ELEMENTS OF ENGINEERING
ME144

Dr. Prabhin Sukumaran
Department of Civil Engineering
prabhinsukumaran.cv@charusat.ac.in

A. Objective of the Course:

This course covers the basics of mechanical and civil engineering. The principles and application of the two core branches of engineering is covered along with the fundamentals of engineering drawing. The objectives of the course are to:

1. **Introduce the universal language and tool of communication for engineers and understand the concepts, elements & grammar of engineering drawing.**
2. **Introduce the important aspects and applications of mechanical engineering and explain the working of different mechanical systems.**
3. **Understand the scope and basic elements of civil engineering.**

Part: C		
10.	Scope of Civil Engineering	02
11.	Introduction to Surveying	06
12.	Elements of building Construction	07

Detail Syllabus

10.	**Scope of Civil Engineering**
10.1	Scope of Civil Engineering,
10.2	Branches of civil engineering,
10.3	Role of civil engineer
11.	**Introduction to Surveying**
11.1	Definition of surveying,
11.2	Objects of surveying, Uses of surveying,
11.3	Primary divisions of surveying, Principles of surveying,
11.4	List of classification of surveying, Definition: Plan and Map, Scales : Plain scale and Diagonal scale, Conventional Symbols
11.5	Introduction to linear and angular measurements, Concepts of land profiling
12.	**Elements of building Construction**
12.1	Types of building, Design loads,
12.2	Building components (super structure and substructure),
12.3	Principles of Planning,
12.4	Basics Requirements of a building Planning,
12.5	Types of Residential Building,

Books

- Khasia R.B. and Shukla R.N., “Elements of Civil Engineering”, Mahajan Publication.
- Punamia B.C., “Surveying”, Vol. I & II.

Branches of Engineering

1. Civil Engineering: discipline that deals with the design, construction, and maintenance of the physical and naturally built environment, including works like roads, bridges, canals, dams, and buildings
2. Mechanical Engineering: Design, test, build and operate all type of machines
3. Electrical engineering: Largest and most diverts; development and design, application and manufacture of systems and devices that use electrical power.
4. Electronic Engineering: Research, design, integration and application of circuits and applications
5. Computer Engineering:
6. Chemical Engineering:
7. Environmental Engineering
8. Agricultural Engineering
9. Architectural engineering
10. Safety Engineering
11. Nuclear Engineering
12. Marine Engineering
13. Industrial Engineering
14. Aeronautical Engineering
15. Geological and Mining Engineering
16. Textile Engineering

Branches of Civil Engineering

1. **Transportation Engineering**:

   Deals with the transport of men and materials through different communication routs. Planning, Designing, execution and Maintaining,

   - Highway engineering: Road
   - Railway Engineering: Rail
   - Waterway Engineering: Sea routes
   - Airport engineering: Airways

2. **Surveying and Leveling:**

   Various type of survey techniques, preparation of plans, contour maps etc. ..

3. **Geotechnique and foundation engineering:**

   Geotechnique: Various parameters of Soil, its behavior on application of load and application as engineering material is studied.

   Foundation: Analysis of soil as a foundation

4. Construction technology and management:

Deals with the properties and suitability of different type of material like, timber, cement, bricks etc.

5. Structural and Design engineering:

Analysis of various type of forces in a building and based on that the reinforcement detailing is done and design is prepared.

6. Estimating and Costing:

Deals with the financial aspect of the construction

7. Environmental Engineering:

Deals with the various means and measures to minimize environmental disintegration

