method even though more tedious, it provides a full check in calculations for all sides.

→ However H.I method is more suitable where it is required to take number of readings ~~fo~~ from the same instrument setting such as for constructional work, profile leveling etc.

Problem:

The following figures were extracted from a levelled field book, some of the entries being illegible owing to exposure to rain. Insert the missing figures and check your results. Rebook all the figures by rise & fall method.

station	BS	IS	FS	Rise	Fall	RL	Remarks
1.	2.285					232.460	BM.I
2.	1.650		2.265 ~~0.020~~	0.0200		232.480	
3.		2.105			0.455	232.025	
4.	~~2.225~~ 1.625		1.960	0.145		232.17	
5.	2.050		1.925		0.300	231.87	
6.		1.665		0.385		232.255	BM 2
7.	1.690		1.325	0.340		232.595	
8.	2.865		2.100		0.41	232.185	
9.			1.625	1.24		233.425	BM.3

Check :

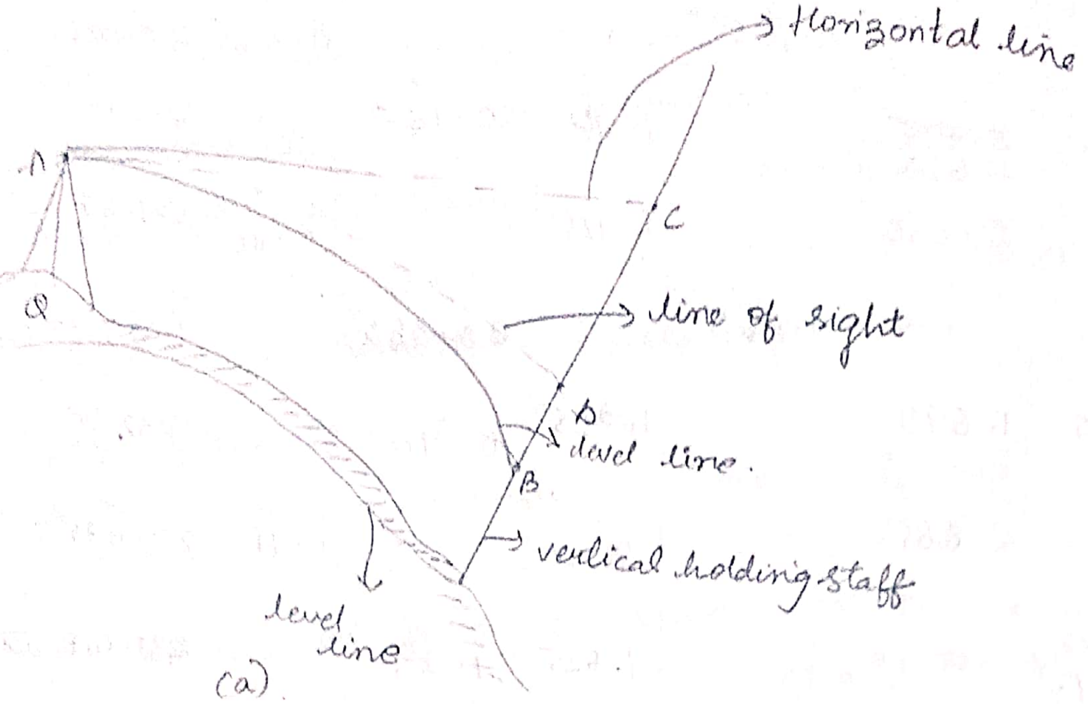
$\Sigma B.S - \Sigma F.S = \Sigma Rise - \Sigma fall = Last\ R.L - first\ RL$

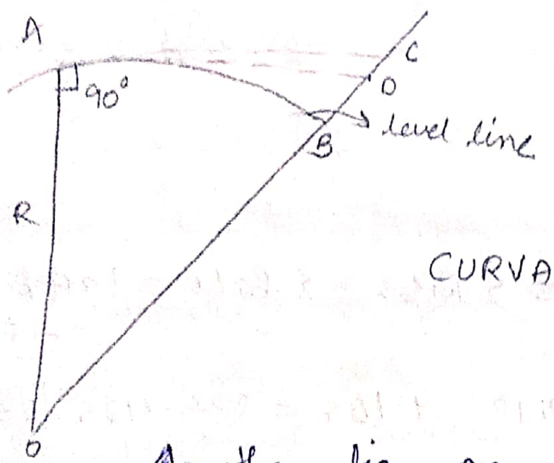
$\Rightarrow 12.165 - 11.2 = 2.13 - 1.165 = 233.425 - 232.460$

$\Rightarrow 0.965 = 0.965 = 0.965$ m (Rise)

Hence checked.

Curvature & Refraction corrections:





CURVATURE & REFRACTION

In the fig AC is horizontal line which deflects upwards from level line AB by an amount of BC. AD is the actual line of sight.

curvature:
Correction: $OC^2 = OA^2 + AC^2$

$\angle CAO = 90°$

$BC = C_c$ (correction for curvature)

$AB = d$ = horizontal distance between A and B

$OB = AO = R$ = Radius of earth in the same units as that of 'd'.

$$(R+C_c)^2 = R^2 + d^2$$

$$\cancel{R^2} + C_c^2 + 2R\,C_c = \cancel{R^2} + d^2$$

$$\cancel{C_c^2 = d^2 - 2RC_c}$$

$$C_c\,(C_c + 2R) = d^2$$

$$\boxed{C_c = \frac{d^2}{C_c + 2R}}$$

$$\boxed{C_c = \frac{d^2}{2R + C_c}}$$

$C_c \rightarrow$ negligible when compared to 2R

$$\boxed{\therefore\ C_c \simeq \frac{d^2}{2R}}$$

Note : 1. Both R and d should be in same units.

2. Take radius of earth 'R' = 6370 KM

$$C_c = \frac{d^2}{2 \times 6370} = 0.07849\ d^2\ m$$

$$\boxed{C_c = 0.07849\,d^2 m}$$

In the above formula d value is in km while C_c will be in meters.

correction for refraction:

$$C_r = \frac{1}{7}\,\frac{d^2}{2R} = 0.01121\,d^2 m$$

$$\boxed{C_r = 0.01121\,d^2\ m}$$

Combined correction for curvature and Refraction:

$$C = C_c - C_r$$

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

$$C = \frac{6d^2}{7 \times 2R}$$

$$C = \cancel{0.0679}\ 0.06728\,d^2\ m$$

$$\boxed{C = 0.06728\,d^2\ m}$$

Problem:

Find the correction for curvature, refraction and combined correction for curvature and refraction for a distance of a) 1200m, b) 2.48 km

Sol:- a) $d = 1200m$

$$C_c = 0.07849d^2 = 113025.6\ m$$

$$C_r = 0.01121\,d^2 = 16142.4\ m$$

$$C = 0.06728d^2 = 96883.2\ m$$

b) $2.48\ km \Rightarrow 2480\ m$

$$C_c = 0.07849d^2 = 482744.89\ m$$

$$C_r = 0.01121\,d^2 = 68945.98\ m$$

$$C = 0.06728d^2 = 413798.912\ m$$

2) Find C, C_c, C_r for a distance of a) 3400 m
b) 1.29 km

Sol:- a) 3400 m.

$C_c = 0.07849 d^2 = 907344.4$ m

$C_r = 0.01121 d^2 = 129587.6$ m

$C = 0.06728 d^2 = 777756.8$ m

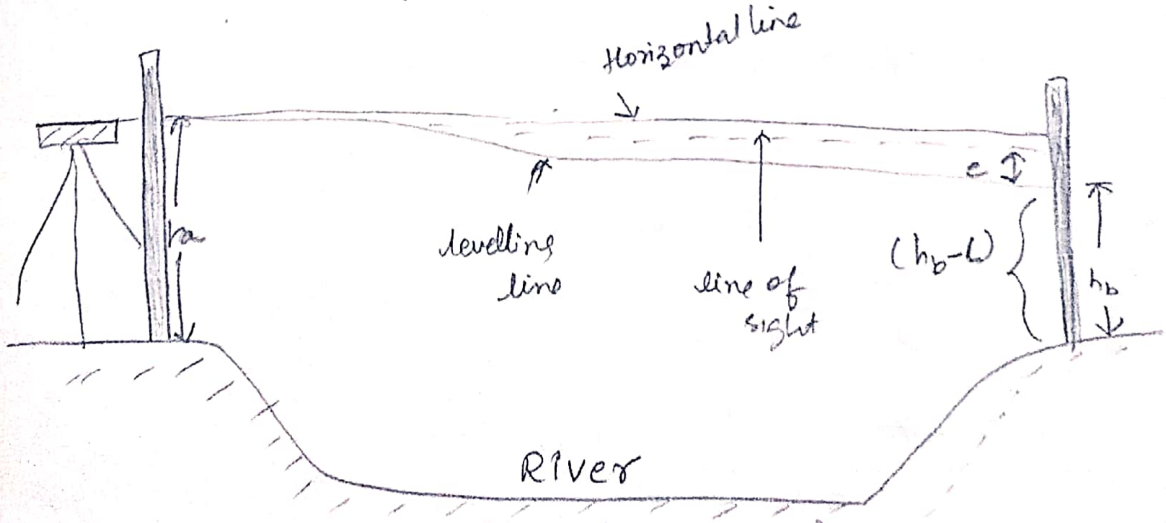
b) 1.29 km = 1290 m

$C_c = 0.07849 d^2 = 130615.20$ m

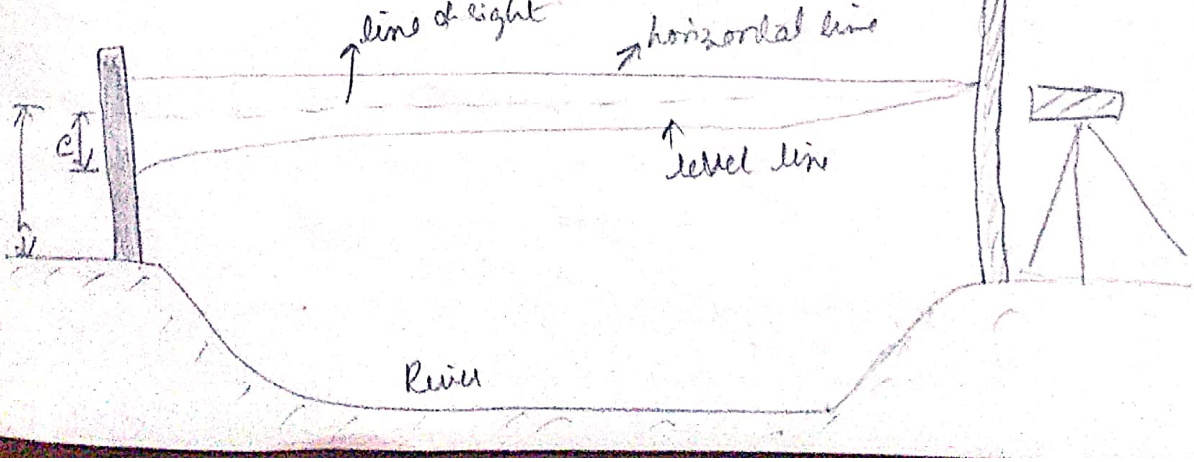
$C_r = 0.01121 d^2 = 18654.56$ m

$C = 0.06728 d^2 = 111960.648$ m

Reciprocal levelling:



$H = h_a - (h_b - e)$



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Cross - sectioning :

Cross - sections are run at right angle to the longitudinal profile and on either side of it for the purpose of lateral outline to the ground surface. They provide the data for estimating quantities of earth work and for other purposes.

Stn	Distance L	C	R	BS	IS	FS	HI	RL	Remarks
BM				1.325			101.325	100	
0		0			1.865			99.460	C/S
L_1	3				1.905			99.420	at 0m
L_2	6				2.120			99.205	chainage
L_3	9				2.825			99.500	
R_1		~~3~~	3		1.705			99.620	
R_2		~~7.50~~	7.5		1.520			99.805	
R_3		~~10~~	10		1.955			99.370	C/S
I		20			1.265			100.060	at
L_1	3				1.365			99.96	20m
L_2	6				0.725			100.600	chainage
L_3	9				2.125			99.20	
R_1			3		1.925			99.400	
R_2			7		2.250			99.075	
R_3			10		0.890			100.435	
						2.120		99.205	

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

$= 99.205 - 100$

0.795 (fall) $= 0.795$ (fall)

Checked.

27/8/19.

Errors in levelling:

Instrumental Errors	Natural Error	Personal error
1) The error due to imperfect adjustment	1) Earth's curvature	1) Mistakes in manipulation.
2) Sluggish bubble	2) Atmospheric refraction	2) Mistakes in rod handling.
3) Error due to movement of objective slide.	3) Variations in temperature	3) Errors in sighting
4) Rod not of standard length	4) Settlement of tripod or turning points	4) Mistakes in reading the rod.
5) Error due to defective joint	5) ~~Error due to defect~~ wind vibrations	5) Mistakes in recording and computing

Contouring:

Contour: It is an imaginary line on the ground joining the points of equal elevation.

Contour interval:

The vertical distance between any two consecutive contours is called contour interval.

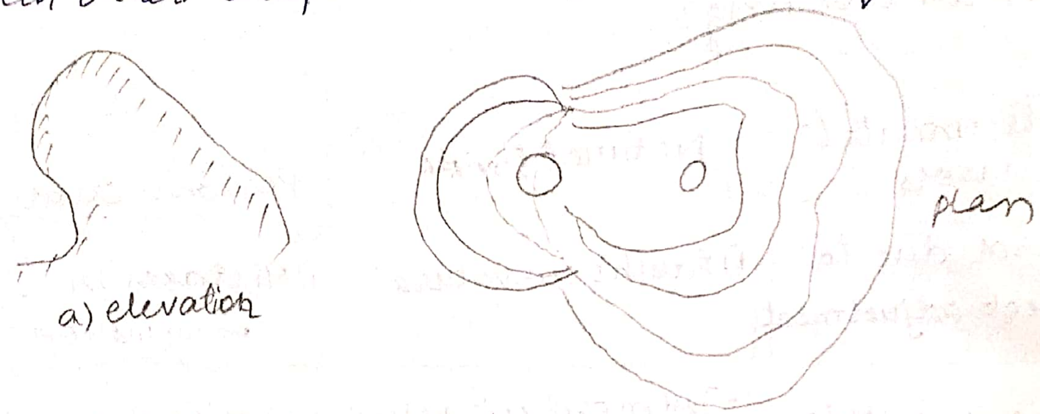
Horizontal Equivalent :

The horizontal distance between 2 points on 2 consecutive contours is called horizontal equivalent.

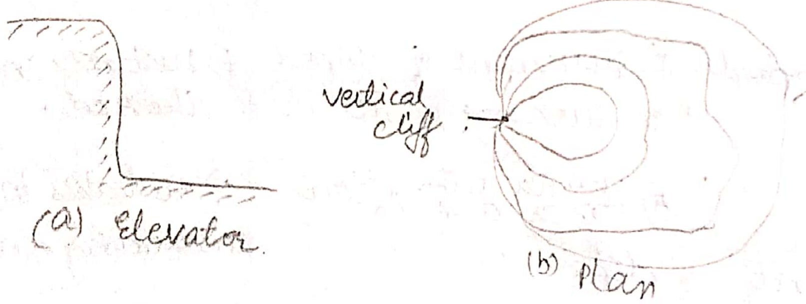
Characteristics of ~~cour~~ Contour :

1. Two contour lines of different elevations cannot cross each other except in case of over hanging cliff a cave.

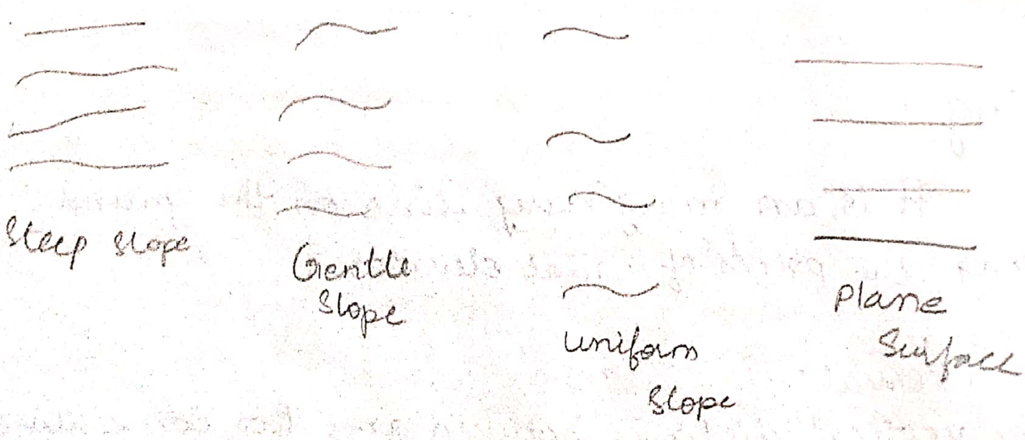
~~2.~~



2. Contour lines of different elevations can unite to form one line only ~~eo~~ in case of vertical ~~plo~~ cliff.



3.

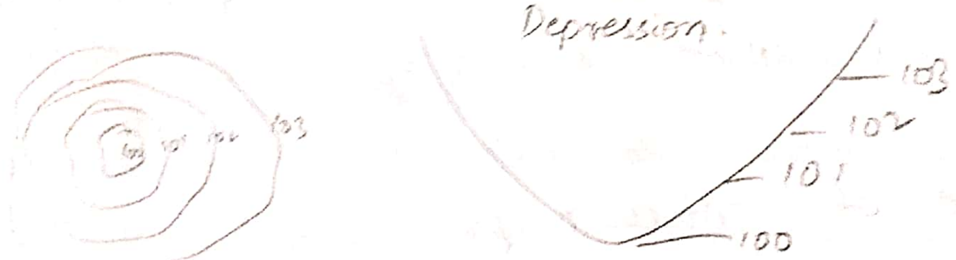


Contour lines close together indicates steep slope if they are far apart it indicates gentle slope. If they are equally spaced, it indicates uniform slopes.

A series of straight, parallel, equally spaced contours represents a plane surface.

4. A contour passing through any point is ⊥ar to the line of steepest slope at that point. 5. A closed contour line with one or more higher ones inside it represents a hill.

If a closed contour line with one or more lower ones inside it indicates a depression without an outlet.



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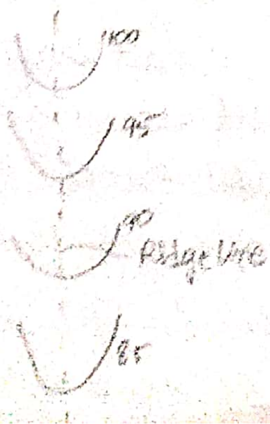
6. Two contour lines having same elevation cannot unite and continue as one line. Similarly a single contour cannot split into 2 lines.

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

8. 

Contour lines cross a water shed or ridge line at right angles. They form U-shaped curves of concave side of curve towards higher ground

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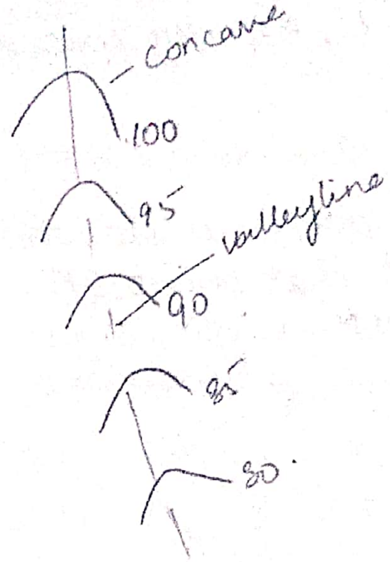
9. 

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

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

Uses of Contour Maps:

1. These are used to find out the nature of the ground.
2. To find out the profile of the ground along that line. It helps in finding out depth of cutting and depth of filling, if formation level of road or railway track is decided.
3. Intervisibility of any two points can be found by drawing profile of the ground along that line.
4. To decide the route of railway, roadway, canal, sewer lines, can be decided to minimize the earth work and balancing the earthwork.
5. Catchment area and quantity of water flow at any point of river can be formed. This study is very important in locating bunds, dams and also

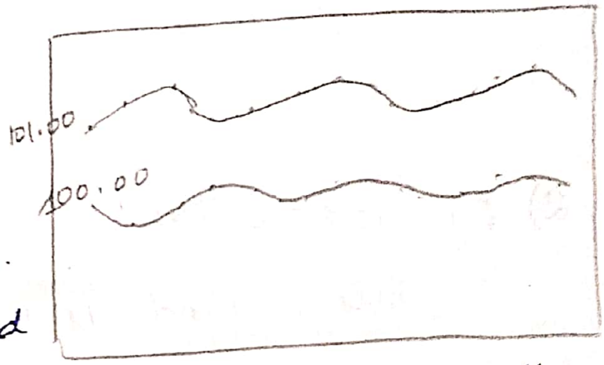
to do find out flood levels.

6. From the contours we can calculate the capacity of reservoir.

Methods of locating Contours:

1. Direct Method
2. Indirect Method.

1. Direct method:



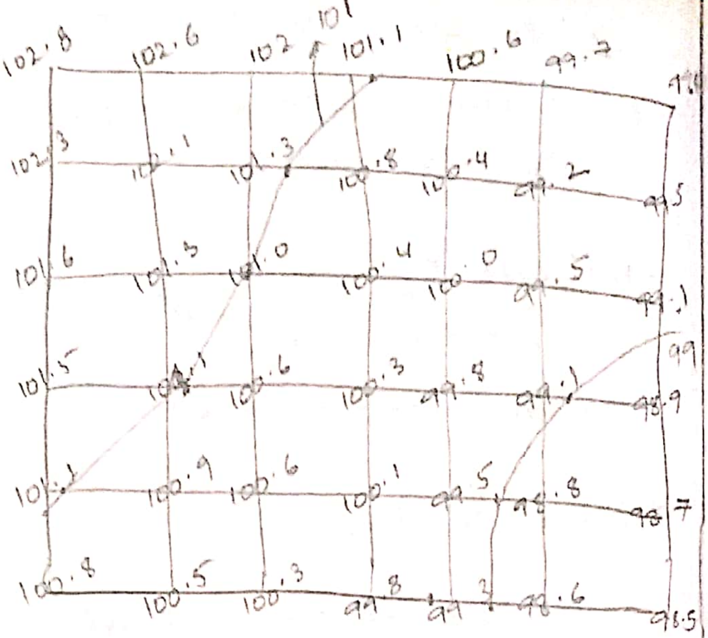
In the direct method, the contour to be plotted is to be traced on the ground. Only those points are surveyed which happens to be plotted. After having surveyed those points, they are plotted and contours are drawn through them. This method is slow and tedious so it is used for small areas and where great accuracy is required.

2. Indirect method:

In indirect method, some suitable guide points are selected and surveyed the guide points need not necessarily be on the contours. These guide points having being plotted, serve as basis for the intercolation of contours. This is the method most commonly used in engineering surveys.

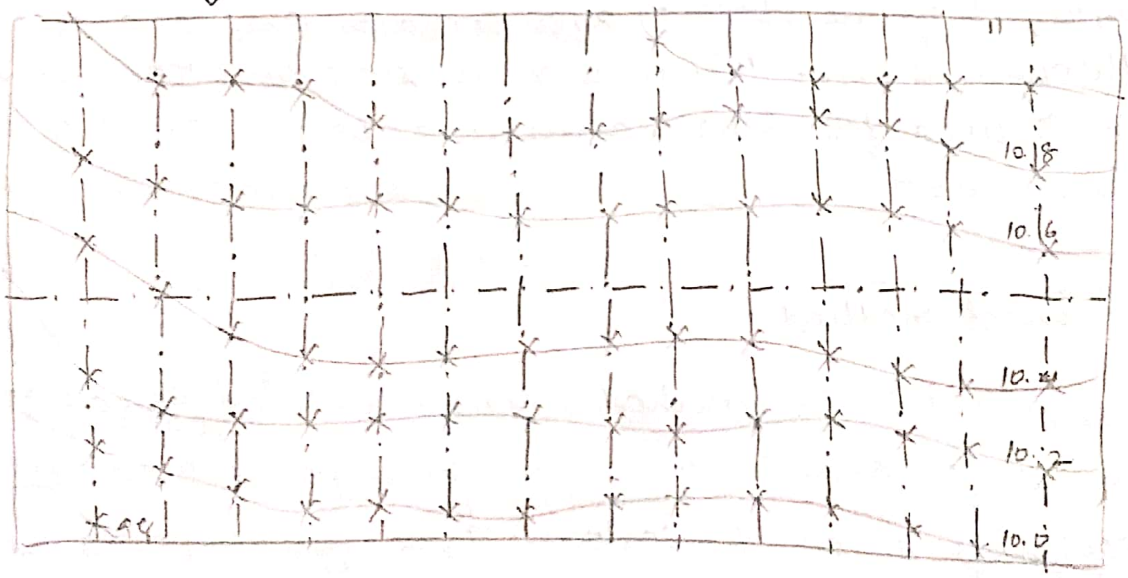
1) By squares:

(5m x 5m)

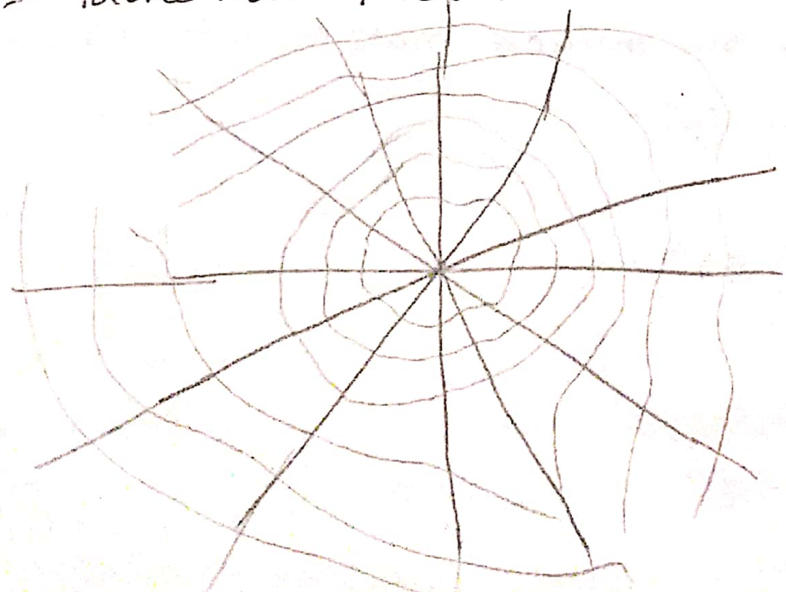


2) By cross-sections:

This method is suitable for Road projects and railway projects



3) Tachemetric / Radial line method:

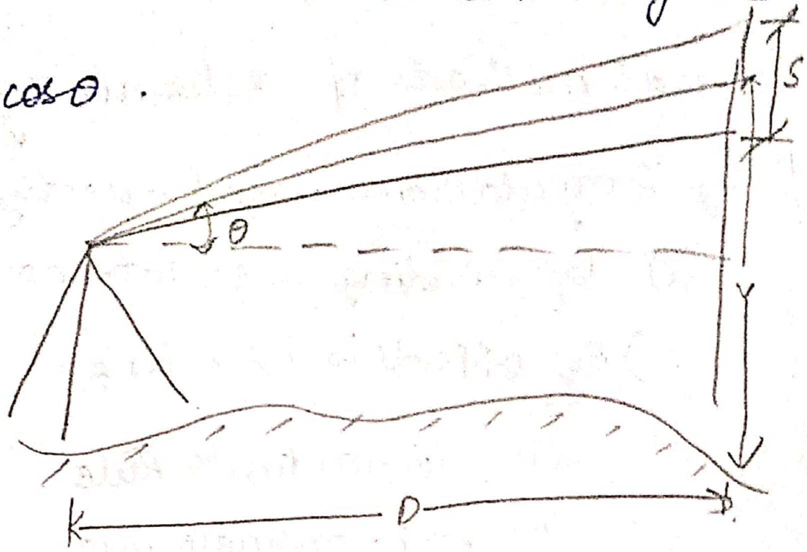


This method is suitable for hilly areas. In this method theodolite with tacheometer is commonly used..

$D = K_1 S \cos^2\theta + K_2 \cos\theta$ ..

$V = D \tan\theta$.

where K_1, K_2 are instrument constants

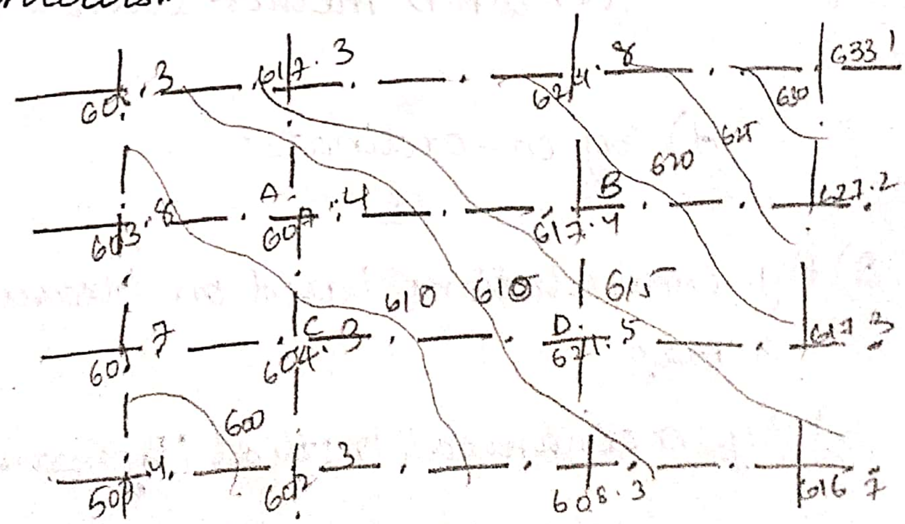


contour gradient:

It is a line lying throughout on the surface of the ground and preserving a constant inclination to the horizontal.

Interpolation of contours:

~~A B~~



MODULE-III

COMPUTATION OF AREAS & VOLUMES

General methods of determining areas:

1) By computations based directly on field measurements.
   a) By dividing area into no. of triangles.
   b) By offsets to base line.
      (i) Mid-ordinate Rule
      (ii) Avg-ordinate rule
      (iii) Trapezoid " "
      (iv) Simpson's one third rule

      at irregular intervals
      at regular intervals.

   c) By latitudes & departures
      (i) D.M.D method (Double Meridian distance method)
      (ii) D.P.D method (Double parallel distance method)
   d) By co-ordinates

2) By computations based on Measurements scaled from a map.

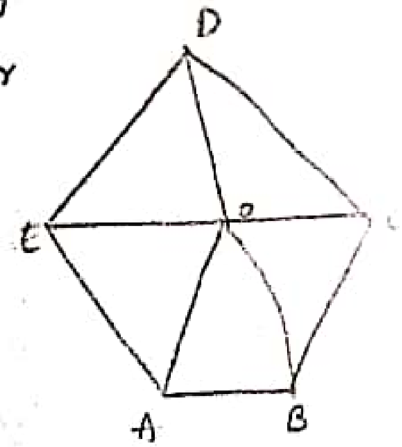
3) By mechanical method (By means of ~~planning~~ planimeter)

a) By dividing area into no. of triangles:

This method is suitable only for the work of small ~~v~~ layout

$$\Delta = \sqrt{s(s-a)(s-b)(s-c)}$$

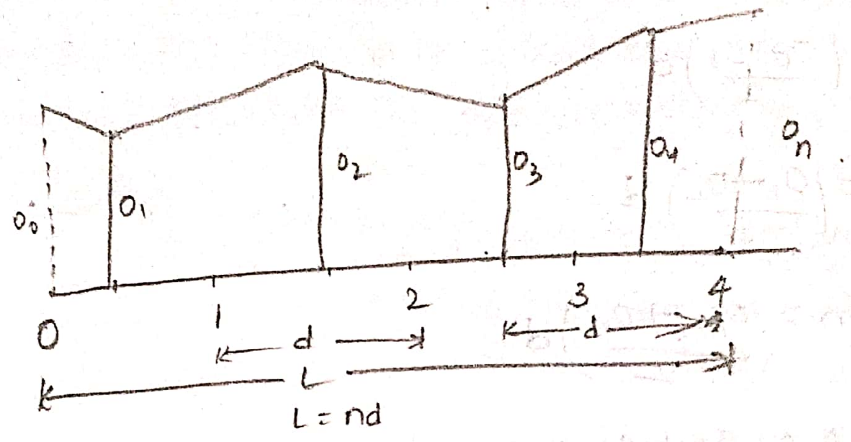
$$s = \frac{a+b+c}{2}$$



Q 1.b) By offsets to a base line: ~~lat~~

at regular intervals:

(i) Mid - ordinate rule:



Area = Δ = Avg ordinate × Length of base

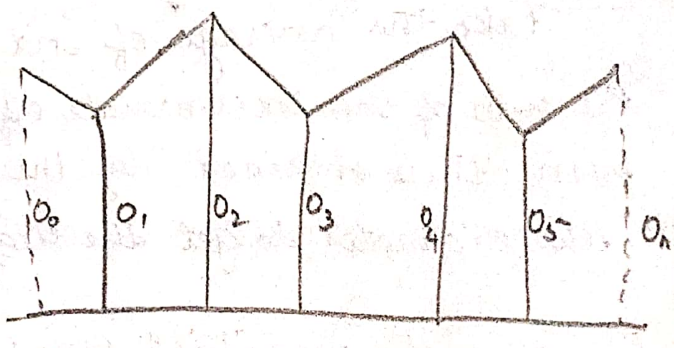
$$= \frac{O_0 + O_1 + O_2 + O_3 + \dots + O_n}{n}(L)$$

$$= \frac{O_1 + O_2 + O_3 + \dots + O_n}{\cancel{n}}(\cancel{n}d)$$

$$\boxed{\Delta = \Sigma O\,(d)}$$

(ii) Avg - ordinate rule:

Δ = Avg ordinate × length of base



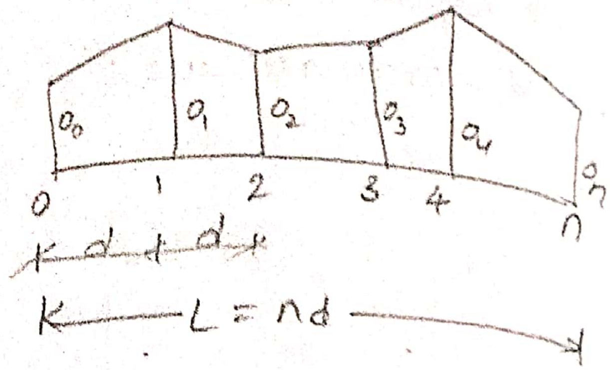
$$\Delta = \left(\frac{O_0 + O_1 + O_2 + \dots + O_n}{n+1}\right)L$$

$$= \left(\frac{\Sigma O}{n+1}\right)L$$

$$\Delta = \left(\frac{L}{n+1}\right)\Sigma O$$

(iii) Trapezoidal Rule :

This rule is more accurate than above 2 rules.



$$\Delta_1 = \left(\frac{O_0+O_1}{2}\right)d$$

$$\Delta_2 = \left(\frac{O_1+O_2}{2}\right)d$$

$$\Delta_n = \left(\frac{O_{n-1}+O_n}{2}\right)d$$

$$\Delta = \Delta_1 + \Delta_2 + \cdots + \Delta_n$$

$$\Delta = \left(\frac{O_0+O_1}{2}\right)d + \left(\frac{O_1+O_2}{2}\right)d + \cdots + \left(\frac{O_{n-1}+O_n}{2}\right)d$$

$$= \left[\frac{2(O_1+O_2+O_3+\cdots O_{n-1})}{2} + \frac{O_0+O_n}{2}\right]d$$

$$\Delta \Rightarrow \left[\frac{O_0+O_n}{2} + O_1+O_2+O_3+\cdots+O_{n-1}\right]d$$

Take the average of end offsets and add them to the sum of the intermediate offsets. Multiply the total sum thus obtained by the common distance between the ordinates do get the required area.

(iv) Simpson's one-third Rule:

This rule is applicable only the number of divisions of area is even. i.e. total no. of ordinates are odd.

Statement: The area is equal to sum of two end ordinates + 4 times the sum of even intermediate ordinates + twice the sum of odd intermediate ordinates, the whole is multiplied by 1/3 the common interval between them.

→ If there is an odd number of divisions, (resulting in even number of ordinates). The area of the last division must be calculated seperately and it has to be added the previous area Δ which is obtained by applying simpson's 1/3 rule.

$$\Delta = \frac{d}{3}\left[(O_0+O_n) + 4(O_1+O_3+O_5+\cdots+O_{n-1}) + 2(O_2+O_4+O_6+\cdots+O_{n-2}\right.$$

Problem :

The following Har offsets were taken at 10m interval from a survey line to an irregular boundary line. Offsets are: 3.25, 5.60, 4.20, 6.65, 8.75, 6.20, 3.25, 4.20, 5.65. Calculate the area enclosed between the survey line, irregular boundary line and the first and last offesets by application of a) mid ordinate b) Avg. ordinate c) trapizodal d) Simpson's 1/3 rd rule.

Sol:-

3.25	5.6	4.20	6.65	8.75	6.20	3.25	4.20	5.65
O_0	O_1	O_2	O_3	O_4	O_5	O_6	O_7	O_8

a) $\Delta = \Sigma Od = (47.75)\,10 = 477.5\,m^2$

b) $\Delta = \left(\frac{L}{n+1}\right)\Sigma O \Rightarrow \frac{80}{(8+1)} \times 47.75$ $L = nd = 8 \times 10 = 80.$

$= 424.44\,m^2$

c) trapizoidal = $\Delta = \left[\frac{3.25+5.65}{2} + 5.6+4.20+6.65+8.75+6.20+3.25+4.20\right]d$

$\Delta = [4.45 + 38.85]10 = 433\,m^2$

d) $\Delta = \frac{d}{3}\left[(O_0+O_n)+4(O_1+O_3+\cdots)+2(O_2+O_4+\cdots)\right]$

$\frac{10}{3}\left[(3.25+5.65)+4(5.6+6.65+6.2+4.2)\right.$
$\left.+2(4.2+8.75+3.25)\right]$

$\Rightarrow \frac{10}{3}\left[8.9+90.6+32.4\right]$

$= 439.67\ m^2$

$\Delta = \frac{10}{3}\left[(3.25+4.2)+4(5.6+6.65+6.2)+2(4.2+8.7+3.21)\right]$

$\frac{a+b}{2}\times h$

Measurement of volume:

Q) List out the meathods of measuring volume and explain the purposes.

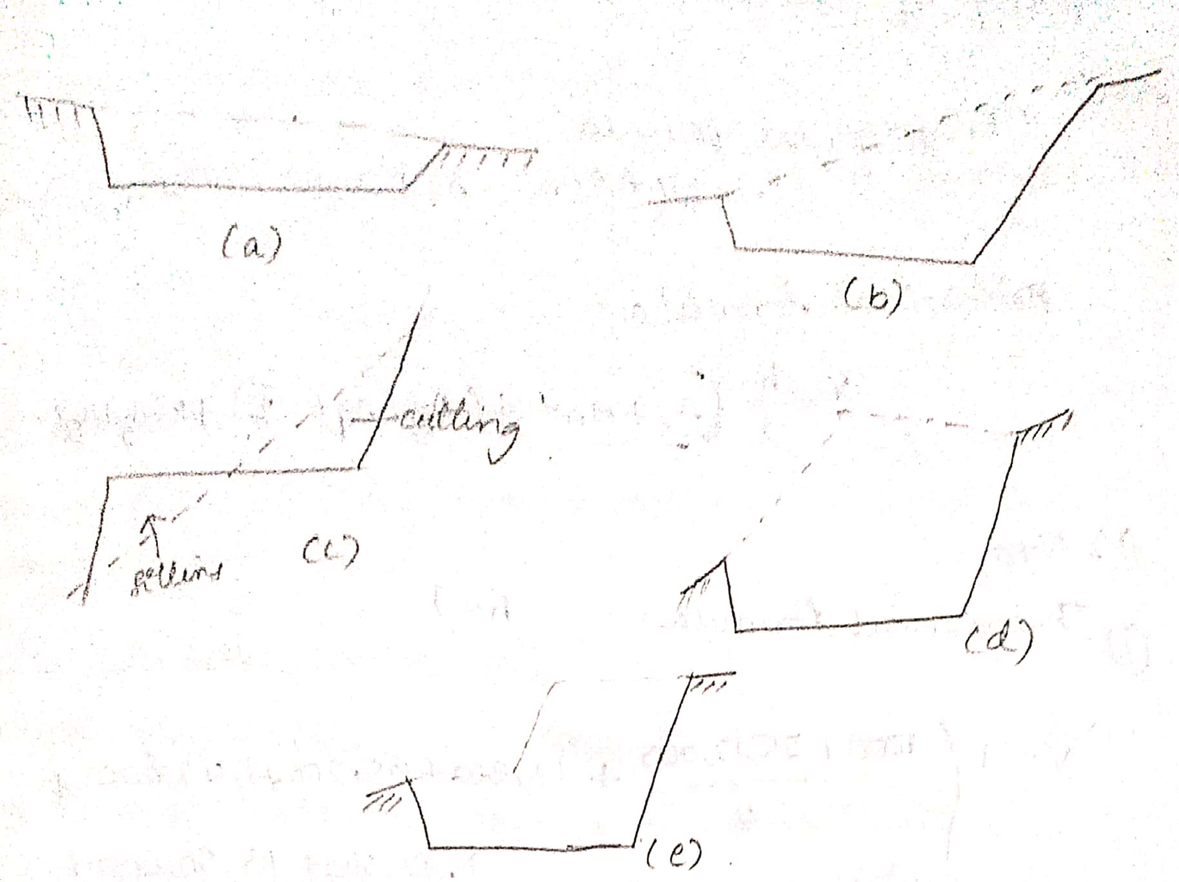
Ans: There are three methods to measure the volume.

1) From cross-sections
2) From spot levels
3) From contours

The first two methods used for calculation of earth work while the third method is adopted for calculation of reservoir capacities.

1) From cross sections:

1. Level section
2. Two-level section
3. Side hill two level section
4. Three level section
5. Multi level section



(a) (b) (c) (d) (e)

problem:

1) The areas with in the contour line at the sight of reservoir and the face of the proposed dam are as follows:

Contour	Area(m^2)
101	1000
102	12,800
103	95,200
104	1,47,600
105	8,72,500
106	13,50,000
107	19,85,000
108	22,86,000
109	25,12,000

Taking 101 as the bottom level of reservoir and 109 as top level calculate.