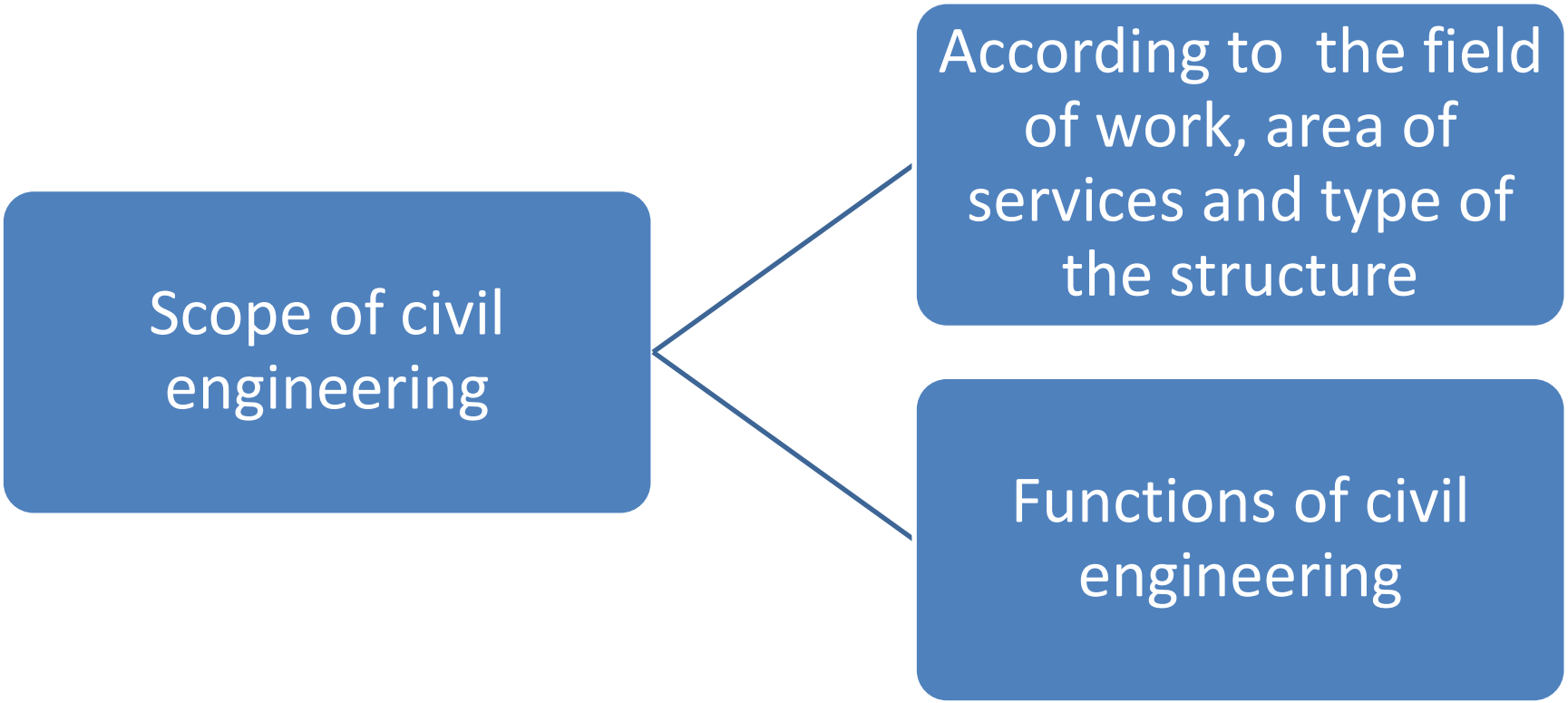
8. Water Resource and Irrigation engineering:

Deals with, how efficiently and optimally use the water resource

9. Town planning:

Planning of town road, water supply and other civil works

Scope of Civil Engineering



1.) According to field of work, area of services and type of the structure

- **Building construction:-**

✓ It includes constructing residential, public buildings and industrial buildings.

✓ It also includes study of building materials, construction techniques of building components like foundation, masonry, doors, windows etc.

- **Construction of heavy structures:-**

✓ It includes the construction of bridges, dams, ports, airports, harbors, well foundations & its various techniques, modern equipments and materials.

- **Geotechnical engineering:-**

✓ It includes the designing methods of various types of foundations, underground structures, earthen dams, earth work for highways & railways.

✓ It also includes soil investigation and its testing.

- **Transportation engineering:-**

✓ Constructing & designing the roadways, railways, bridges, harbors, airports.

✓ It also includes the traffic engineering & study of the highway materials.

..contd

- **Water resources engineering:-**

✓ Constructing structures relating to water resources engineering like dams, canal structures, hydro power structures.

✓ It also irrigation methods, flow management, rain water harvesting, flood control and water power engineering.

- **Environmental engineering:-**

✓ Constructing structures related to water treatment plant, water distribution network, drainage system and pumping system.

✓ It also includes solid waste management and pollution control from the town.

- **Town planning:-**

✓ Planning of town by zoning of the land, planning road network, planning other services like drainage, water distribution system.

✓ Preparing master plan of the town planning schemes and regulating construction by building bylaws.

…contd

2.) According to the functions of civil engineering

- **Surveying:-**

✓ To carry out surveying for setting out of works & preparing map of land.

✓ Measurements of distances and angles are taken by surveying instruments.

✓ With the help of leveling, levels are taken and prepare a contour map.

- **Planning:-**

✓ To carry out planning of a building is for the purpose to satisfy basic needs of the occupants.

- **Structural analysis and design:-**

✓ To carry out that the structure is safe from the various loads acting on it.

✓ To carry out the design of the structure with the help of various constructing materials e.g. steel or concrete.

- **Professional practice**

❖ **Estimating:-**

✓ To prepare estimate of work from the data of drawing, specifications and rates.

❖ **Costing and accounts:-**

✓ To carry out the costing to know the actual expenditure in the payment of bills to the contractor, and many other expenditure, during construction of the work.

….contd

❖ **Valuation:-**

✓ To carry out valuation of the property like land or land with building.

✓ Valuation is carried out for the purpose of knowing the fair & just price or market value of the property for the purpose of sales, purchases, insurance, taking loans & other purposes.

❖ **Contracts:-**

✓ To carry out the construction of work through contractor according to the conditions of the contract. On the bases of the contractor's qualification, past performance and rates filled in the tender papers, work is allocated to the contractor.

• **Construction management:-**

❖ **Planning and scheduling:-**

✓ To carry out the project planning and according to prepare different schedules.

✓ Scheduling is the process to fix the execution of the project activity after planning.

✓ Scheduling can be done using bar chart or critical path methods.

❖ **Construction execution & supervision:-**

✓ To carry out the actual execution and supervision of the construction activity of the project as per the plan, specification & condition of the contract.

✓ To manage material storing, handling equipments, safety of the labor & to observe the labor laws.

…contd

- **Quality control and research:-**

✓ To have a quality check of the material, equipment.

✓ During the actual construction, the quality of the material can be checked with the help the testing equipments.

✓ Materials should be used as per the specifications.

- **Maintenance of structure:-**

✓ To carry out the maintenance of the structure after the construction is over.

✓ Structure needs maintenance & proper care. Due to continuous utilization of the structure, wear and tear occur therefore the maintenance of the structure is required.

✓ Different types of the repair works are to be done for the maintenance of the structure. Current repairs, special repairs & major repairs are the different types of the repairs.

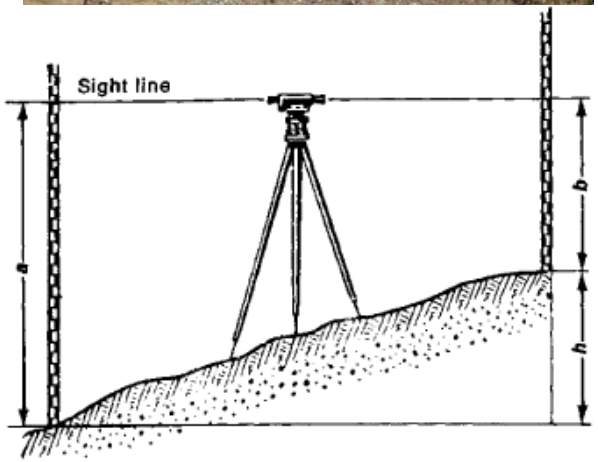
…contd

Role of the civil engineer in society

- The main role of civil engineer is **surveying, planning, designing, constructing, maintaining** of the various types of the structures.
- To **solve different engineering problems** with the help of enough experience of field, numerical methods, laboratory techniques.
- To carry out **soil investigations** for the design of the foundations.
- To carry out the **leveling and surveying and prepare map** to fix the boundaries of the plots and to calculate the area and the volume.
- To **fix the alignment** of the various paths for making the roadways, railways.
- To carry out the **planning & supervise proper the execution** of the actual construction activity.
- To **prepare the proper drawing, analyzing and designing** the various types of the structures.
- To **invite the tenders & to select contractor** for the work.
- To carry out **valuation of land or building** for the purpose of finding its scale or purchase price or taxation.
- To **fulfill the basic needs of the occupants** by using fundamentals of the building planning & by the help of the various building materials.