Capacity of reservoir.

Sol:- Trapezoidal formula:

$$V = h\left(\frac{A_1 + A_n}{2} + A_2 + A_3 + \cdots + A_{n-1}\right)$$

Prismoidal formula:

$$V = \frac{h}{3}\left[A_1 + A_n + 4(A_2 + A_4 + \cdots A_n) + 2(A_3 + A_5 \cdots)\right]$$

~~(i) Tra~~

(i) Trapezoidal formula: $h = 1$

$$V = 1\left(\frac{1000 + 25,12,000}{2} + 12,800 + 95,200 + 1,47,600 + 8,72,500 + 13,50,000 + 19,85,000 + 22,86,000\right)$$

$$V = (1256500 + \text{"}\ )$$

$$V = 8905600\ m^3$$

(ii) Prismoidal formula:

$$V = \frac{1}{3}\Big[1000 + 25,12,000 + 4(12,800 + 1,47,600 + 13,50,000 + 22,86,000) + 2(95,200 + 8,72,500 + 19,85,000)\Big]$$

$$= \frac{1}{3}\left[2513000 + 4(3796400) + 2(2952700)\right]$$

$$= \frac{1}{3}\left[2513000 + 15185600 + 5905400\right]$$

$$= 78,68,000\ m^3$$

c) By latitudes & Departures

(i) By double meridian distance method (D.M.D)

Area by D.M.D:

This method is most often used for connecting the area of a closed traverse. This method is known as DMD method.

To calculate area by this method the latitudes and the departures of each line of the transverse is balanced, a reference meridian is then assumed to pass through the most westerly station of the traverse and the double meridian distances of the lines are computed.

→ Meridian distances

The meridian distance of any point in a traverse is the distance of that point to the reference meridian measured at right angles to the meridian.

The meridian distance of a survey line is defined as the meridian distance of its mid point. The meridian distance (abbrevated as M.D) is also sometimes called as longitude. In the fig the reference meridian is chosen through the most westerly station A.

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The meridian distance represend by 'm' of AB = half of its departure $M_1 = D_1/2$. In the same way the meridian distance of second line BC, will be given by.

$$m_2 = m_1 + D_1/2 + D_2/2$$

Similarly, the third line CO's meridian dist is calculated by $m_3 = m_2 + D_2/2 - D_3/2$

The meridian distance of last line DA is given by $m_4 = m_3 + \left(-D_3/2\right) + \left(\frac{-D_4}{2}\right)$

(or)

$$m_4 = D_4/2$$

Statement:

Hence, the rule for meridian distance may be stated as follows, the M.D of any line is equal to the meridian dist of preceeding line + Half the departure of preceeding line + Half the departure of the line itself.

NOTE:

Acc to the above statement, the meridian dist of 1st line will be equal to half of its departure. In applying the rule proper attention to be paid to the signs of the departures i.e +ve sign for eastern departure and -ve sign for western departure.

Meridian distances / longitude:

* Area by latitude and meridian distances:

In the above fig east, west lines are drawn from each station to the reference meridian. Thus, getting triangles and trapeziums. One side of each triangle or trapezium. So formed will be one of the lines, the base of the triangle or trapezium will be latitude of that line, height of the triangular (or) trapezium will be the meridian distance of the line. Therefore area of each triangle (or) trapezium = Latitude of the line x meridian distance of line

$A_1 = L_1 \times M_1$

$A_2 = L_2 \times m_2$.

In the above fig the area of traverse ABCD = algebraic sum of areas of dDCc

traverse ABCD = Algebraic sum of areas of dDCc,

C = Bb, dDA, ABb.

The latitude (L) will be taken +ve if it is northing and -ve if it is southing then

Area (A) = Area of ADCc + Area CcbB - Area of dDA - Area of ABb

$A = L_3m_3 + L_2m_2 - L_4m_4 - L_1m_1$

$$\boxed{A = \Sigma Lm}$$

① The following table gives corrected latitudes and departures in m of the sides of a closed traverse ABCD

Side	Latitude N (northing)	Latitude S (southing)	Departure E (Easting)	Departure W (westing)
AB	+108 (L_1)	-	+4 (D_1)	-
BC	+15 (L_2)	-	+249 (D_2)	-
CD	-	-	+4 (D_3)	-
DA	0 (L_4)	-	-	-257 (D_4)

Compute area by meridian distances and latitude

Sol:- $m_1 = D_1/2 = 4/2 = 2$

$m_2 = m_1 + \frac{D_1}{2} + D_2/2 = 2 + 4/2 + 249/2 = 128.50$

$m_3 = m_2 + D_2/2 - D_3/2 = 128.5 + \frac{249}{2} - 4/2 = 251$

$m_4 = D_4/2 = -257/2 = -128.50$

Area $= L_1m_1 + L_2m_2 + L_3m_3 + L_4m_4$

$= 108(2) + 15(128.50) + (-123)(251) + (-128.5)0$

Area $= 216 + 15(128.50) - 123(251)$

Area $= 28729.5\ m^2$

(2) Side Latitude Departure

Side	Latitude	Departure
PQ	$+128 (L_1)$	$+9 (D_1)$
QR	$+15 (L_2)$	$+258 (D_2)$
RS	$-143 (L_3)$	$+9 (D_3)$
SP	$0 (L_4)$	$-276 (D_4)$

Calculate area by latitudes and MD method.

Sol:- $m_1 = D_1/2 = 9/2 = 4.5 \, m$

$m_2 = m_1 + D_1/2 + D_2/2 = 4.5 + 4.5 + 258/2$

$= 138 \, m$

$m_3 = m_2 + D_2/2 - D_3/2$

$= 138 + 258/2 - 9/2 = 262.5 \, m$

$m_4 = D_4/2 = \frac{-276}{2} = -138 \, m$

Area $= L_1 m_1 + L_2 m_2 + L_3 m_3 + L_4 m_4$

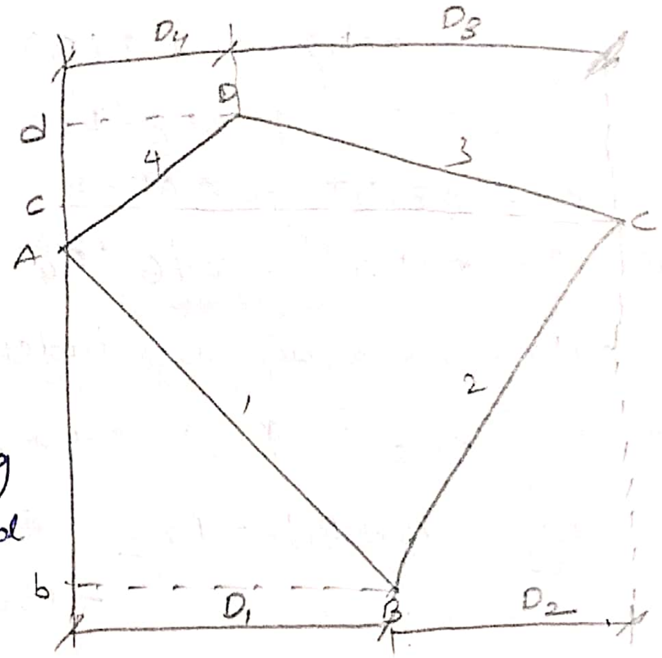
$= 128(4.5) + 15(138) + (-143)(262.5) + 0$

Area $= 576 + 2070 - 37537.5$

$= +34891.5 \, m^2$

DMD (Double Meridian distance)

The DMD of a line is equal to sum of the meridian distances of two extremities.



Statement :

The rule for finding DMD of any line stated as follows. The DMD of any line is equal to DMD of preceeding line + departure of the preceeding line + departure of the line itself.

Attention should be paid to the sign of the departure. The DMD of the first line will be equal to its departure. The DMD of last line is also equal to its departure. But this fact should be used as a check.

→ DMD is represented by 'M'.

DMD of AB $= M_1 =$ m of A + m of B.

$= 0 + D_1$

$M_1 = D_1$

DMD of BC $= M_2 =$ m of B + m of C

$M_2 = \cancel{D_1 + D_3 + D_4}\ D_1 + D_1 + D_2$.

$$\boxed{M_2 = M_1 + D_1 + D_2}$$

DMD of 'CD' $= M_3 =$ m of 'C' + 'm' of D

$= \cancel{D_1 + D_2 + D_4} = M_1 + D_1 + D_2 + D_2 - D_3$

$$\boxed{M_3 = M_1 + D_1 + D_2 + D_2 - D_3}$$

$$\boxed{M_3 = M_2 + D_2 - D_3}$$

DMD of DA = $M_4 = M_1 + D_1 + D_2 + D_2 - D_3 \mp D_3 \mp D_4$

$$\boxed{M_4 = M_3 \pm D_3 - D_4}$$

Area by Latitudes and DMD:

In the above fig, the area of traverse ABCD =

Area of DdcC + area of CcbB + − Area of dDA − Area ABb.

Area of DdcC $= \frac{1}{2}(dD + cC) \times L = \frac{1}{2}\left[M_3L_3 + M_2L_2 - M_4L_4 - M_1L_1\right]$

Methodology:

1. Multiply DMD of each line with its latitude
2. Find the algebraic sum these products
3. The required area will be ½ of the sum.

Q)

Line	L	D	DMD (M)	Area ($M \times L$) (m²)
AB	+108	+4	+4	432 m²
BC	+15	+249	4+4+249 = 257	3855
CD	+123	+4	257+249+4 = 510	−62730
DA	0	−257	257	0

Area $= \frac{\Sigma A}{2} = \frac{1}{2}(432 + 3855 - 62730)$

$= +1986 m^2 \quad \frac{1}{2}(58443.)$

$A = 29221.5\ m^2$

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① Line	L(m)	D(m)	DMD(M)	Area (M × L) m²
PQ	+128	+9	+9	1152
QR	+15	+258	9+9+258 = 276	4140
RS	−143	+9	~~278~~+258+9 = 543	−77649
SP	0	−276	543+9−276 = 276	0

$\Sigma A = -72357$

$$\text{Area} = \frac{1}{2}\Sigma A = 36178.5\ m^2$$

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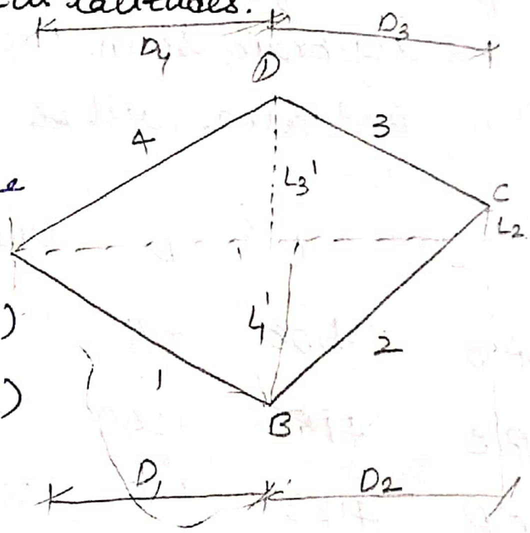
Area from departures & total latitudes:

If L_1', L_2', L_3' are total latitudes of the ends of the lines. Then area =



$$\text{area} = \frac{1}{2}[D_1(0-L_1') + D_2(-L_1'+L_2') + (D_3)(L_2'+L_3') + (D_4)(L_3'+0)]$$

$$\cancel{\frac{1}{2}[0 - D_1L_1' + D_2L_1' + D_2L_2' + D_3L_2' + D_3L_3'}$$

$$= \frac{1}{2}[-D_1L_1' - D_2L_1' + D_2L_2' - D_3L_2' - D_3L_3' - D_4L_3']$$

$$= \frac{1}{2}[-L_1'(D_1+D_2) + L_2'(D_2-D_3) - L_3'(D_3+D_4)]$$

$$= \frac{-1}{2}[L_1'(D_1+D_2) - L_2'(D_2-D_3) + L_3'(D_3+D_4)]$$

$$= \frac{-1}{2}[L_1'(D_1+D_2) + L_2'(D_3-D_2) + L_3'(D_3+D_4)]$$

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Note :

The -ve sign to the area has no significance. So we can neglect ~~the~~ '–' sign.

Step wise procedure to find out area by this method :

1) find total latitude (L') of each station of traverse.

2) find algebraic sum of departures of two lines meeting at that station.

3) Multiply the total latitude of each station by corresponding algebraic sum of departures which are found in step-2.

4) Half the algebraic sum of total Latitudes and departures will give the required area.

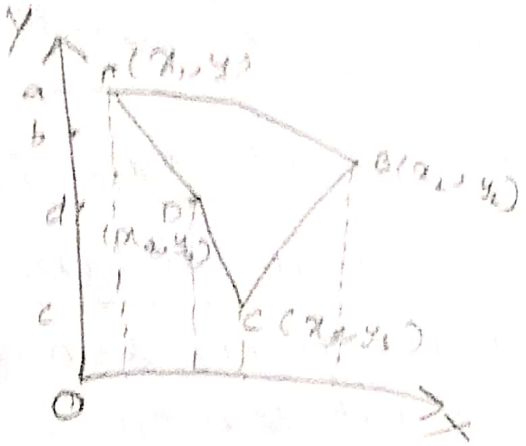
Problem :

1 Line	2 L	3 D	4 Stn	5 Total latitude (L')	6 Algebraic sum of adjoining departures	Double area (5×6)
AB	+108	+4				
			B	~~253~~ ~~123~~ 108	253	27324
BC	+15	+249				
			C	~~253~~ 123	253	31119
CD	-123	+4				
			D	~~200~~ 0	-253	0
DA	0	-257				
			A	0	-253	0
						ΣA = 58443

$\therefore$ Area $= \frac{1}{2} \Sigma A$

$= \frac{1}{2} \times 58443 = 29221.5$

Area by Co-ordinates:



Let $(x_1, y_1), (x_2, y_2), (x_3, y_3), (x_4, y_4)$ be the co-ordinates of the stations A, B, C, D resp. of a traverse ABCDA. If A is the total area of the traverse, then area

$$A = \frac{1}{2}\begin{vmatrix} x_1 & x_2 & x_3 & x_4 & x_1 \\ y_1 & y_2 & y_3 & y_4 & y_1 \end{vmatrix}$$

$$= \frac{1}{2}\Big[(x_1y_2 - x_2y_1) + (x_2y_3 - x_3y_2) + \cancel{(x_3y_2 - x_2y_3)}$$
$$+ (x_3y_4 - x_4y_3) + (x_4y_1 - x_1y_4)\Big]$$

Problem:

Line	(N) Latitude	(E) Departure	Station	Independent co-ordinates North(y)	East (x).
AB	+108	+4	A	100 x_1 ~~+208~~	100 y_1 104
BC	+15	+249	B	208 y_1	~~353~~ 104 y_2
CD	−123	+4	C	~~100~~ 223	353
DA	0	−257	D	~~100~~ 100	~~100~~ 357
			A	100	100

$$= \frac{1}{2}\begin{vmatrix} 100 & 104 & 353 & 357 & 100 \\ 100 & 208 & 223 & 100 & 100 \end{vmatrix}$$

$= \frac{1}{2}\left[(100\times208 - 100\times104) + (104\times223 - 208\times353) + (353\times100 - 223\times357) + (357\times100 - 100\times100)\right]$

$= \frac{1}{2}\left[10400 + (-50232) + (-44311) + 25700\right]$

$= \frac{1}{2} \cancel{f} \Rightarrow 29221.5\ m^2$

problem:

Coordinates of A (100, 802), B (711, 802), C (635, 852)

D (994, 902) E (241, 952)

F (884, 1002)

G (266, 1052)

H (811, 1102)

I (100, 1102)

Sol:- $\frac{1}{2}\left| \begin{array}{ccccccccc} 802 & 802 & 852 & 902 & 952 & 1002 & 1052 & 1102 & 1102 \; 802 \\ 100 & 711 & 635 & 994 & 241 & 884 & 266 & 811 & 100 \; 100 \end{array} \right|$

$\frac{1}{2}\left[(802\times711 - 802\times100) + (802\times635 - 711\times852) + (852\times994 - 902\times635) + (902\times241 - 994\times952) + (952\times884 - 241\times1002) + (1002\times884 - 1052\times266) + (1052\times811 - 266\times1102) + (1102\times100 - 811\times1102) + (1102\times100 - 802\times100)\right]$

$= \frac{1}{2}\left[490022 + (-96502) + (274118) + (-728906) + (600086) + (605936) + (560040) + (-783522) + (30000)\right]$

$= \frac{1}{2}\left[951272\right] = 475636$

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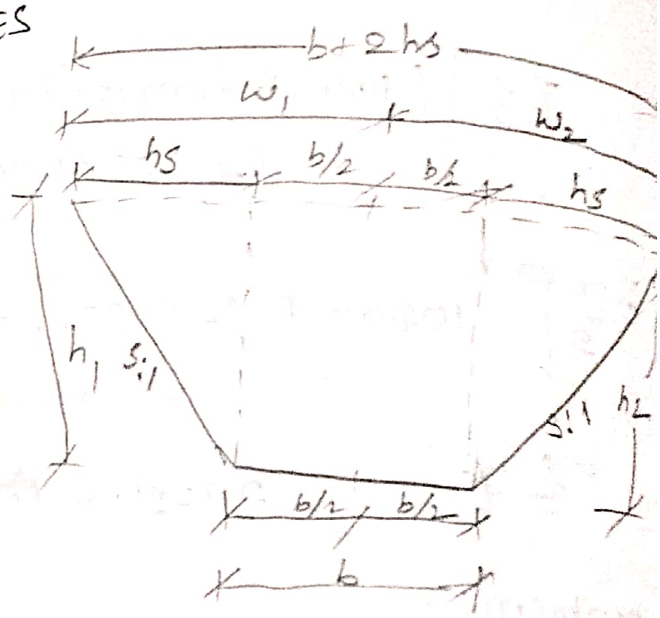
30/9/19 . VOLUMES



SINGLE LEVEL SECTION:

$$w_1 = w_2 = \frac{b}{2} + hs$$

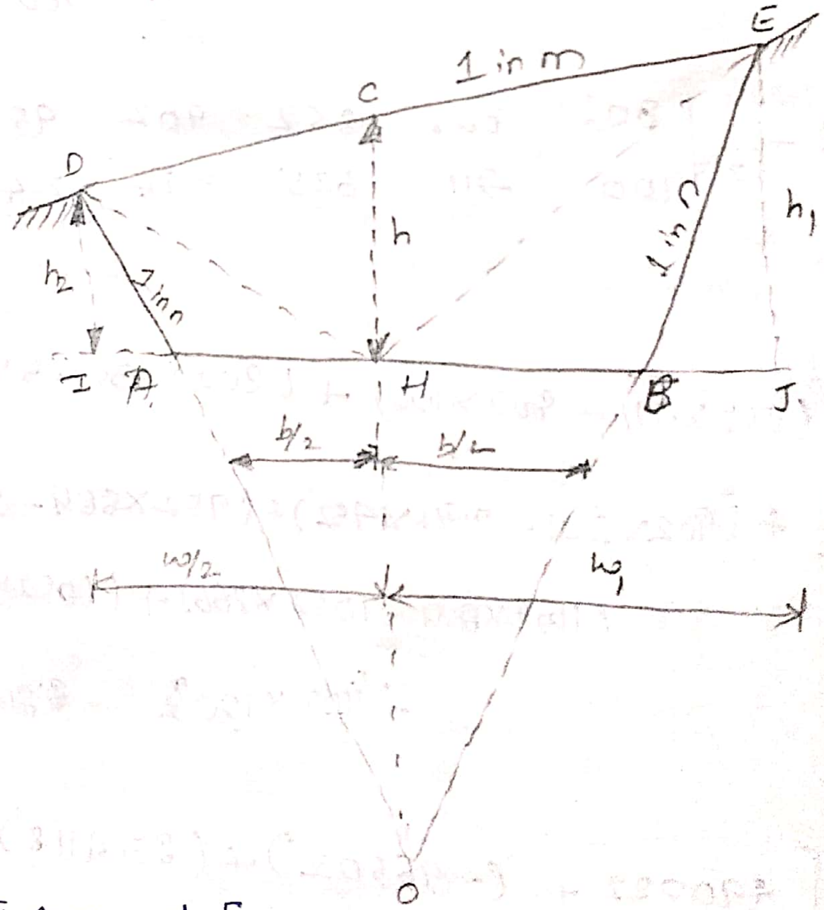
$$w_1 + w_2 = b + 2hs .$$

$$\text{Area} = \left[\frac{(b+2hs)+b}{2}\right] h$$

$$= \frac{\cancel{2}(b+hs)}{\cancel{2}} \times h$$

$$A = (b+hs)\,h$$

Two-level section:



Area of DCEBA = Area of [ΔDAH + Δ EBH + Δ DCH + ΔECH]

$$= \left[\left(\frac{1}{2} \times \frac{b}{2} \times h_2\right) + \left(\frac{1}{2} \times \frac{b}{2} \times h_1\right) + \left(\frac{1}{2} \times w_2 \times h\right) + \left(\frac{1}{2} \times w_1 \times h\right)\right]$$

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$\Rightarrow \frac{1}{2} \times \frac{b}{2} (h_1 + h_2) + \frac{1}{2} h (w_1 + w_2)$