Surveying and levelling

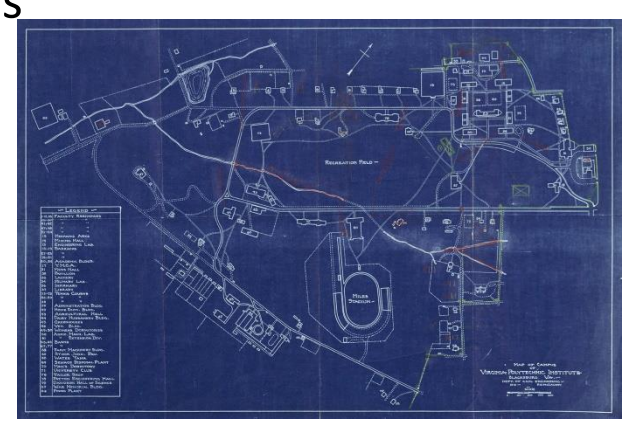
1. Surveying: Is the art of determining the relative position of various points above, on or below the surface of the earth.
2. Levelling: Is the art of determining the relative vertical distance of different points
   i. Measurement Taken
      a) Vertical distance
      b) Horizontal Distance
      c) Angle
         a) Horizontal
         b) Vertical
   ii. Computation
   iii. Preparation of maps and plans
   iv. Used for
      a) Calculation of length
      b) Area
      c) Volume
3. Art of tracing the points on a map to the ground
4. Purpose of the surveying:

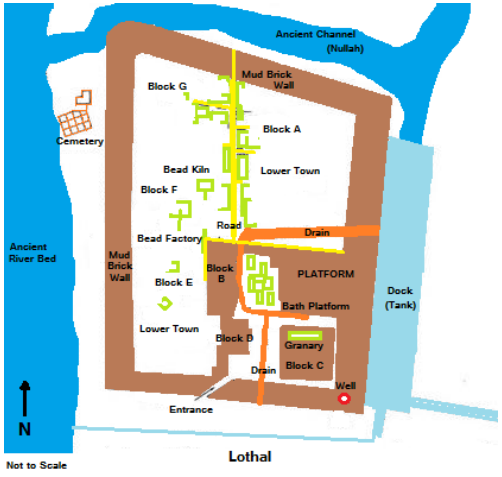


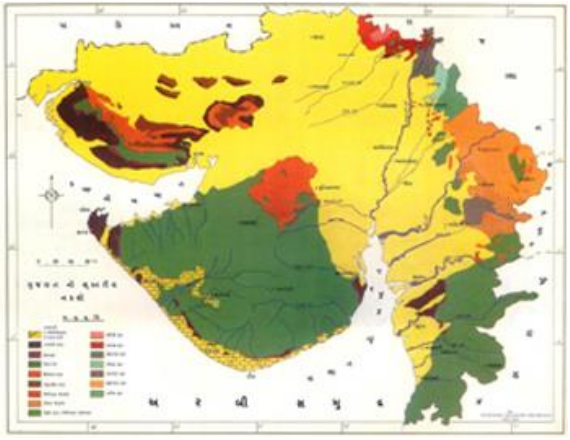
- Take measurements to determine the relative position of the point
- Make layouts , maps or plans to mark the proposed position of structure on the surface
- Determine the area, volume and other relative quantity.