$\frac{1}{2} \left[\frac{b}{2} (h_1 + h_2) + h (w_1 + w_2) \right]$

$BJ = nh_1 \longrightarrow (i)$

$\downarrow$

$HJ - HB$

$w_1 - \frac{b}{2} = nh_1$

$\boxed{w_1 = nh_1 + \frac{b}{2}}$

Also $w_1 = (h_1 - h) m$

$(h_1 - h) m = mh_1 + \frac{b}{2}$

$nh_1 + \frac{b}{2} = (h_1 - h) m$

$nh_1 = h_1 m - hm - \frac{b}{2}$

$nh_1 - mh_1 + mh + \frac{b}{2} = 0$

$h_1 (n - m) + mh + \frac{b}{2} = 0$

$h_1 = \frac{-\frac{b}{2} - mh}{n - m}$

$\boxed{h_1 = \frac{\frac{b}{2} + mh}{m - n}}$

$\boxed{h_1 = \frac{m}{m - n} \left(\frac{b}{2m} + h \right)}$

sub h_1 value in w_1

we have $w_1 = n \times \frac{m}{m - n} \left(\frac{b}{2m} + h \right) + \frac{b}{2}$

$= \frac{bn}{2(m - n)} + \frac{hmn}{m - n} + b/2$

$$w_1 = \frac{b}{2} + \frac{mn}{m-n}\left(h + \frac{b}{2m}\right)$$

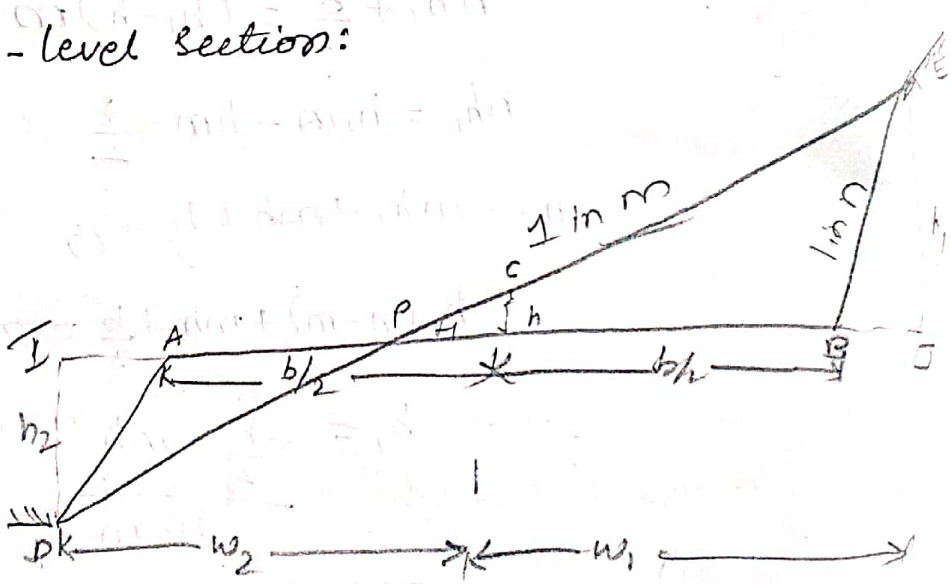
$$w_2 = \frac{b}{2} + \frac{mn}{m+n}\left(h - \frac{b}{2m}\right)$$

$$h_2 = \frac{m}{m+n}\left(h - \frac{b}{2m}\right)$$

$$A = \frac{1}{2}\left[\frac{b}{2}(h_1 + h_2) + h(w_1 + w_2)\right]$$

$$\boxed{A = \frac{n\left(\frac{b}{2}\right)^2 + m^2(bh + nh^2)}{(m^2 - n^2)}}$$

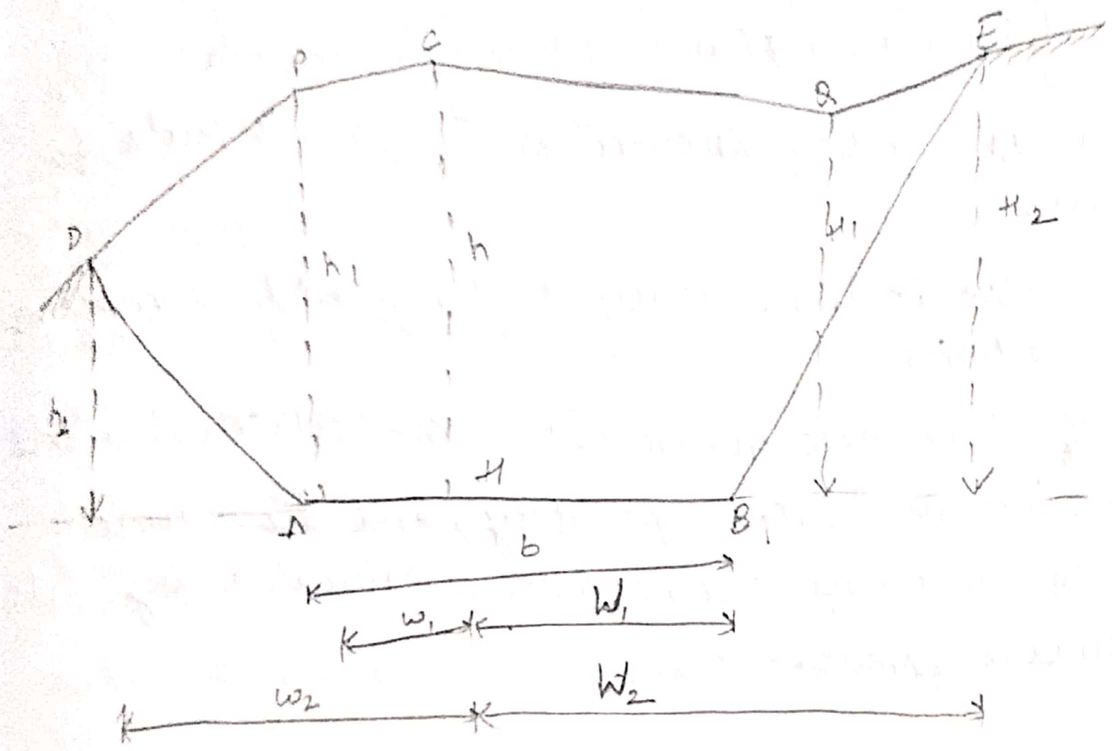
Side Hill Two-level Section:



$$A_1 = \frac{1}{2}\left(\frac{b}{2} + mh\right)\left\{\frac{m}{m-n}\left(\frac{b}{2m} + h\right)\right\} = \frac{\left(\frac{b}{2} + mh\right)^2}{2(m-n)}$$

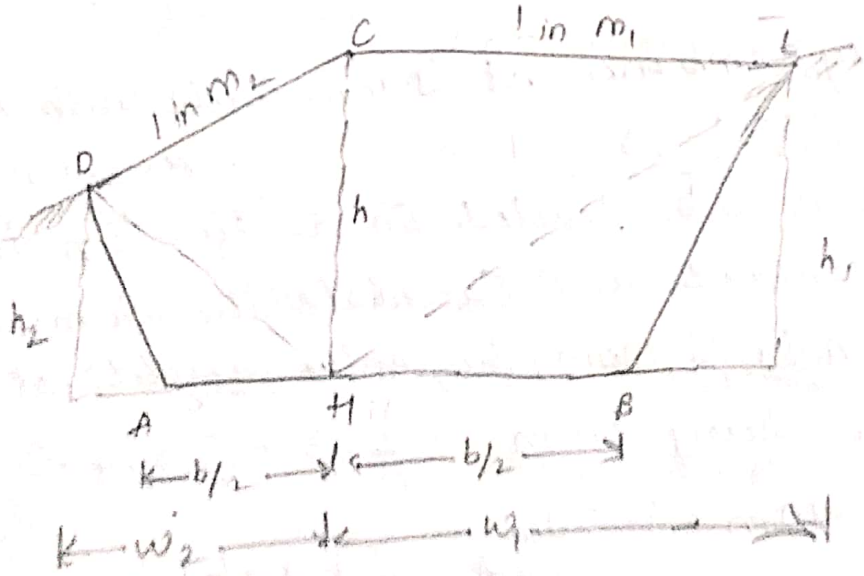
$$A_2 = \frac{\left(\frac{b}{2} - mh\right)^2}{2(m-n)}$$

~~Three~~ Multi level section :



$$A = \frac{1}{2}\left[h_2\left(+\frac{b}{2} - w_1\right) + h_1(w_2 + 0) + h(w_1 + W_1) + H_1(W_2) + H_2\left(-w_1 + \frac{b}{2}\right)\right]$$

Three level section :



$$A = \left[\frac{b}{4}(h_1 + h_2) + \frac{h}{2}(w_1 + w_2)\right]$$

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Prismoidal formula:

$$V = \frac{d}{3}\left[(A_1 + A_n) + 4(A_2 + A_4 + \cdot A_{n-1}) + 2(A_3 + A_5 + \cdots + A_{n-2})\right]$$

This is also known as Simpson's rule for volume.

Here also it is necessary to have odd number of cross-sections.

If there are even number of cross-sections, the end strip must be treated separately, and the volume between remaining sections may be calculated by Prismoidal formula.

Trapezoidal formula (Avg end area method):

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

Problem:

A railway embankment is 10m wide with side source $1\frac{1}{2} : 1 \Rightarrow \frac{3}{2} : 1 \Rightarrow 3:2$. Assuming the ground is to be leveled in a direction transverse to the centered line. Calculate the volume content in a length of 120m, the centre heights at 20m intervals being in m 2.2, 3.7, 3.8, 4, 3.8, 2.8, 2.5

Sol:- $b = 10m$ $d = 20m$

$A = (b + nh)h$

$n = 1.5$

$h_1, h_2, h_3 \cdots h_7 = 2.2, 3.7, 3.8 \cdots 2.5$

$A_1 = 2.2(1.5(2.2) + 10) = 29.26$

$A_2 = 3.7(10 + 1.5(3.7)) = 57.53.$

$A_3 = 3.8(10 + 1.5(3.8)) = 59.66$

$A_4 = 4(10 + 1.5(4)) = 64$

$A_5 = 3.8(10 + 3.8(1.5)) = 59.66$

$A_6 = 2.8(10 + 1.5(2.8)) = 39.76.$

$A_7 = 2.5(10 + 1.5(2.5)) = 34.375.$

prismoidal:

$$V = \frac{20}{3}\left[(29.26 + 34.375) + 4(57.53 + 64 + 39.36) + 2(59.66 + 59.66)\right]$$

$$= \frac{20}{3}\left[63.635 + 4(643.56) + 2(238.64)\right]$$

$$= 63\overset{1}{\cancel{0}}6.56\, m^3.$$

Trapezoidal:

$$V = d\left[\frac{A_1 + A_n}{2} + A_2 + A_3 + \cdots A_{n-1}\right]$$

$$= 20\left[\frac{29.26 + 34.375}{2} + 57.53 + 59.66 + 64 + 59.66 + 39.76\right]$$

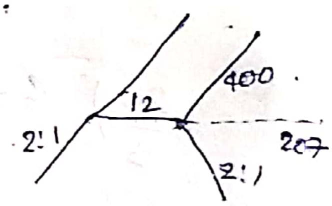
$$\cancel{2.20}\,[\quad = 6248.55\, m^3.$$

Q) A railway embankment 400m long is 12m wide at formation level and has side slope 2:1 The ground levels at every 100m along the centre line are as follows

Distance	RL	FL	Depth of filling
0	204.80	207	2.2m h_1
100	206.20	208	1.8 m h_2
200	207.50	209	1.5 m h_3
300	207.20	~~300~~ 210	2.8 h_4
400	208.30	211	2.7 h_5

The formation level at 'o' chinage is 207m and embankment has a rising gradient of 1 in 100 The ground is level across the centre the line. Calculate Volume of earthwork.

Sol :-



$b = 12, \quad d = 100$

$n = 2$

$A = h(b+nh)$

$A_1 = 2.2(12 + 2(2.2)) = 36.08 \text{ m}^2$

$A_2 = 1.8(12 + 2(1.8)) = 28.08 \text{ m}^2$

$A_3 = 1.5(12 + 2(1.5)) = 22.5 \text{ m}^2$

$A_4 = 2.8(12 + 2(2.8)) = 49.28 \text{ m}^2$

$A_5 = 2.7(12 + 2(2.7)) = 46.98 \text{ m}^2$

prismoidal

$$V = \frac{100}{3}\left[36.08 + 46.98 + 4(28.08 + 49.28) + 2(22.5)\right]$$

$= 14583.33$

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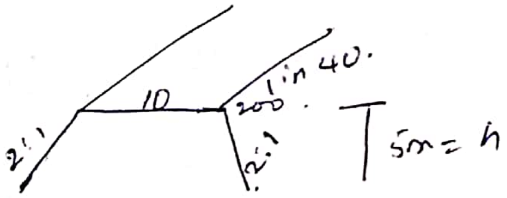
Trapezoidal :-

$$V = 100\left[\frac{36.08 + 46.98}{2} + 28.08 + 22.5 + 49.28\right]$$

$$= 14139\ m^3.$$

Q) A road embankment 10m wide at formation level with side slopes 2:1 and with an avg height of 5m is constructed with an average gradient 1 in 40 from contour 220m to 280m find the volume of earth work.

~~Sol~~ Sol :-



Diff in level between both the ends of the road = 280 − 220 = 60m

$$60 \times 40 = 2400m = L$$

$$A = (b + nh)\,h$$

$$= (10 + 2(5))\,5$$

$$= 100\ m^2$$

$$V = A \times L$$

$$= (100 \times 2400)$$

$$= 24 \times 10^4\ m^3.$$

Q) Find out the volume of earthwork in a road Cutting non long ~~along the centre~~ from the following data, formation between 10m, side slope 1 to 1 or 1:1

The avg depth ~~earth~~ of cutting along the centre of line is 5m, slope of ground in C/s 10:1.

Sol:-

$$A = \frac{n\left(\frac{b}{2}\right)^2 + m^2(bh + nh^2)}{m^2 - n^2}$$

$L = 120m$, $n = 1$, $m = 10$.

$h = 5m$, $b = 10m$

$$A = \frac{1\left(\frac{10}{2}\right)^2 + (10)^2\left(10(5) + 1(5)^2\right)}{(10)^2 - (1)^2}$$

$$= \frac{7525}{99} = 76.01\ m^2$$

$V = A \times L$

$= 76.01 \times 120 = 9121.2\ m^3$.

THEODOLITE SURVEYING:

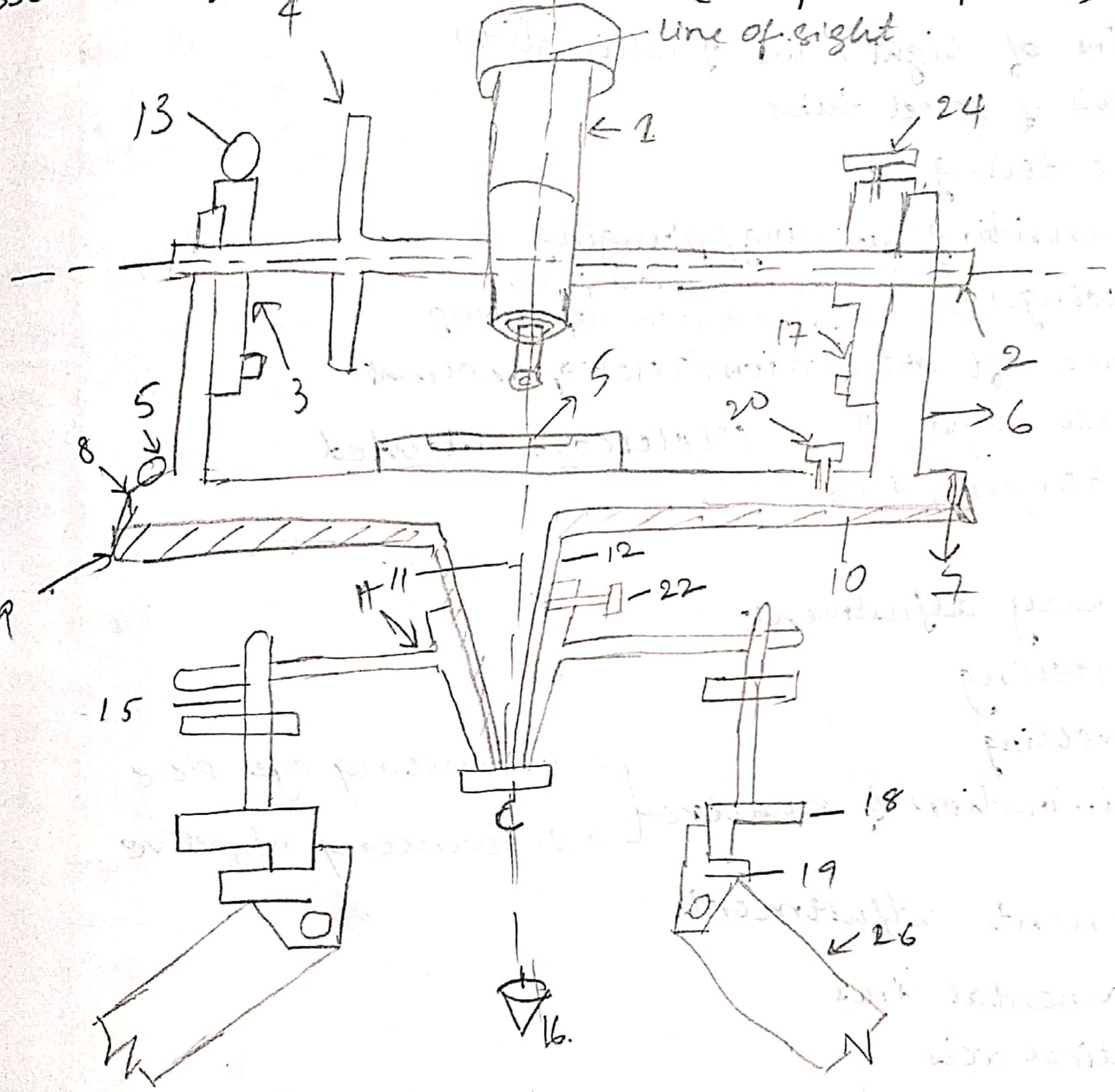
Theodolite :

Theodolite is a most precise instrument designed for measurement of horizontal angle and vertical angle, locating points on line, prolonging survey lines, establishing grades, determining difference in elevation, setting out of curves.

Types of theodolites:

1. Transit theodolite
2. Non-transit theodolite.

Essentials of transit theodolite (component parts):



1. Telescope
2. Trunnion Axis
4. Vernier circle
3. Vernier frame
5. Plate level
6. standards (A frame)
7. Upper plate
8. Horizontal plate vernier
9. Horizontal circle
10. Lower plate
11. Inner axis
12. Outer axis
13. Altitude level
14. Levelling head
15. Levelling screw
16. Plumb bob
17. Arm of vertical circle clamp
18. Foot plate
19. Tripod Head
20. upper clamp
22. Lower clamp
24. Vertical circle clamp
26. Tripod

optical plummet : ⊕

Definitions :

1. vertical axis
2. Horizontal axis / Trunnion Axis / transit
3. Line of sight / line of collimation.
4. Axis of level tube
5. Centering
6. Transiting / reversing / plunging
7. Swinging
   - clock wise – Right swing
   - Anti clockwise – left swing
8. Face left observation / Telescope normal
9. Face right " / Telescope inverted.
10. changing face.

Temporary adjustments

1. centering
2. levelling
3. Elimination of Parallax
   1. Focussing eye piece
   2. Focussing objective.

Permanent adjustments :

(i) Fundamental lines

1. vertical axis
2. Horizontal axis
3. L. C (line of collimation)
4. Axis of plate level
5. " " Altitude level
6. " " striding " (If provided)

optical plummet :

(ii) Desired relations:

1. Axis of plate level must lie in a plane perpendicular to vertical axis.

2. Line of collimation must be ⊥lar to the horizontal axis at the intersection with vertical axis.

3. Horizontal axis must be ⊥lar to vertical axis

4. Axis of altitude level (telescope level) must be parallel to the line of collimation.

5. Vertical circle vernier must ~~tead~~ read '0' when line of collimation is horizontal

6. Axis of striding level (if provided), must be parallel to the horizontal axis.

Uses of theodolite:

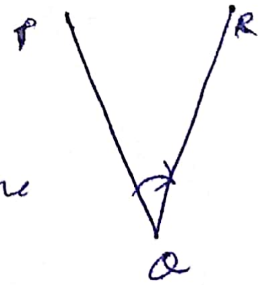
1. prolonging survey lines to 2. take horizontal angle and
3. to take vertical angle
4. Take deflection angle
5. To take magnetic bearings
6. To set curves
7. To measure direct angles.
8. To run a straight line b/w 2 points
9. To fix C/L of a road / railway track / canal / sewer line
10. To locate the point of intersection of two straight lines.
11. To locate points on a line
12. To Determine difference in elevation
13. To establish gradients.

Measurement of Horizontal angles:

It is of two methods:
1. Method of Repetition
2. Method of Reiteration.

1. Method of Repetition:

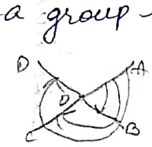
This method is used to measure horizontal angle to a ~~final~~ finer degree of accuracy than ~~to~~ that obtained with the least count of verniers.