Use of Surveying

- Preparation of Map
  1. To prepare the topographical maps
  2. Prepare cadastral maps showing boundaries, houses and properties
  3. Engineering map
  4. Military map
  5. Geological map
  6. Archaeological map

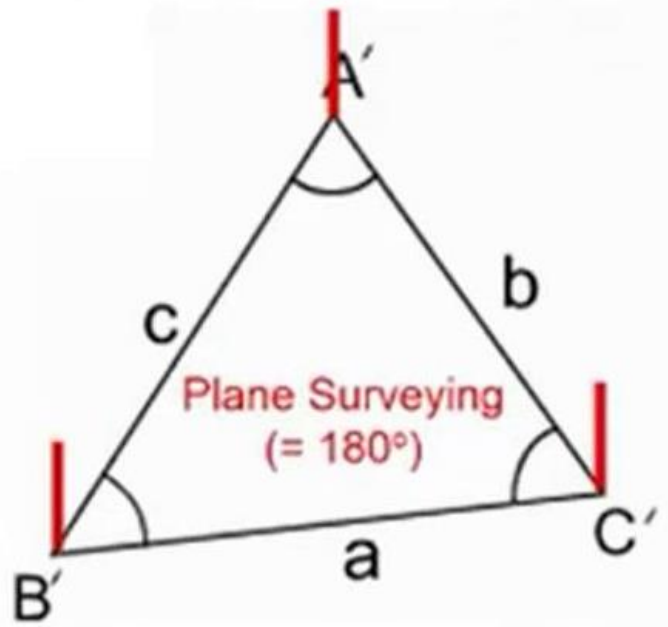


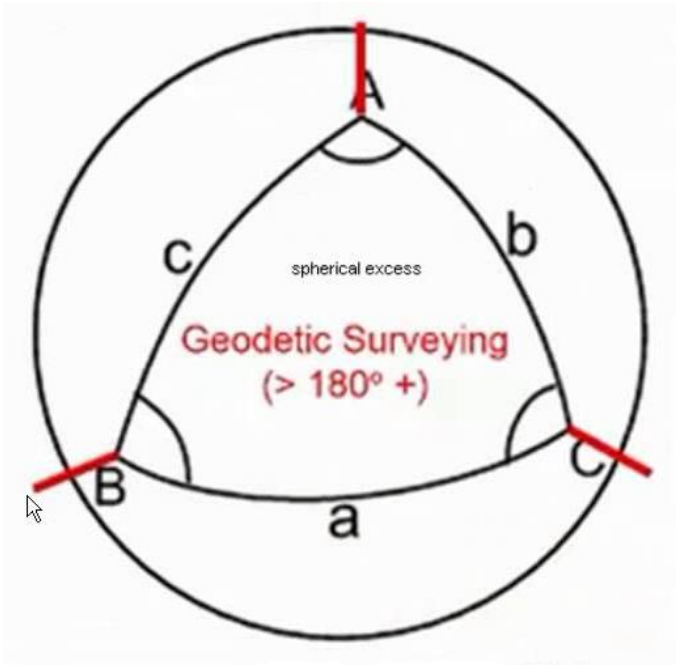




Primary Divisions of Surveying

- Primary Classification:
  - Division is based on the basis weather the curvature of the earth is taken in to consideration or not
    - Plane Surveying :
      - Curvature of earth is neglected and assumed as plane surface
      - Horizontal surface:
      - Vertical line:
      - Plane survey can be used when considered for a small area (Less than 250 Km^2)
      - Degree of accuracy is comparatively low
    - Geodetic surveying
      - Curvature of earth is taken in to consideration
      - Large distance and large area
      - Refined methods of observation and adjustment





Difference between plane survey and geodetic survey

Plane Survey

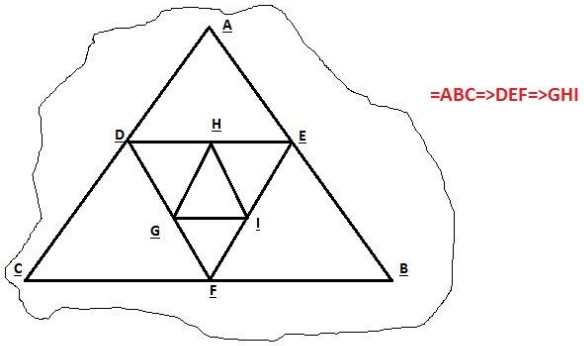
1. Curve of the earth is ignored
2. Used for relatively small area (<250 SqKm)
3. Used for establishing relatively less important area
4. Direction of plumb lines are assumed to be parallel to one another
5. Lower accuracy
6. Angle of triangle formed by any three line considered to be plane

Geodetic Survey

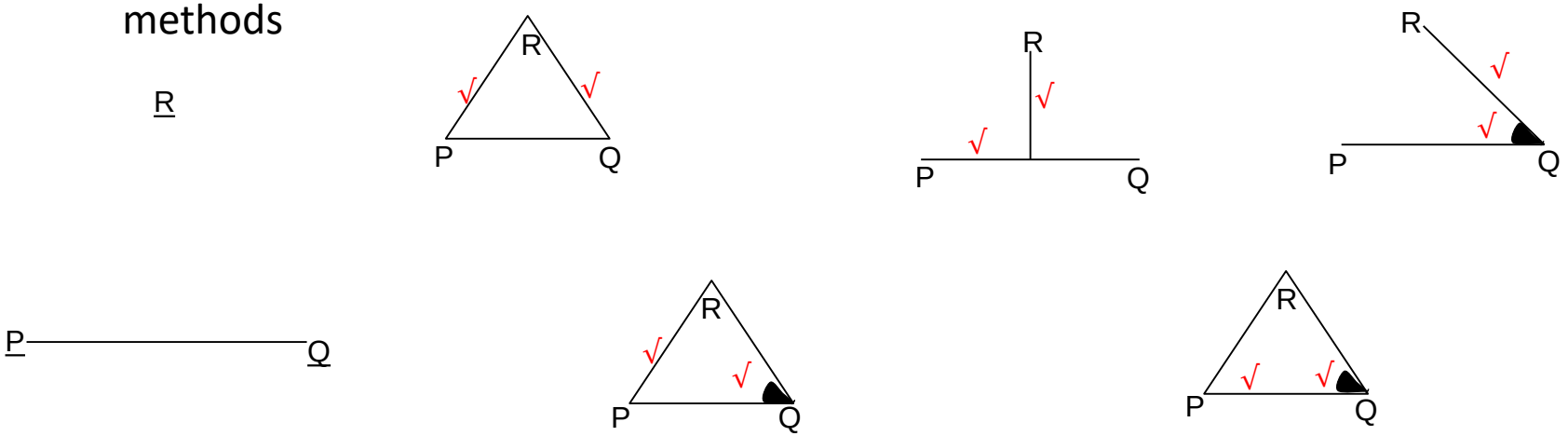
1. Curvature of earth is taken it to consideration
2. Used for larger area (>250SqKm)
3. Used for establishing precise points
4. Direction of plumb lines are different at various points
5. High accuracy and high precise instruments are used
6. Angle of triangle formed by any three line considered to be plane

Principles of Surveying:

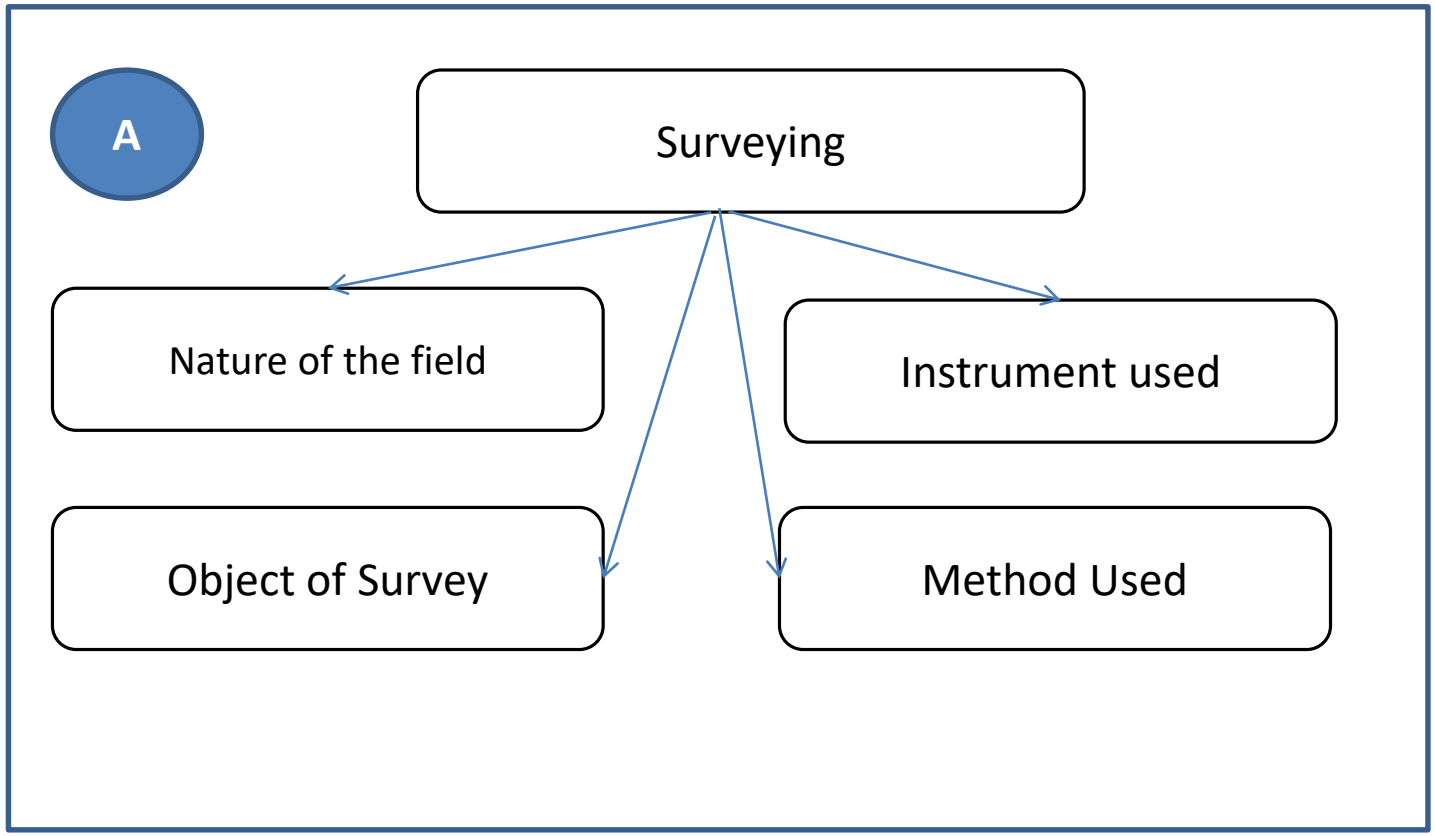
- Work should be done from “whole to part” and not from “part to whole”