Inst at	Sighted to	Face left A ° ' "	Face left B ° ' "	Right swing mean ° ' "	No of Repetition	Horizontal angle (FL) ° ' "	Face right A ° ' "	Face right B ° ' "	Left swing Mean ° ' "	No. of Repetition	Horizontal angle (FR) ° ' "	Avg Horizontal angle $\frac{FL+FR}{2}$

(ii) Reiteration method:

This method is suitable for measurement of angles of a group having a common vertex point.



Procedure: 1. Set instrument at 'O' and level it. Set one vernier to 0° and bisect A accurately.

2. Loose upper clamp and turn telescope clockwise to B. Read both verniers. The mean of vernier readings will give ∠AOB.

3. Similarly bisect 'C' and 'D' successively, and take readings. Since the graduated circle remains fixed in entire process each included angle is obtained while taking difference between two consecutive readings.

4. On final sight to 'A' reading on A should match with the initial reading. If not the error is to be distributed to all angles. If error is large repeat the experiment and take fresh set of readings.

Inst at	Sighted to	Face left	Swing Mean	Horizontal	Face right	Avg

5. Repeat steps 2-4 with other face.

Measurement of Vertical Angle:

Vertical angle is the angle which the inclined line of sight makes with the horizontal.

Inst at	Sighted to	Face left A (° ′ ″)	Face left B (° ′ ″)	Mean (° ′ ″)	Horizontal angle (° ′ ″)	Face right A (° ′ ″)	Face right B (° ′ ″)	Mean (° ′ ″)	Horizontal angle	Avg H.A
O	A									
	B									

Table for vertical angle

Inst at	Sighted to	Face left C (° ′ ″)	Face left D (° ′ ″)	[illegible] mean (° ′ ″)	Vertical angle (° ′ ″)	Face right C (° ′ ″)	Face right D (° ′ ″)	[illegible] mean (° ′ ″)	Vertical angle	Avg V.A

Principles of Electronic Theodolite:

Theodolites used for angular measurements can be classified as 3 types.
(i) Vernier theodolites (ii) Micrometer theodolites (optical theodolites) (iii) Electronic theodolites.

Electronic theodolite:

1. In this absolute angle measurement is provided by a diamond system with opto electronic scanning.
2. These are provided with control panels with keyboards with LCD (Liquid crystal display).

3. The LCD's with points and symbols present the measured data clearly.
4. The keyboard contains multi function keys.
5. The main operations require only a single key stroke.
6. Electronic theodolites works with electronic speed and efficiency.
7. They measure electronically and open the way to electronic data acquisition and data processing.
8. They have two models manufactured by ~~M/s WILD HERBRUGG LTD~~ M/s WILD HEERBRUGG LTD

(i) WILT - T - 1000 Elect theod
(ii) WILT - T - 2000 ~~Elect the~~ & T-2000-S Elect theod

24/10/19

Trignometrical levelling:

It is the process of determining the difference of elevations of stations from observed vertical angle and known distances, which are assumed to be either horizontal or geodetic lines at MSL.

It can be done by 3 cases:

Case(i) Base of object is accessible

Case(ii) Base of object is inaccessible (Instrument stations in the same vertical plane as the elevated object.

There are three cases to calculate RL of Q.

Case(a) Instrument axes at same level

case(b) Instrument axes at at different levels.

(i) B is higher than A

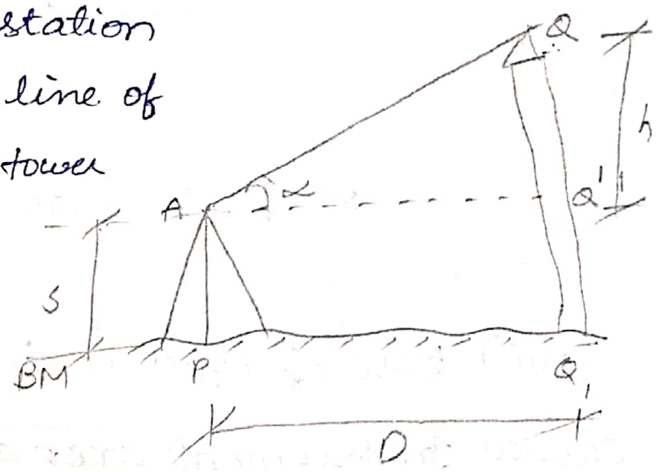
(ii) A is higher than B

Case(c) Instrument axes at very different levels

(3rd case not in syllabus)

case(i) Base of object is accesible:

let P is instrument station
AQ' is line of sight or line of collimation. Q' is top of tower or vane.
h is equal to QQ' = height of top of pole from line of sight.



D is horizontal distance from instrument station P and base of the ~~two~~ tower Q_1.

$$\tan\alpha = \frac{h}{D} \quad \Rightarrow h = D\tan\alpha$$

$$RL \text{ of } Q = RL \text{ of } BM + S + h$$

problem:
An instrument was set up at P and angle of elevation to a vane 4m above foot of staff held at Q was $9°30'$. The horizontal distance between P and Q was 2000m. Determine RL of staff station Q, given that RL of instrument axis was 2650.38 m

sol:-

$\cancel{Q = 4m}$ $\quad \alpha = 9°30'$

$S = 4m$

$D = 2000m$

RL of Q = ? $\quad$ RL of BM = ~~2650.38~~m

$$C = 0.06728 D^2 \text{ mts}$$

$$C = 0.06728 (2)^2$$

$$C = 0.27m$$

$$h = D\tan\alpha = (2000) \times \tan 9°30' = 334.68m$$

$$h + C = 334.68 + 0.27 = 334.95m$$

RL of top of Vane = RL of inst axis + h + c

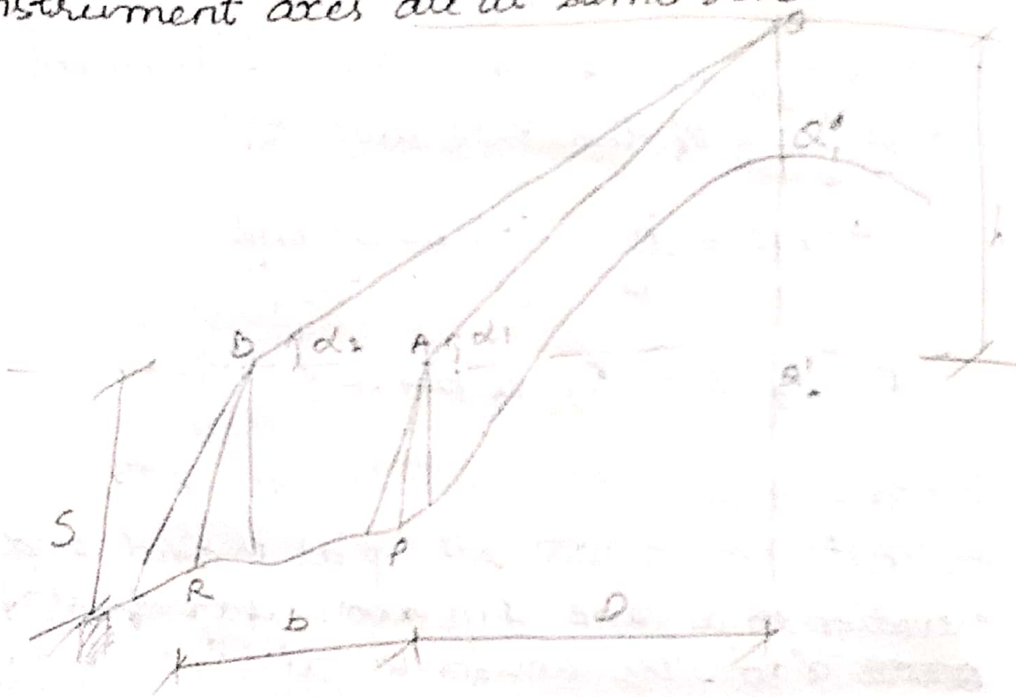
$= 2650.38 + 334.95$

$= 2985.33m$

RL of 'Q' $= 2985.33 - 4 = 2981.33m$.

Case (ii) Base of object is inaccessible:

Case (a) Instrument axes are at same level



Consider $\Delta AQQ'$ $\tan\alpha_1 = \frac{h}{D}$

$h = D\tan\alpha_1 \rightarrow (1)$

$\Delta BQQ'$ $\tan\alpha_2 = \frac{h}{b+D}$

$h = (b+D)\tan\alpha_2 . \rightarrow (2)$

$(1) = (2)$

$D\tan\alpha_1 = (b+D)\tan\alpha_2$

$D\tan\alpha_1 = b\tan\alpha_2 + D\tan\alpha_2$

$D\tan\alpha_1 - D\tan\alpha_2 = b\tan\alpha_2$

$D(\tan\alpha_1 - \tan\alpha_2) = b\tan\alpha_2$

$$\boxed{D = \frac{b \tan\alpha_2}{(\tan\alpha_1 - \tan\alpha_2)}}$$

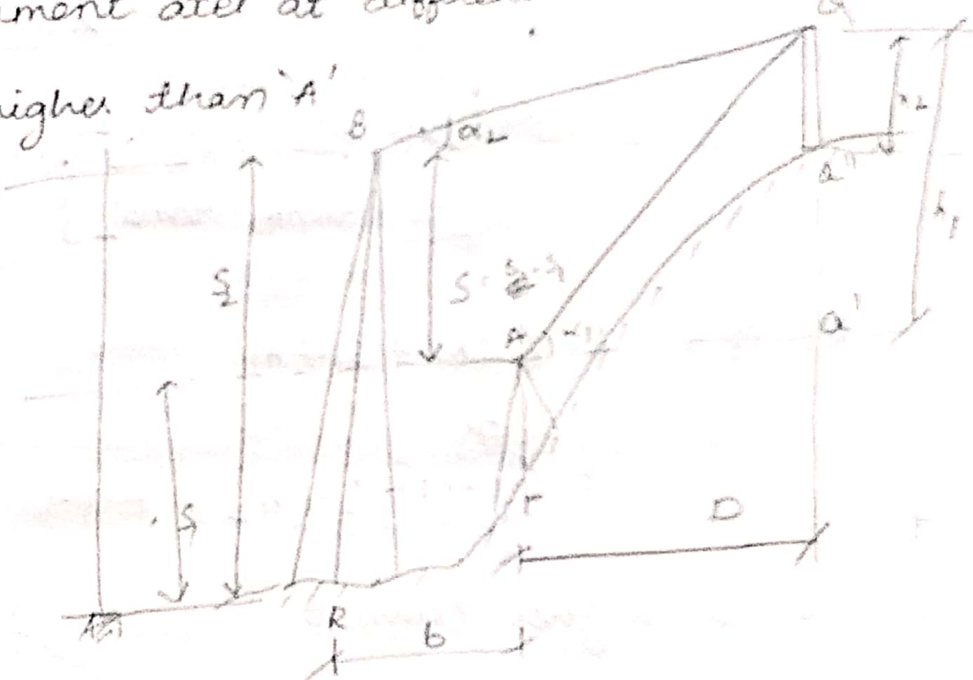
$h = D \tan\alpha_1$

$$\boxed{h = \frac{b \tan\alpha_2 \tan\alpha_1}{(\tan\alpha_1 - \tan\alpha_2)}}$$

RL of 'Q' = RL of BM + S + h.

case (b) Instrument axes at different levels

(i) 'B' is higher than 'A'



consider $\Delta AQQ'$

$$\tan\alpha_1 = \frac{h_1}{D}$$

$$h_1 = D\tan\alpha_1 \rightarrow ①$$

$\Delta BQQ''$

$$\tan\alpha_2 = \frac{h_2}{b+D}$$

$$h_2 = (b+D)\tan\alpha_2 \rightarrow ②$$

$$h_1 - h_2 = S$$

$$D\tan\alpha_1 - (b+D)\tan\alpha_2 = S$$

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$$D\tan\alpha_1 - b\tan\alpha_2 - D\tan\alpha_2 = S$$

$$D(\tan\alpha_1 - \tan\alpha_2) - b\tan\alpha_2 = S$$

$$D(\tan\alpha_1 - \tan\alpha_2) = S + b\tan\alpha_2$$

$$\boxed{D = \frac{S + b\tan\alpha_2}{\tan\alpha_1 - \tan\alpha_2}}$$

$$\boxed{h_1 = \frac{S + b\tan\alpha_2}{(\tan\alpha_1 - \tan\alpha_2)} \times \tan\alpha_1}$$

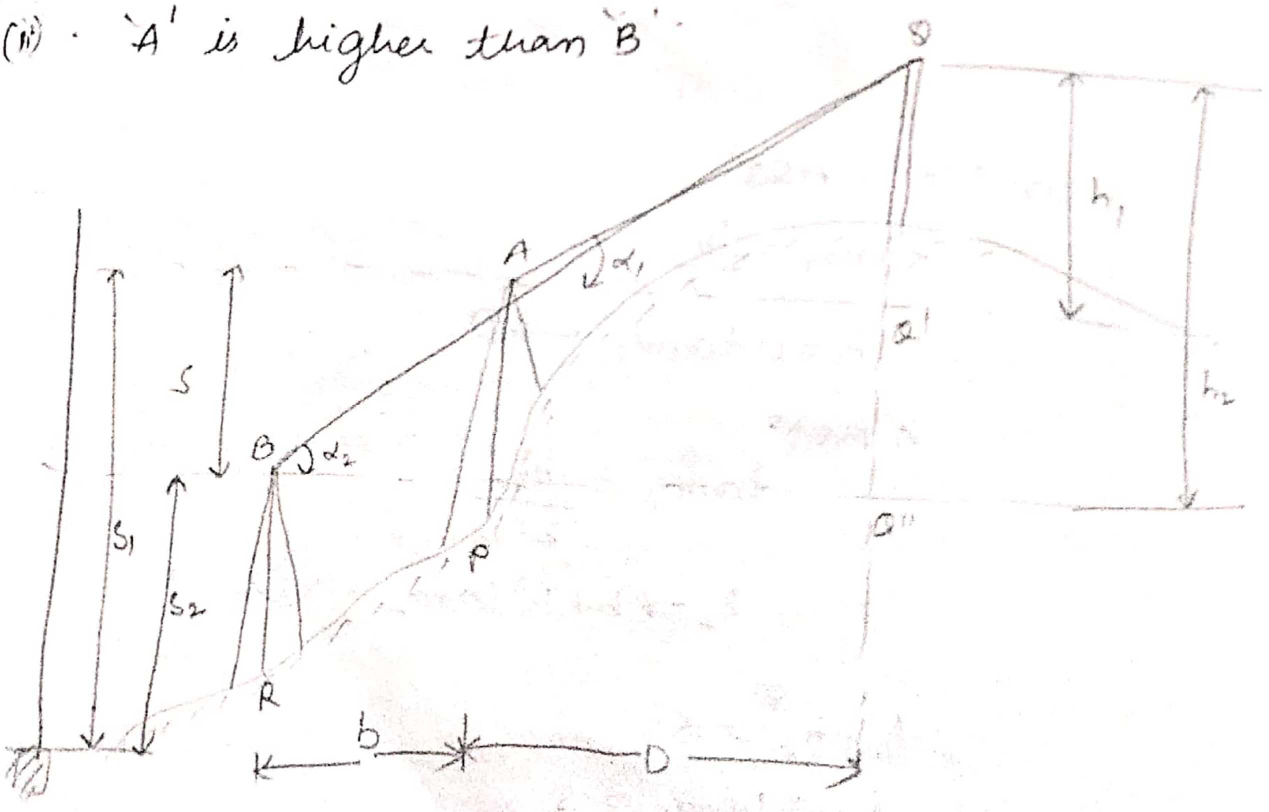
$$\boxed{h_2 = \left[b + \frac{S + b\tan\alpha_2}{(\tan\alpha_1 - \tan\alpha_2)}\right] \times \tan\alpha_2}$$

RL of Q = RL of BM + $S_1 + h_1$

or

RL of BM + $S_2 + h_2$

(ii) · 'A' is higher than 'B'



$\Delta AQQ'$

$h_1 = D\tan\alpha_1 \longrightarrow (1)$

$\Delta BQQ''$

$h_2 = (b+D)\tan\alpha_2 \longrightarrow (2)$

$h_2 - h_1 = S$

$S = (b+D)\tan\alpha_2 - D\tan\alpha_1$

$S = b\tan\alpha_2 + D\tan\alpha_2 - D\tan\alpha_1$

$S = D(\tan\alpha_2 - \tan\alpha_1) + b\tan\alpha_2$

~~D = S~~ $S - b\tan\alpha_2 = D(\tan\alpha_2 - \tan\alpha_1)$

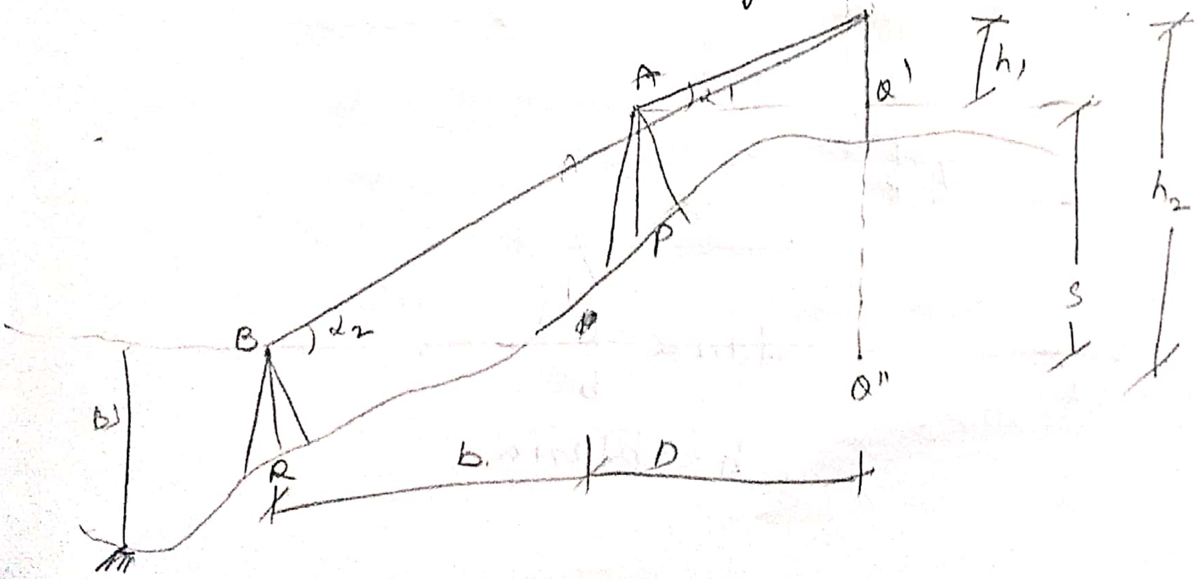
$$\boxed{D = \frac{S - b\tan\alpha_2}{(\tan\alpha_2 - \tan\alpha_1)}}$$

$$\boxed{h_1 = \left(\frac{S - b\tan\alpha_2}{(\tan\alpha_2 - \tan\alpha_1)}\right)\tan\alpha_1}$$

$$\boxed{h_2 = \left(b + \frac{S - b\tan\alpha_2}{\tan\alpha_2 - \tan\alpha_1}\right)\tan\alpha_2}$$

RL of Q = RL of BM + S_1 + h_1

Case (c): Instrument axes at very different levels.



If $S_2 - S_1$ or S is too great then we will adopt this method.

S = diff in level between two axes A and B

$$h_1 = D \tan\alpha_1$$
$$h_2 = (b + D)\tan\alpha_2$$

(2) − (1)

$$S = (b + D)\tan\alpha_2 - D\tan\alpha_1$$

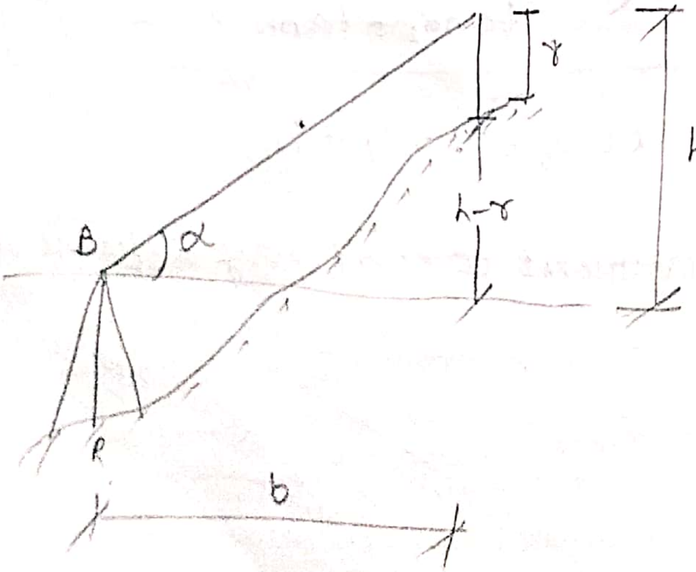
$$S = D(\tan\alpha_2 - \tan\alpha_1) + b.\tan\alpha_2$$

$$S - b\tan\alpha_2 = D(\tan\alpha_2 - \tan\alpha_1)$$

$$b\tan\alpha_2 - S = D(\tan\alpha_1 - \tan\alpha_2)$$

$$\boxed{D = \frac{b\tan\alpha_2 - S}{\tan\alpha_1 - \tan\alpha_2}}$$

$$h_1 = \frac{b\tan\alpha_2 - S}{\tan\alpha_1 - \tan\alpha_2} \times \tan\alpha_1$$



$$\tan\alpha = \frac{h}{b}$$

$$h = b\tan\alpha$$

From above fig we have height of station P' above axis at B. = $h - \gamma$

$\boxed{h - \gamma = b \tan\alpha - \gamma}$

Height of axis at A above axis at B is.

$S = h - \gamma + h'$

$S = b \tan\alpha - \gamma + h'$

where h' = height of instrument at B.

substituting the value of 'S' in eqn D and h_1, we will get D and h_1.

RL of 'Q' = RL of Inst axis at A + h_1

(or) RL of Inst axis at B + h_2.

RL of Q = RL of BM + B.S at B + S + h_1

where

$\boxed{S = b \tan\alpha - \gamma + h'}$

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MODULE-IV
TRAVERSING

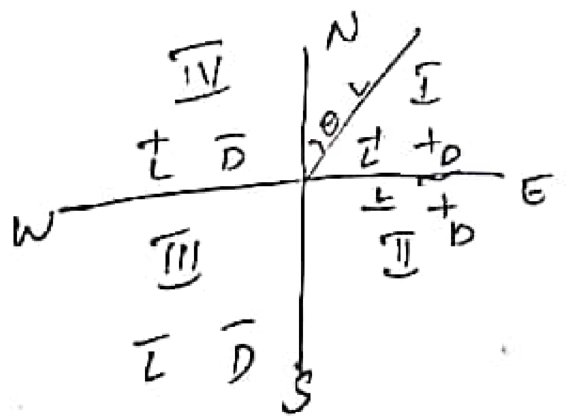
Methods of Traversing:

1) Chain traversing - linear -
2) Chain & compass traversing (loose needle method) - chain & compass
3) Transit tape traversing
   a) By fast needle method - Theodolite with compass.
   b) By measurement of angles b/w lines. - Theodolite - accurate than all above methods.
4) Plane table traversing .

Checks for closed traverse :

1) Sum of Interior angles = $(2n-4)90^\circ$.
2) Sum of exterior angles is $(2n+4)90^\circ$
3) Traverse by deflection angles
   algebraic sum of deflection angle = 360°.
   By taking right deflection as +ve and left deflection as negative.
4) Traverse by direct observation of bearings.
   F.B of last line = its $B.B \pm 180^\circ$ measured at initial station.

Traverse Computations:



latitude is always ∥ to N-S meri

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

Latitude: It is defined as its co-ordinated length measured parallel to true north or magnetic north or any other reference direction.

Departure:

It is defined as its co-ordinated length measured ⊥ar to the meridian direction.

Northing: Latitude of line is +ve when measured north ward or upward is termed as northing.

Easting: Departure of line is +ve when measured eastward is termed as easting.

Consecutive co-ordinates or Dependent co-ordinates:

Latitude and departure co-ordinates of any point with reference to the preceeding point are equal to latitude and departure of line joining the preceeding point to the point under consideration. Such coordinates are known as consecutive co-ordinates.

Independent co-ordinates:

The co-ordinates of traverse stations can be calculated wrt a common origin.

The total latitude and departure of any point wrt a common origin are called independent co-ordinates or total co-ordinates of that point.

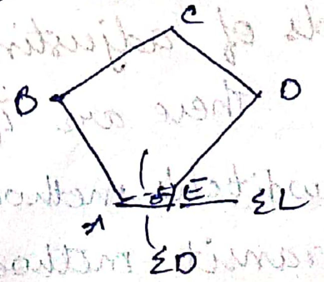
Closing error:

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

Direction of closing error =

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

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



The sign of (+ or -) ΣD & ΣL will thus define the quadrant in which the closing error lies.

Adjustment of angular error:

In a closed traverse if angles are measured with same degree of precesion error in sum of angles may be distributed equally to each angle of the traverse.

Adjustment of bearings:

e = error

N = sides we get

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

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

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

⋮

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

Balancing of Traverse:

The term balancing is generally applied to the operation of applying corrections to the latitude and departure, so that $\Sigma L = 0$ & $\Sigma D = 0$.

This applies only when survey forms a closed polygon.

Methods of adjusting traverse:

There are 4 methods.

1. Bowditch's method
2. Transit method
3. Axis method
4. Graphical method.

Bowditch's method:

→ The errors in linear measurements are directly proportional to $\sqrt{l}$ · and errors in angular measurements are inversely proportional to $\sqrt{l}$. where l is length of a line.

→ Bowditch's rule also termed as compass rule is mostly used to balance a traverse where linear and angular measurements are of equal precision.

→ Total error in latitude and in departure is distributed in proportion to the lengths of sides.

Bowditch's Rule:

Correction to latitude or departure of any line

$$(C_L \text{ or } C_D) = \frac{\text{length of that side } (l)}{\text{Perimeter of traverse}} \times \text{total error in latitude or departure.}$$

$$C_L = \Sigma L \times \frac{l}{\Sigma l}$$

$$C_D = \Sigma D \times \frac{l}{\Sigma l}.$$

Gales traverse table:

Traverse computations are usually done in a tabular form, a more common form is called Gale's traverse table.

Procedure:

1. Adjust interior angles to satisfy geometrical conditions i.e sum of interior angles $(2n-4)90°$ and sum of adjust exterior angles $(2n+4)90°$.

   In case of compass traverse, bearings are adjusted for local attraction if any.

2. Starting with observed bearings of one line, calculate bearings of all other lines. Reduce all bearings to quadrantal system.

3. Calculate consecutive co-ordinates (i.e L&D)
4. Calculate ΣL and ΣD.
5. Apply necessary corrections to latitude and departures so that $\Sigma L = 0$ and $\Sigma D = 0$. The corrections may be applied either by transit rule or by compass rule depending up on type of traverse
6. Using corrected consecutive co-ordinates, calculate independent co-ordinates to the points so that they are all +ve, the whole of the traverse thus lying in North-East quadrant.

Omitted Measurements:

Omitted measurements are missing quantites can be calculated by latitudes and departures provided the quantities required are not more than 2.

In such cases there can be no ~~ck~~ check on the field work nor the survey can be balanced.

Since for a closed traverse $\Sigma L = 0$, $\Sigma D = 0$ we have $\Sigma L = l_1 \cos\theta_1 + l_2 \cos\theta_2 + l_3 \cos\theta_3 + \dots = 0$

$$\Sigma D = l_1 \sin\theta_1 + l_2 \sin\theta_2 + l_3 \sin\theta_3 + \dots = 0$$

where l_1, l_2, l_3 etc. are lengths of the lines. $\theta_1, \theta_2, \theta_3$ etc are their reduced bearings

There are 4 cases in omitted measurements;

Case (i): Bearing or length ~~are~~ or bearing and length of one side omitted.

Case (ii): Length of one side and bearing of another side

Case (iii): Lengths of two sides omitted.

Case (iv): Bearings of two sides omitted.

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Line of Length (1)	Point (2)	Angle (3)	Correction (4)	Corrected angle (5)	(6) WCB	(7) R.B	(8) Consecutive Co-ordinates N	S	E	W	(9) Corrections N	S	E	W	(10) Corrected consecutive Co-ordinates N	S	E	W	(11) Independent coordinates N	E
	A	95°24'	-6'	95°18'			107.97		3.77		+0.2		-0.01		108.23		3.76		200*	100*
AB 250					86.42	N86°42'E														
	B	88°42'	-6°	86°36'			14.39		249.57		+0.03	-	-0.71		14.42		248.8		214.42	346.85
BC 123					178.06'	S1°54'E														
	C	88°12'	-6'	88°06'				122.94	4.12			+0.29	-0.01			122.6	4.11		91.77	352.96
CD 256					270°00'	N 90°N														
	D	88°06'	-6'	88°00'			0			256.00	+0			0.33	0			256.73	91.77	96.23
DA 108					2°00'	N2°E														
SUM		360°24'	-24'	360°00'			122.36	122.94	257.46	256.00	+0.29	-0.29	-0.73	+0.73	122.65	122.65	258.3	256.73		
							-0.56		+1.46		+0.58		-1.46		0		0			

GALES TRAVERSE TABLE

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Case(I)

Problem:

The table below gives the lengths and bearings of lines of a traverse ABCDE. The length and bearing of EA having been omitted. Calculate length and bearing of line EA.

Line	Length (m)	Bearing
AB	204	87°30'
BC	226	20°20'
CD	187	280°
DE	192	210° 30'
EA	?	?

Sol:-

Line	Latitude +	Latitude −	Departure +	Departure −
AB	8.90		203.80	
BC	211.91		78.53	
CD	32.47			184.16
DE		−165.43		−97.44
EA				

$\Sigma L' = 87.84$ $\Sigma D' = \cancel{195.60}\ 0.73$

Latitude of EA $+ \Sigma L' = 0$.

Latitude of EA $= -87.86$

Dep of EA $= -0.72$

$$\tan\theta = \frac{\Sigma D}{\Sigma L} = \frac{0.72}{87.86}$$

$$\theta = 0^\circ 28'$$

$$\theta = S\,0^\circ 28' W$$

$$\theta = 180^\circ 28'$$

$$\text{length of } EA = l = \frac{L}{\cos\theta} = \frac{87.86}{\cos 0^\circ 28'} = 87.86\text{ m}$$

case (ii).

Length of one side & Bearing of another side omitted:

problem:

In a closed traverse ABCDE, the line AB and bearing of line EA couldn't be measured in the field. From the measurements, the following information is available.

sol:-

Line	length in mts	WCB Bearings	RB/QB
AB	?	95°	S 85° E
BC	140m	27°28'	N 27°28' E
CD	163m	317°30'	N 42°30' W
DE	173m	260°00'	S 80° W
EA	201 m	?	

(l cosθ)
Latitude

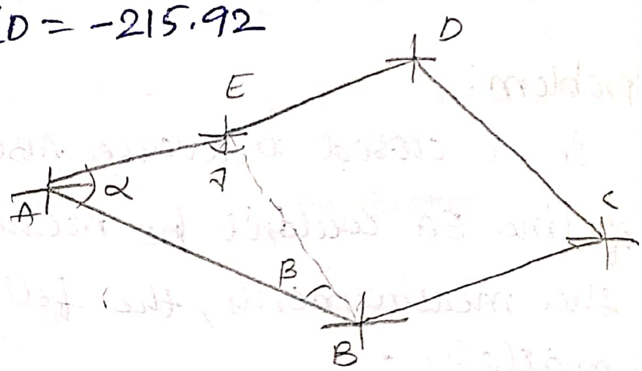
Departure (l sinθ)

+	−	+	−
124.22		64.57	
120.18			110.12
	30.04		170.37

$\Sigma L = 214.36$ $\Sigma D = -215.92$

length of closing line

EB =



latitude of EB + 214.36 = 0

Dep of EB − 215.92 = 0

∴ Dep of EB = − ~~214.36~~ 215.92

lat of EB = − 214.36

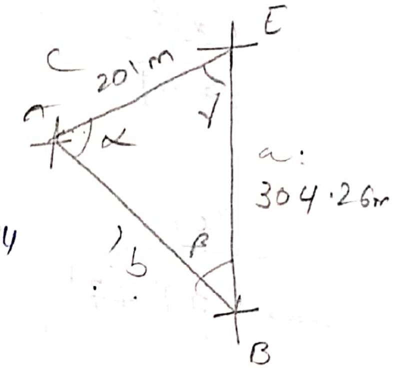
length of closing line = EB = $\sqrt{(215.92)^2 + (-214.36)^2}$

$= 304.26\,m$

$\tan\theta = \frac{\Sigma D}{\Sigma L} = \frac{215.92}{214.36}$ = S 45° 12' 27.82'' E

$\boxed{\theta = 134° 47' 32.18''}$

consider $\triangle ABE$



β = Bearing of BE − Bearing of BA

$= 314^\circ 47' 32.14'' - 275^\circ 0' 00''$

$= 39^\circ 47' 32.14''$.

$\cos\alpha$ = ~~Bearing~~ $\cancel{\dfrac{a^2+b^2-c^2}{2ab}}$

$= \cancel{\dfrac{(304.26)^2 + b^2 - (201)^2}{2(304.26)(b)}}$

Apply sine rule

$$\frac{AE}{\sin\beta} = \frac{304.26}{\sin\alpha}$$

$$\frac{201}{\sin(39^\circ 47' 32.14'')} = \frac{304.26}{\sin\alpha}$$

$$314.05 = \frac{304.26}{\sin\alpha}$$

$$\sin\alpha = \frac{304.26}{314.05}$$

$$\alpha = \sin^{-1}\left(\frac{304.26}{314.05}\right)$$

$$\alpha = 75^\circ 39' 22.31''$$

$\gamma = 180 - (\alpha + \beta)$

$= 64^\circ 33' 5.55''$

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$$\frac{AE}{\sin\beta} = \frac{AB}{\sin\gamma}$$

$$\frac{201}{\sin 39^\circ 47'} = \frac{AB}{\sin 64^\circ 33'}$$

$$AB = 283.64\,m.$$

γ = Bearing of EB + Bearing of EA

$64^\circ 33' 5.55'' = -134^\circ 47' 32.18'' +$ Bearing of EA.

Bearing of EA $= 199^\circ 20' 37.73''$

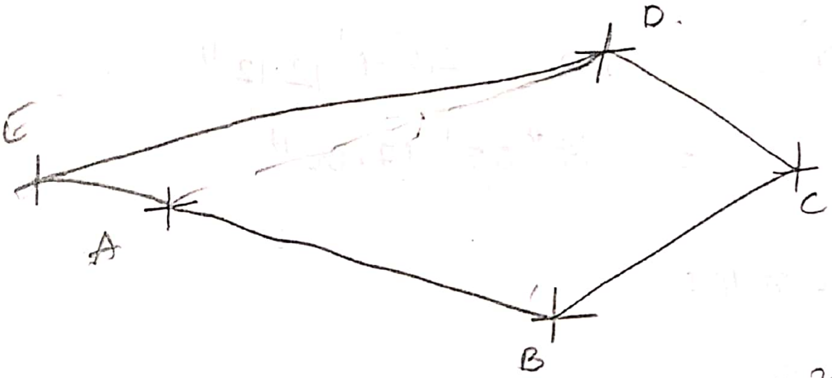
Case (iii) lengths of two sides omitted

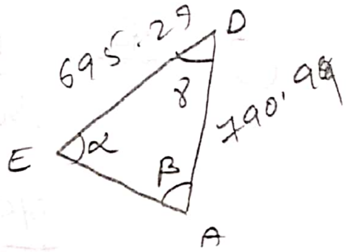
Problem:

A closed traverse was conducted around an obstacle and following observations were made workout missing quantities.

Sides	Length (m)	Azimuth (WCB)	R.B	Latitude ($l\cos\theta$) +	Latitude ($l\cos\theta$) −	Departure ($l\sin\theta$) +	Departure ($l\sin\theta$) −
AB	500	98° 30'	S 81°30' E		73.90	494.51	
BC	620	30° 20'	N 30°20' E	535.12		313.12	
CD	468	298° 30'	N 61°30' W	223.31	~~223.31~~		411.29
DE	?	230°	S 50° W				
EA	?	150° 10'	S 29°50' E				

$\Sigma L = 684.53$ $\Sigma D = 396.33$





$\therefore$ Latitude of DA $+ 684.53 = 0$

Latitude of DA $= -684.53$

Departure of $\overset{DA}{\cancel{EB}} + 396.33 = 0$

Departure of DA $= -396.33$.

Length of closing line DA $= \sqrt{(684.53)^2 + (396.33)^2}$

$= 790.99$ m

$\tan\theta = \frac{\Sigma D}{\Sigma L} = \frac{396.33}{684.53}$

$\therefore \theta = S\,30^\circ\,4'\,12.12''\,W$

$\theta = 210^\circ\,4'\,12.12''$

$\alpha =$ Bearing of $\overset{EA}{\cancel{EA}}$ $-$ Bearing of ED

$\alpha = (\cancel{180^\circ}\,150^\circ 10') - (\cancel{180}\,230^\circ - 180^\circ)$

$\alpha = \cancel{130^\circ 30' 10''}\ 100^\circ 10'$

$\beta =$ Bearing of AD $-$ Bearing of AE

$\beta = (210^\circ 4' 12.12'' - 180^\circ) - (180^\circ + 150^\circ 10')$

$= 59^\circ 54' 12.12''$

γ = Bearing of DE - Bearing of DA

$\gamma = 230 - 210°4'12.12''$

$= 19°55'47.88''$

Apply sine rule:

(1) ~~~~

$$\frac{DA}{\sin\alpha} = \frac{DE}{\sin\beta}$$

$$\frac{790.99}{\sin(100°10')} = \frac{DE}{\sin(59°54'12.12'')}$$

DE = 695.27 m.

(2).

$$\frac{DE}{\sin\beta} = \frac{EA}{\sin\gamma}$$

$$\frac{695.27}{\sin(59°54'12.12'')} = \frac{EA}{\sin(19°55'47.88'')}$$

EA = 274.04 m

Case(iv) Bearings of two sides omitted.

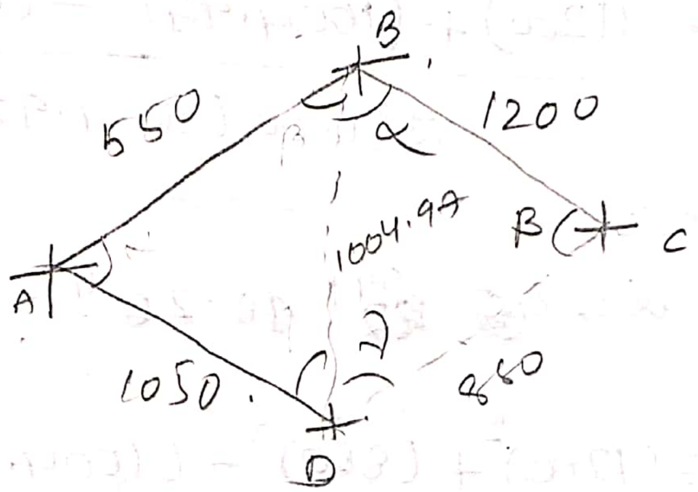
Problem:

~~When bearings of two sides are~~

While traversing, a closed traverse lining Naini, allahabad, a closed traverse ABCD was made. Due to obstructions it was not possible to observe the bearings of lines BC and CD. Calculate the missing bearings.

Line	length (m)	WCB	R.B	Latitude +	Latitude −	Departure +	Departure −
AB	~~5500~~ 550	60°	N 60° E	275		476.31	
BC	1200	294° 57' 6.82"					
CD	880	239° 43' 18.4"					
DA	1050	310°	N 50° W	674.93			804.35

$\Sigma L = 949.93$ $\Sigma D = -328.04$



Latitude of BD + 949.93 = 0 | Departure of BD − 328.04 = 0

Latitude of BD = − 949.93 | Departure of BD = 328.04

$$\text{length of } BD = \sqrt{(-949.93)^2 + (328.04)^2}$$

$$= 1004.97 \text{ m.}$$

$$\tan\theta = \frac{\Sigma D}{\Sigma L} = \frac{328.04}{949.93} \Rightarrow \theta = 19^\circ 3' 4.92''.$$

$$\theta = S\ 19^\circ 3' 4.92'' E$$

$$\theta = 160^\circ 56' 55.08''$$

Apply cosine rule:

$$\cos\alpha = \frac{(1200)^2 + (1004.97)^2 - (880)^2}{2(1200)(1004.97)}$$

~~cos α =~~

$\alpha = 45^\circ 59' 48.26''$

$$\cos\beta = \frac{(1200)^2 + (880)^2 - (1004.97)^2}{2(1200)(880)}$$

$\beta = 55^\circ 13' 48.42''$

$\gamma = 100 - (\alpha + \beta)$

$= 180 - (45^\circ 59' 48.26'' + 55^\circ 13' 48.42'')$

$= 78^\circ 46' 23.32''$

Δ BCD

$\therefore \alpha =$ Bearing of CD − Bearing of BC

$45^\circ 59' 48.26'' + 160^\circ 56' 55.08'' =$ Bearing of BC

Bearing of BC $= 114^\circ 57' 6.82''$

α = Bearing of DC − Bearing of DB

$78°46'23.32'' =$ Bearing of DC − $(180° + 160°56'55.08'')$

Bearing of DC = $59°43'18.4''$

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Tacheometric surveying :

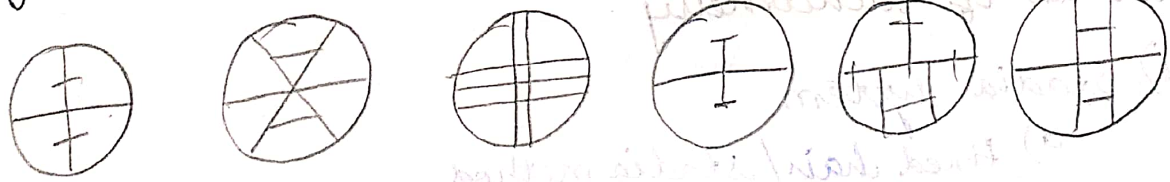
Tacheometry or telemetry is a branch of angular surveying in which the horizontal and vertical distances of points are obtained by optical means as opposed to the ordinary slower process of measurements by tape or chain.

This method is very fast and convenient. It is best adopted in obstacles such as steep and broken ground and deep ravines, streches of water (or) swamps etc where chaining is difficult or impossible.

The primary object of tacheometry is preparation of contour maps or plans requiring both horizontal and vertical control.

It provides a check on distances measured with tape.

Types of stadia diaphragms:



Features of thaceometer:

→ Multiplying const should have a value of 100 (K) and additive constant (C) should have a value of '0'

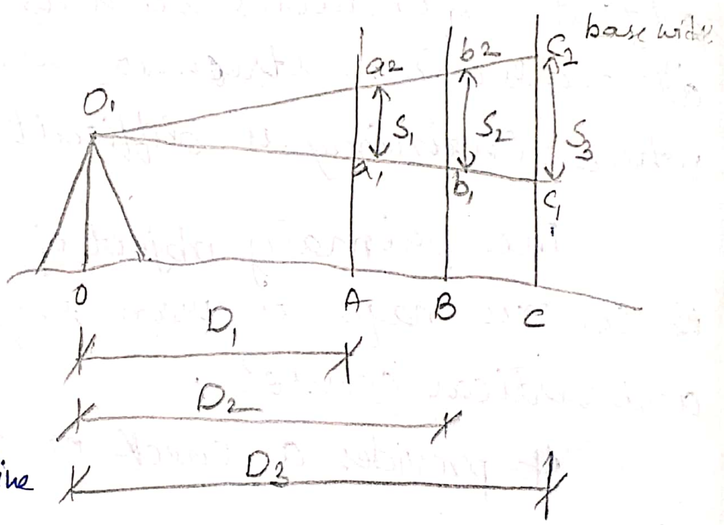
→ The axial horizontal line should be exactly midway between other two lines.

→ Telescope should be truely Anallictic lens
→ Telescope should be powerful having a magnification of 20-30 diameters.

* For small distances up to 100m ordinary leveling staff is used.
* For greater distances stadia rod is used.

Principle of tacheometry:
This is based on isosceles △le. ~~Inan~~ In an isosceles △le, the ratio of ⊥ar distance from apex to base and base width is always constant.

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



where $\frac{f}{i} = k$ is known as Multiplying constant
f = focal length of objective
i = Stadia intercept

Methods of tacheometry:
1) Stadia system
   a) Fixed hair/ stadia method
   b) movable hair method/ subtense method
2) Tangential system
3) Measurements by means of special instruments.

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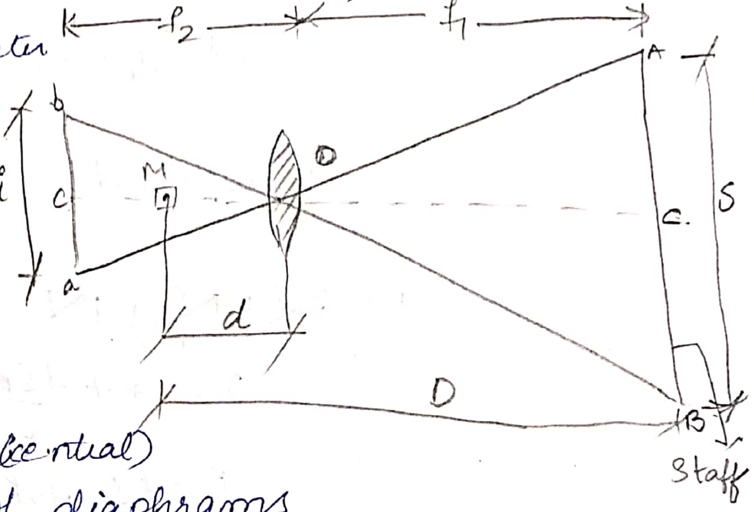
Fixed hair / Stadia Method :

* principle of Stadia Method :

(Distance equation $D = KS + C$)



where 'O' is optical center of objective glass

ACB = points cut by three lines of ~~side~~ sight corresponding to three wires.

a, b, c = top, axial (central) and bottom hairs of diaphrams

ab = i = interval between stadia hairs (stadia interval or stadia intercept)

AB = S = staff intercept

f_1 = horizontal distance of staff from optical center of objective

f_2 = horizontal distance between cross wires from 'O'

M = center of instrument corresponding to vertical axis.

d = distance of vertical axis of instrument from O

D = distance between instrument center to staff

By law of similar Δles,

$$\frac{f_1}{f_2} = \frac{S}{i}$$

∵ The rays ~~bof~~ BOb & AOa pass through ~~the~~ 'O', they are straight so that Δ AOB and Δ boa are similar Δles.

∵ f_1, f_2 are conjugate focal distances, from lens formula $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$

Multiplying numerator with ff_1 on both sides

$$\frac{ff_1}{f} = \frac{ff_1}{f_1} + \frac{ff_1}{f_2}$$

$$f_1 = f + \frac{f f_1}{f_2}$$

$$\cancel{f_1} \quad f_1 = f + f\left(\frac{s}{i}\right) \qquad \boxed{\because \frac{f_1}{f_2} = \frac{s}{i}}$$

$$\boxed{D = f_1 + d}$$

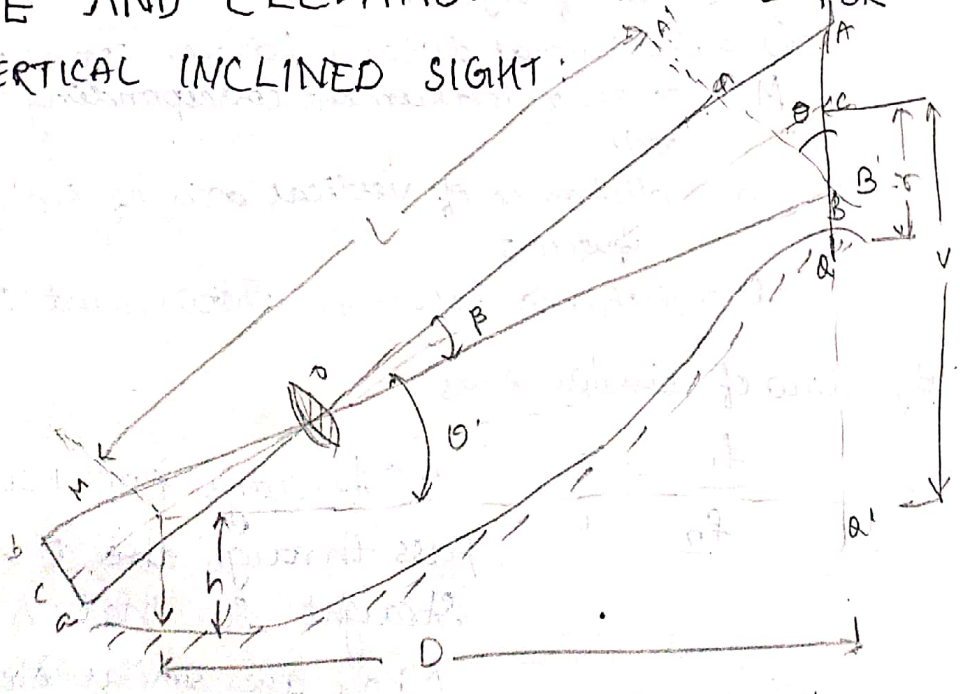
$$D = \cancel{f\left(1 + \frac{s}{i}\right)} + d$$

$$D = f + \frac{fs}{i} + d$$

$$D = \underbrace{\frac{f}{i}}_{K} s + \underbrace{f + d}_{C}$$

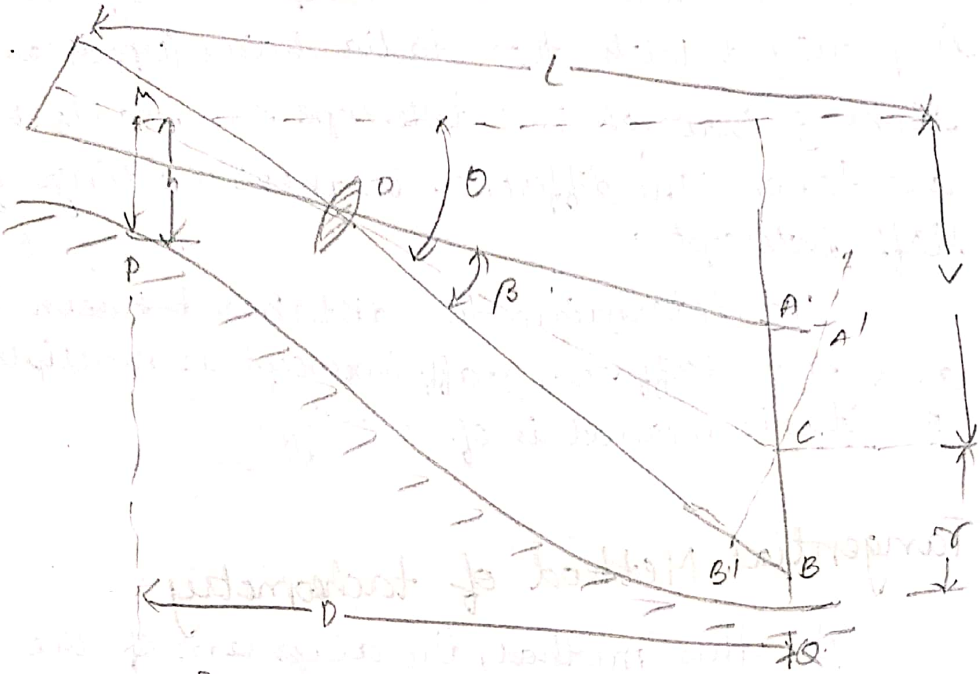
$\boxed{D = Ks + C}$ is known as distance equation

DISTANCE AND ELEVATION FORMULAE FOR STAFF VERTICAL INCLINED SIGHT :



Elevated sight: vertical holding

Elevation of staff station (Q) = Elevation of instrument station + h + V − r



Depressed sight - vertical holding

$$\boxed{D = KS\cos^2\theta + C\cos\theta}$$

$$\boxed{V = KS\frac{\sin 2\theta}{2} + C\sin\theta}$$

Elevation of staff station Q = Elevation of $P + h - V - \gamma$

Problem:

Two distances of 20m and 100m were accurately measured out and the intercepts on the staff b/w the outer stadia web were 0·196m and the former distance & 0·996m at the later. Calculate the tacheometric constants.

sol:- $D = KS + C$.

$S_1 = 0.196m \quad D_1 = 20m$

$S_2 = 0.996m \quad D_2 = 100m$

$D_1 = KS_1 + C$

$20 = K(0.196) + C \rightarrow (1)$

$K = 100$

$C = 0.4$

$D_2 = KS_2 + C$

$100 = K(0.996) + C \rightarrow (2)$

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Stadia method:

In this method, the diaphram of the tachometer is provided with two Stadia hairs (upper and lower) looking through the telescope the Stadia hair readings are taken. The difference in these readings gives the staff intercept.

To determine the distance between the Station and the staff. The staff intercept is multiplied by k i.e 100

The Stadia method is of two types:

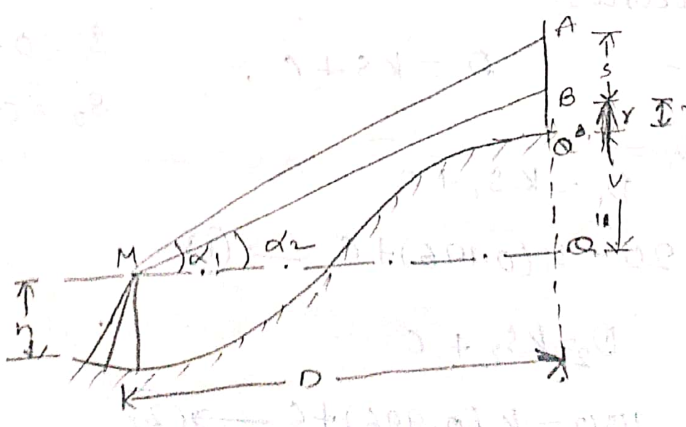
Tangential Method of tacheometry:

In this method, the diaphram of the tachometer is not provided with stadia hair. The readings are taken by single horizontal hair.

The staff consists of two vanes or targets at a known distance apart. To measure the staff intercept, two pointings are required. The angles of elevation or depression are measured and their tangents are used for finding the horizontal distances and elevations.

The stadia method requires only one observation but tangential method requires two pointings of telescope.

Case(i): Both Angles are angles of elevation



Take Δle BMQ'

$$\tan\alpha_2 = \frac{V}{D}$$

$$V = D\tan\alpha_2 \rightarrow ①$$

Δ AMQ'

$$\tan\alpha_1 = \frac{(V+S)}{D}.$$

$$V+S = D\tan\alpha_1 \rightarrow ②$$

② − ①

$$S = D\tan\alpha_1 - D\tan\alpha_2$$

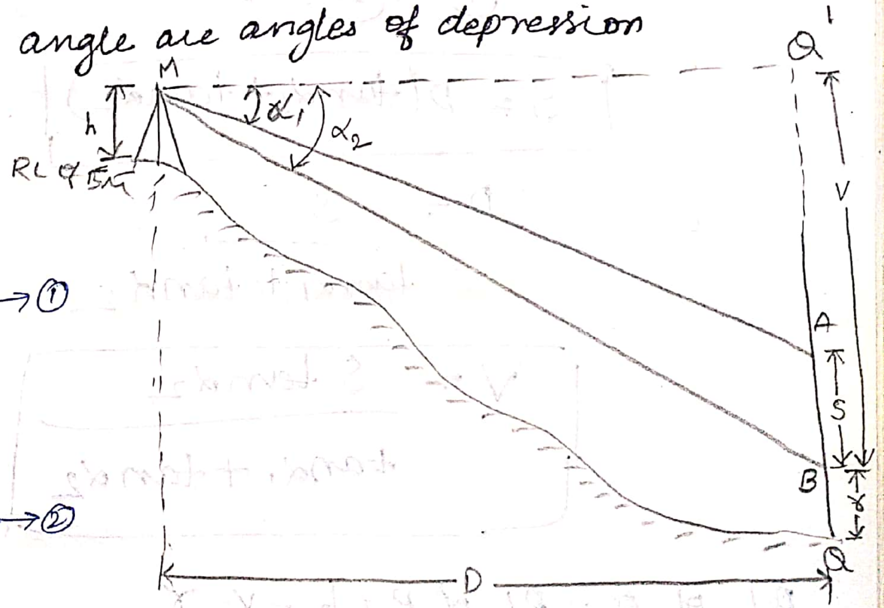
$$S = D(\tan\alpha_1 - \tan\alpha_2)$$

$$D = \frac{S}{\tan\alpha_1 - \tan\alpha_2}$$

$$V = D\tan\alpha_2$$

$$\boxed{V = \frac{S\tan\alpha_2}{\tan\alpha_1 - \tan\alpha_2}}$$

Case (ii): Both angle are angles of depression



Δ AMQ'

$$\tan\alpha_1 = \frac{V-S}{D}$$

$$V-S = D\tan\alpha_1 \rightarrow ①$$

Δ BMQ'

$$\tan\alpha_2 = \frac{V}{D}$$

$$V = D\tan\alpha_2 \rightarrow ②$$

~~② − ①~~

~~① − ②~~ ② − ①.

$$S = D(\tan\alpha_2 - \tan\alpha_1)$$

$$\boxed{D = \frac{S}{\tan\alpha_2 - \tan\alpha_1}}$$

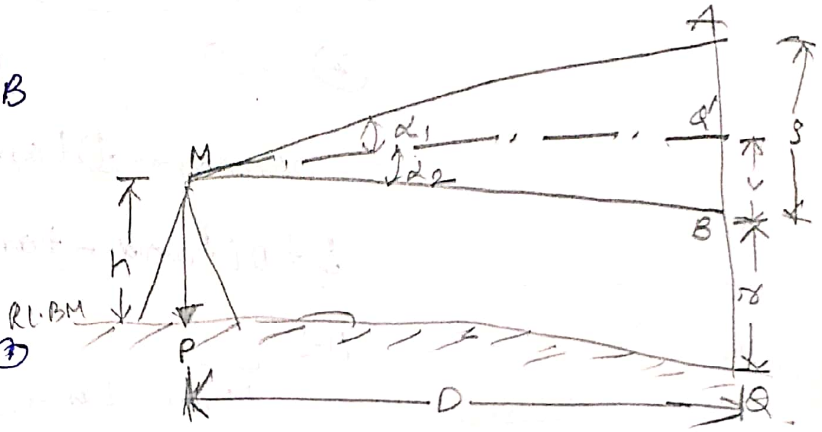
$$V = \frac{S\tan\alpha_2}{(\tan\alpha_2 - \tan\alpha_1}$$

RL of Q' = RL ~~of~~ BM $+ h - V - \gamma$

Case (iii):

One angle elevation and other depression

Consider $\Delta MQ'B$



$$\tan\alpha_2 = \frac{V}{D}$$

$$\boxed{V = D\tan\alpha_2} \rightarrow (1)$$

$\Delta MAQ'$

$$\tan\alpha_1 = \frac{S-V}{D}$$

$$S - V = D\tan\alpha_1 \rightarrow (2)$$

(1) + (2)

$$\boxed{S = D(\tan\alpha_1 + \tan\alpha_2)}$$

$$D = \frac{S}{\tan\alpha_1 + \tan\alpha_2}$$

$$\boxed{V = \frac{S\tan\alpha_2}{\tan\alpha_1 + \tan\alpha_2}}$$

RL of Q = RL of P $+ h - V - \gamma$

problem:

The vertical angles to vanes fixed at ~~one~~ 1m and 3m above the foot of the staff vertically at a station A were $+2^\circ 30'$ and $+5^\circ 48'$ respectively. Find horizontal distance and RL of A if height of the instrument determined from observation on to a BM is 438.556 m above datum.

Sol:-

$$\alpha_2 = 2^\circ 30'$$

$$\alpha_1 = 5^\circ 48'$$

Case(i)

$$D = \frac{S}{\tan\alpha_1 - \tan\alpha_2} \qquad V = D \tan\alpha_2$$

$$D = \frac{3-1}{-\tan(2^\circ 30') + \tan(5^\circ 48')} = 34.53\,m$$

$$V = (34.53)\tan(5^\circ 48')$$

$$V = 1.508\,m.$$

$$RL \text{ of } A = 438.556 + V - r$$

$$= 438.556 + 1.508 - 1$$

$$= 439.064\,m$$

MODULE – V

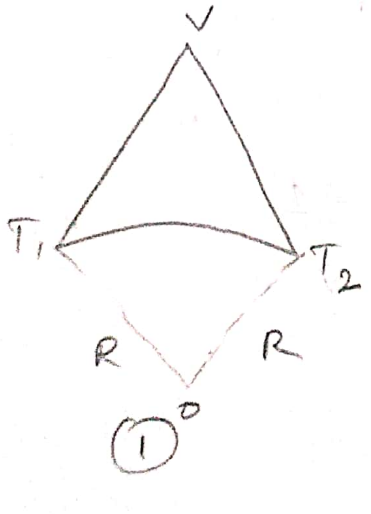
CURVES.

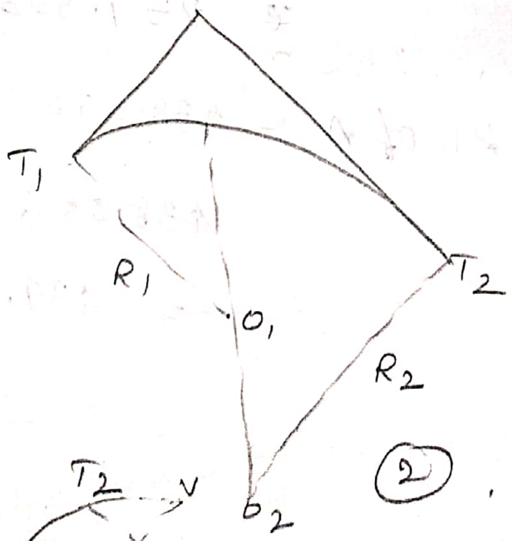
Curves are generally used on highways, railways where it is necessary to change the direction of motion.

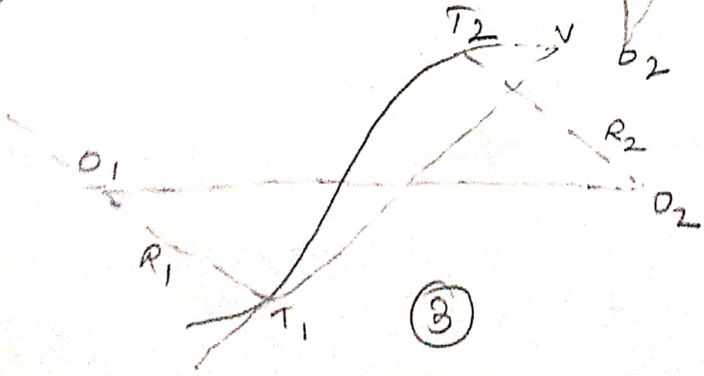
A curve may be circular, parabolic, or spiral and is alway tangential to two straight directions.

Types of curves:

1. Simple circular curve
2. Compound curve
3. Reverse curve.





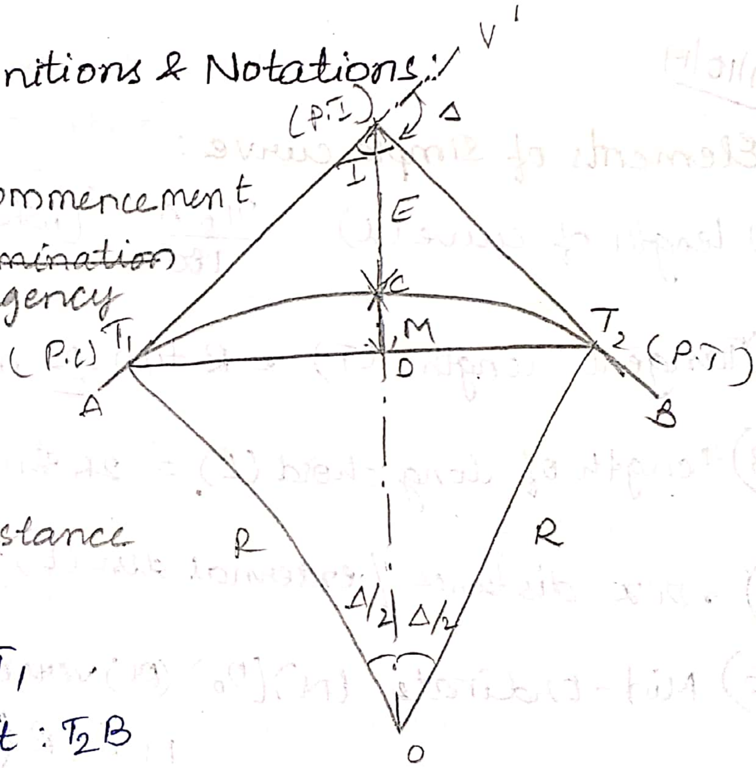


Simple curve: It is one which consists of a single arc of a circle. It is tangential to the both straight lines.

compound curve: It consists of two or more simple arcs that run in the same direction and joins at a common tangent point.

Reverse curve: It is the one which consists of two circular arcs of same ~~arc~~ & are different Radii having their centres to the different sides of common tangent. Both the arcs thus bend in different directions with common tangent at their junction.

Simple Curves: Definitions & Notations:



P.C – point of commencement.

P.T – Point of ~~termination~~ tangency

P.I –

M – Mid ordinate

E – ~~Ape~~ External distance

1. Back tangent: AT_1
2. Forward tangent: T_2B
3. Point of intersection: V.
4. P.C → point of commencement or point of curve
5. P.T – point of tangency i.e end of the curve
6. Intersection angle: $\angle I = I$
7. Deflection angle: Δ
9. Tangent distance: (T) VT_1 and VT_2
10. External distance: E – V to C
11. Length of l: 'l' The curved length from T_1 to T_2

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12. long chord (L): It is a chord joining PC and PT

13. Mid ordinate (M): It is the ordinate from the midpoint of long chord to the mid point of the curve

14. ~~Normal~~ Right hand curve: If the curve deflects to the right of the direction of the progress of survey, it is called as right hand curve.

15. Left hand curve: If the curve deflects to the left of the direction of progress of survey, it is called left hand curve.

16. P. I - point of Intersection

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Elements of simple curve:

1) length of curve (l) $= \frac{\pi R \Delta}{180°}$ (where Δ is indegrees)

2) Tangent length (T) $= R \tan \frac{\Delta}{2}$ m

3) length of long chord (L) $= 2R \sin \frac{\Delta}{2}$ m

4) Apex distance / external dist (E) $= R(\sec \frac{\Delta}{2} - 1)$

5) Mid-Ordinate (M)(O_o) (or) versed Sine of Curve

$$M = R\left(1 - \cos \frac{\Delta}{2}\right)$$

6) $\Delta = 180 - I$

7) ~~chain~~ chainage of 1st tangent point

T_1 = chainage of intersection 'V'

− tangent length (T)

8) Chainage of 2nd tangent point

T_2 = chainage of T_1 + length of curve (l)

Setting out simple curve:

This can be done by two methods

1) Linear methods
2) Angular methods

1. Linear Methods:

In this ~~linear~~ chain/tape is used.

→ These methods are used when high degree of accuracy is not required and when curve is short

2. Angular Methods:

In this method theodolite is used with or without a chain or tape.

Linear methods of setting out a curve:

a) ~~The~~ By ordinates or offsets from long chord

b) By successive bisection of arcs

c) By offsets from tangents

(i) Radial offsets

(ii) Perpendicular offsets.

d) By offsets from chords produced or by deflection distances

Angular or instrumental methods of setting out a curve:

(1) Rankine's method of tangential (or) deflection angle

(2) Two theodolite method

(3) Tacheometric method.

a) By ordinates or offsets from long chord

$$O_0 = R - \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$$

$$O_x = \sqrt{R^2 - x^2} - (R - O_0)$$

Problem:

Calculate the ordinates at 10m distance for a circular curve having long chord of 80m and a versed ~~sign~~ sine of 4m.

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Sol:- $x = 10m$ $L = 80m$ $M = 4m$, $O_0 = 4m$

$$O_x = \sqrt{R^2 - x^2} - (R - O_0)$$

$$\Rightarrow O_0 = R - \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$$

$$4 = R - \sqrt{R^2 - (40)^2}$$

$$\sqrt{R^2 - (40)^2} = R - 4$$

$$\cancel{R^2} - (40)^2 = \cancel{R^2} + 16 - 8R$$

$$8R = 16 + (40)^2$$

$$8R = 1616$$

$$\boxed{R = 202m}$$

$$\begin{array}{r} 1600 \\ 16 \\ \hline 1616 \end{array}$$

$$O_x = \sqrt{R^2 - x^2} - (R - O_0)$$

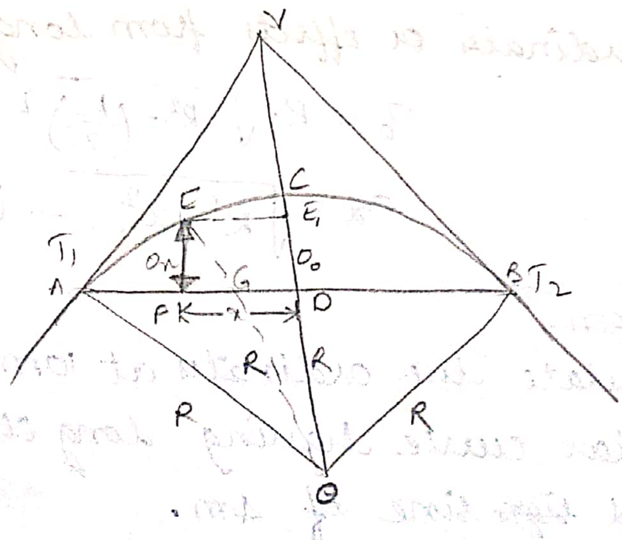
$$O_{10} = \sqrt{(202)^2 - (10)^2} - (202 - 4)$$

$$O_{10} = 3.75 m$$

$$O_{20} = \sqrt{(202)^2 - (20)^2} - (202 - 4) = 3.007 m$$

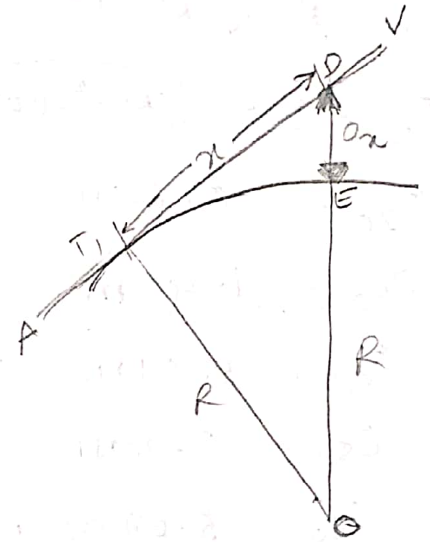
$$O_{30} = \sqrt{(202)^2 - (30)^2} - (202 - 4) = 1.75 m$$

$$O_{40} = \sqrt{(202)^2 - (40)^2} - (202 - 4) = 0$$



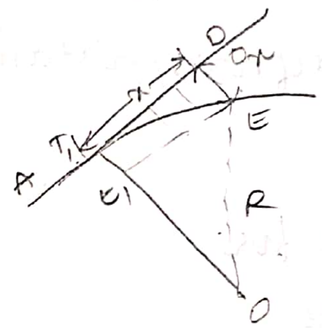
(iii) By offsets from the tangents setting out by Radial offset.

a) $O_x = \sqrt{R^2 + x^2} - R$



b) Setting out by perpendicular offset:

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



Problem:

Determine the offsets to be set out at half chain interval along the tangents to locate a 16 chain curve, the length of each chain being 20m.

Sol:- $x = \frac{1}{2}$ Chain $R = 16$ chain

$= \frac{1}{2}(20) = 10\,m$ $= 16 \times 20 = 320\,m$.

~~Perpendicular offset~~ Radial offset:

$O_{10} = \cancel{320} + \sqrt{(320)^2 + (10)^2} - 320 = 0.156 = 0.16\,m$

$\cancel{O_{20} = 320 - \sqrt{(320)^2 - (20)^2} =}$

$O_{20} = \sqrt{(320)^2 + 20^2} - 320 = 0.624 = 0.62\,m$

$O_{30} = \sqrt{320^2 + 30^2} - 320 = 1.403 = 1.40\,m$

$O_{40} = \sqrt{320^2 + 40^2} - 320 = 2.490 = 2.49\,m$

$O_{50} = 3.88\,m$, $O_{60} = 5.58\,m$ $O_{70} = 7.57\,m$

O

Ilar offsets:

$$O_{10} = R - \sqrt{R^2 - x^2}$$

$$O_{10} = 320 - \sqrt{(320)^2 - (10)^2} = 0.16m$$

$$O_{20} = 0.62m$$

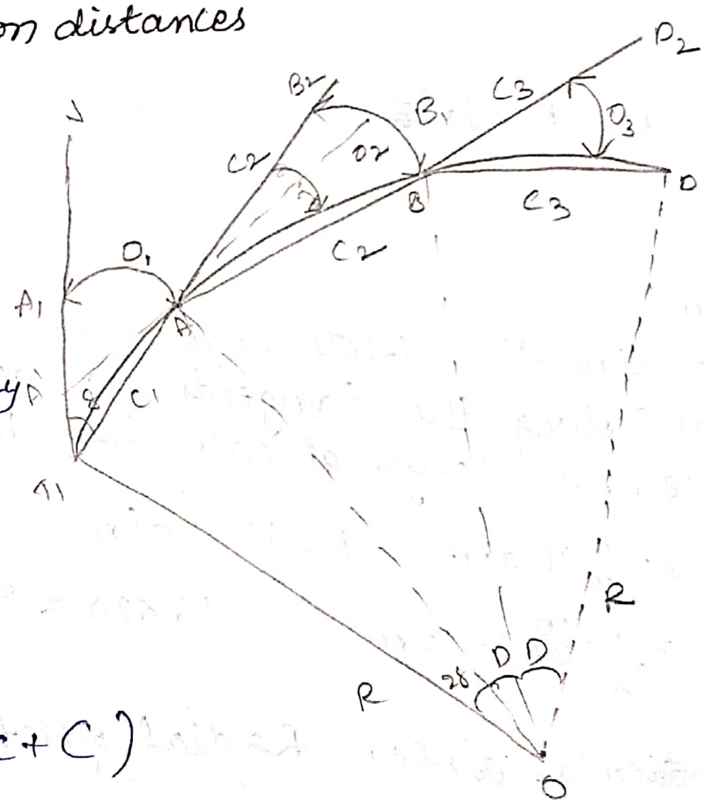
$$O_{30} = 1.40m$$

$$O_{40} = 2.51m$$

$$O_{50} = 3.93m$$

$$O_{60} = 5.67m$$

d) By ~~offset~~ deflection distances



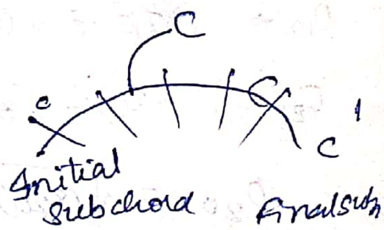
It is useful for
→ Long curves
→ This method is used on highway curves where theodolite is not available.

$$O_1 = \frac{c^2}{2R}$$

$$O_2 = \frac{c}{2R}(c + C)$$

$$O_3 = O_4 = O_{n-1} = \frac{C^2}{R}$$

$$O_n = \frac{c'}{2R}(C + c')$$



problem:
Two tangents intersect at a chainage 59+60 the deflection angle being 50° 30'. Calculate necessary data for setting out a curve of 15 chains Radius to connect to connect two tangents if it is intended to set out the curve offsets from chords. Take peg interval = 100 links.

Sol:- $R = 15$ chains $\quad \Delta = 50^\circ 30'$ $\quad \Rightarrow 100 \times 0.2 = 20\,m$

$= 15 \times 20 = 300\,m$

The length of chain = 20m (100 links).

$$T = R \tan \frac{\Delta}{2}$$

$$= 300 \tan \left(\frac{50^\circ 30'}{2}\right)$$

$$= 141.48\,m$$

$$\text{Length of curve } (l) = \frac{\pi R \Delta}{180^\circ} = 264.42\,m$$

Chainage of (V) P.I = 59 chains + 60 links

$= 59(20) + 60(0.2)$

$= 1180 + 12$

$= 1192\,m$

Chainage of T_1 = chainage of $V - T$

$= 1192 - 141.48 = 1050.52\,m$

Chainage of T_2 = chainage of $T_1 + l$

$= 1050.52 + 264.42 = 1314.94\,m$

The chainage of each peg = 100 links

$= 100 \times 0.2 = 20\,m$

Length of first subchord : 'c' = $1060 - 1050.52$

$= 9.48\,m$

length of last subchord $c' = 1314.94 - 1300$

$= 14.94\,m$

$C = 20\,m$.

No. of full chords $= \cancel{1300}\ \cancel{1060 - 1300}\ \dfrac{1300 - 1060}{20} = 12$ of each 20m. leng

Total no. of chords $= 1 + 12 + 1$
$= 14$

$$O_1 = \frac{C^2}{2R}$$

$$O_1 = \frac{(9.48)^2}{2 \times 300} = 0.149 \text{ m}$$

$$O_2 = \frac{C}{2R}(c + C) = \frac{20}{2 \times 300}(9.48 + 20)$$

$$= 0.98 \text{ m}$$

$$O_3 = O_4 = O_{n-1} = \frac{C^2}{R} = \frac{(20)^2}{300} = 1.33 \text{ m}$$

$$O_n = \frac{c'}{2R}(C + c')$$

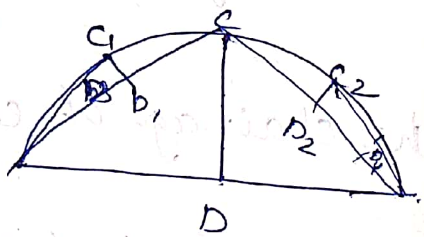
$$= \frac{14.94}{2 \times 300}(20 + 14.94) = 0.87 \text{ m}$$

b) By succesive bisection of Arcs (or) Chords.

$$CD = R\left(1 - \cos\frac{\Delta}{2}\right)$$

$$C_1D_1 = C_2D_2 = R\left(1 - \cos\frac{\Delta}{4}\right)$$

$$C_3D_3 = C_4D_4 = R\left(1 - \cos\frac{\Delta}{8}\right),$$



Problem:

Q) It is required to set out a curve of radius 100m with pegs at approximately 10 m centres. $\Delta = 60°$, draw up the data necessary for pegging out the curve ~~Cant~~ chord bisection method.

Sol:- $\Delta = 60^\circ$, $R = 100m$

$$CD = R\left(1 - \cos\frac{\Delta}{2}\right) = 100\left(1 - \cos\frac{60}{2}\right) = 13.40 \, m$$

$$C_1D_1 = C_2D_2 = R\left(1 - \cos\frac{\Delta}{4}\right) = 100\left(1 - \cos\left(\frac{60}{4}\right)\right) = 3.41 \, m$$

$$C_3D_3 = C_4D_4 = R\left(1 - \cos\frac{\Delta}{8}\right) = 100\left(1 - \cos\frac{60}{8}\right) = 0.86 \, m$$

Q. Two straights AB and BC are connected by a circular curve of radius 300m. Calculate elements of curve if $\Delta = 30^\circ$

Sol:- $R = 300m$, $\Delta = 30^\circ$

1) Length of curve $l = \frac{\pi R \Delta}{180^\circ} = \frac{\pi \times 300 \times 30^\circ}{180^\circ} = 157.08 \, m$

2. Tangent length $(T) = R \tan\frac{\Delta}{2} = 300 \tan\frac{30^\circ}{2} = 80.38m$

3. Length of longchord $(L) = 2 \times 300 \times \sin\frac{30^\circ}{2} = 155.29m$

4. Apex distance $E = 300\left(\sec\frac{30}{2} - 1\right) = 10.58 \, m$

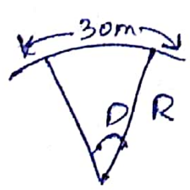
5. Mid ordinate $(M) = 300\left(1 - \cos\frac{30}{2}\right) = 10.22$

6. Ch of T_1 = Chainage of V − tangent length
$= 1192 - 80.38 = 1111.62$

7. Ch of T_2 = ~~1192~~ $1111.62 + 157.08 = 1268.7m$

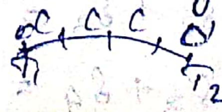
8. $I = 180 - \Delta = 180 - 30 = 150^\circ$

1) Normal chord : (C) : A chord between two successive regular stations on a curve

2) 

$R = \frac{1719}{D}$

3) $D = \frac{1719}{R}$

4) Subchord (C) : subchord is any chord shorter than normal chord. 

Angular methods :

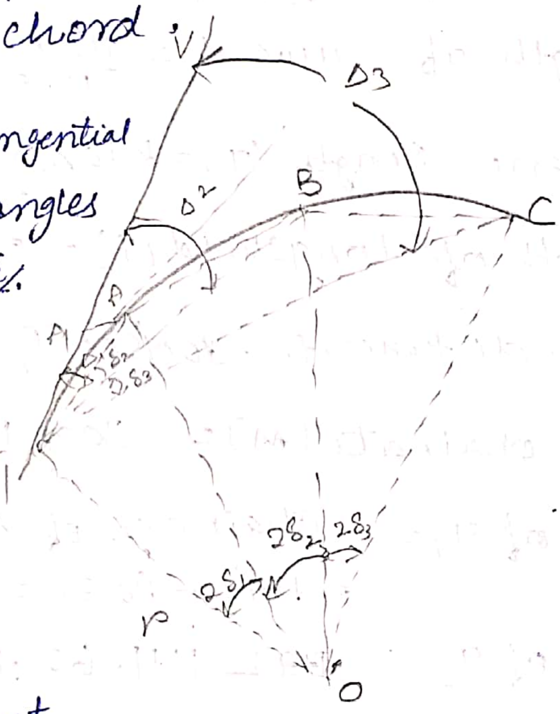
1) Rankine's method of Tangential (or) deflection angles:

. . A deflection angle to any point on the curve is the angle at point of curve between back tangent and chord from PC to that point.

Rankine's method is based on the principle that the deflection angle to any point on a curve is measured by half the angle subtended by the arc from P.C to that point. It is assumed that length of arc is app equal to chord.

$\Delta_1, \Delta_2, \Delta_3$ = total tangential angles or deflection angles to the points A, B, C etc.

capital C_1, C_2, C_3 = length of the chords T_1A, AB, BC



T_1V = Rear tangent

T_1 = P.C , $\delta_1, \delta_2, \delta_3$ = tangential angles or the angles which each of the succesive chords T_1A, AB, BC etc makes with the respective tangents to the curve at T_1, A, B

formulae :

$\Delta_1 = \delta_1 = 1718.9 \frac{C}{R}$ (small) minutes

$\Delta_2 = \delta_1 + \delta_2 = \Delta_1 + \delta_2$

$\Delta_3 = \delta_1 + \delta_2 + \delta_3 = \Delta_2 + \delta_3$

$\Delta_4 = \delta_1 + \delta_2 + \delta_3 + \delta_4 = \Delta_3 + \delta_4$

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$$\Delta_n = \delta_1 + \delta_2 + \delta_3 + \cdots + \delta_n = \Delta_{n-1} + \delta_n = \frac{\Delta}{2}.$$

Hence the deflection angle for any chord is equal to deflection angle for the previous chord + tangential angle for that chord.

problem:

Calculate the necessary data for setting out the curve when two tangents intersect at a chainage (59+60), deflection angle is $50° 30'$. Radius is 15 chains $= 300m$. Peg interval $= 100$ links i.e $20m$. length of chain $= 20m$ i.e 100 links. If it is intended to setout the curve by Rankine's method of tangential angles. If the theodolite has a least count of 20sec; Tabulate actual readings of deflection angles to be setout.

Sol:-

$C = 9.48\,m$

$C' = 14.94\,m \quad C = 20m$

$$\delta_1 = 1718.9\frac{C}{R} = 1718.9 \times \frac{9.48}{300}, = \cancel{54.31\,m}$$

$$= 54.32' = 54 \quad = \cancel{54' 19' 2.06''}$$

$$= 0° 54' 19''$$

$$\Delta_2 = \Delta_1 + \delta_2 \qquad \delta_2 = \frac{1718.9 \times 20}{R} = \frac{114.593'}{60}$$

$$= 1° 54' 35.60''$$

$$\delta_2 = \delta_3 = \cdots = \delta_{13} = 1° 54' 35.60''$$

$$\delta_{14} = 1718.9\frac{C'}{R} = \frac{1718.9 \times 14.94}{300} = \frac{85.601'}{60}$$

$$\delta_{14} = 1° 25' 35''$$

$\Delta_1 = \delta_1 = 0° 54' 19''$

$\Delta_2 = \Delta_1 + \delta_2 =$

$\Delta_3 = \Delta_2 + \delta_3 =$