- Position of new station should be fixed by at least two independent methods

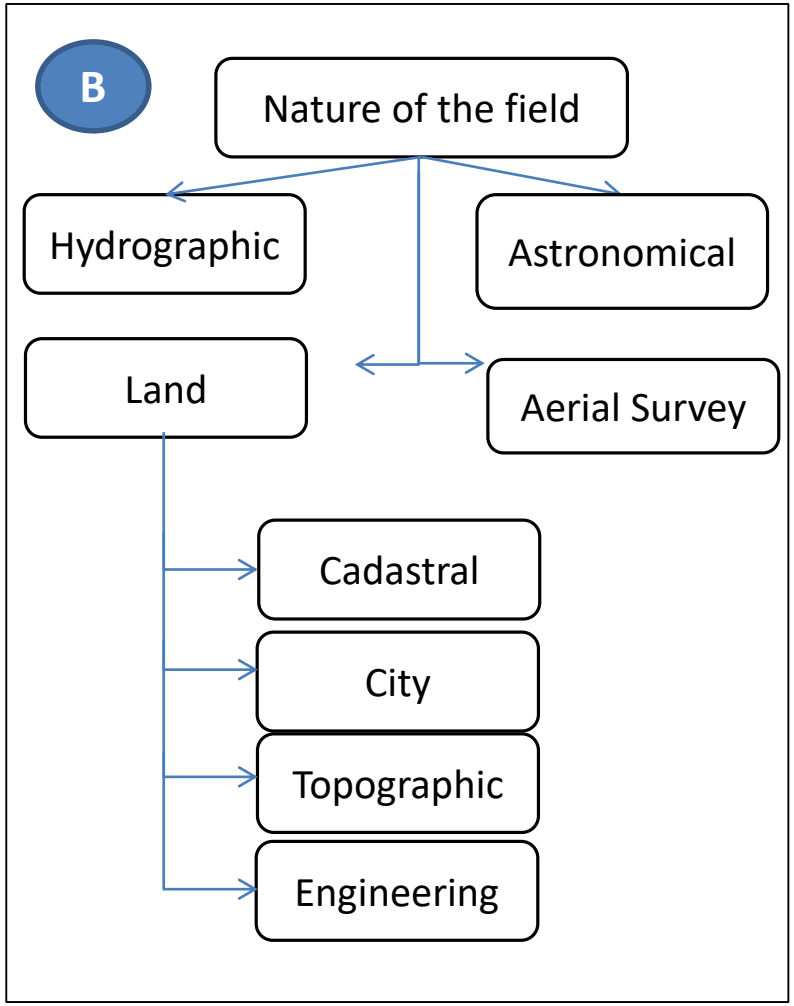


Classification of Survey

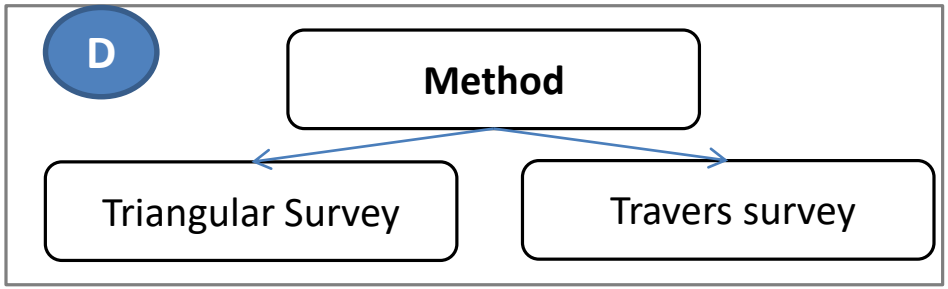


- **Hydrographic Survey:**
  - On or near the body of water.
  - Locating shore line
  - Estimation of water flow
  - Profiling of area beneath the water
- **Land Survey**
  - Determining boundaries and area of land
    - Topographic survey:
    - City survey:
    - Engineering survey: design and planning of engineering work
      - Reconnaissance survey
      - Preliminary survey
      - Location Survey
    - Cadastral Survey: Boundaries of private bodies
- **Astronomical survey:**
  - Determination of earth location (lat, long, time by observing astronomic bodies
- Aerial Survey
  - Conducted from aircraft
  - Photographs were taken and study

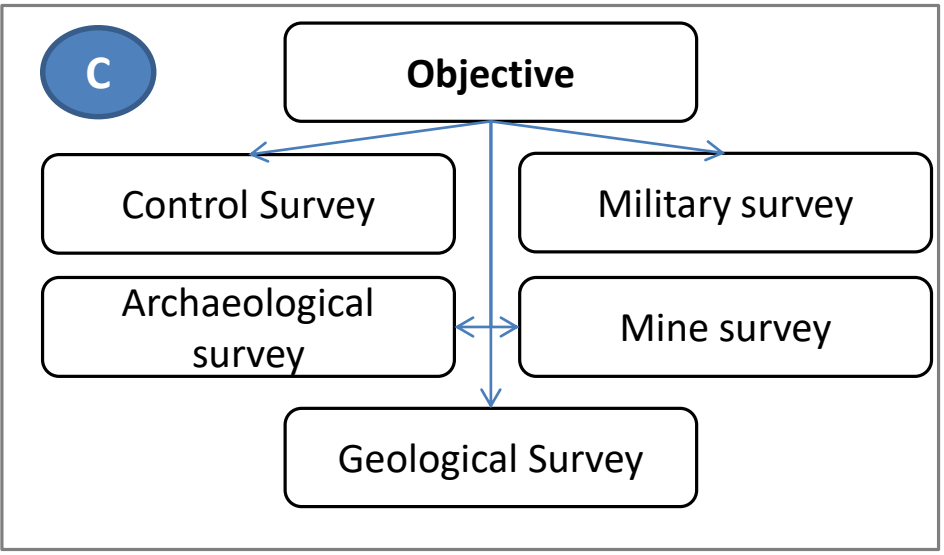
Classification Nature of the field



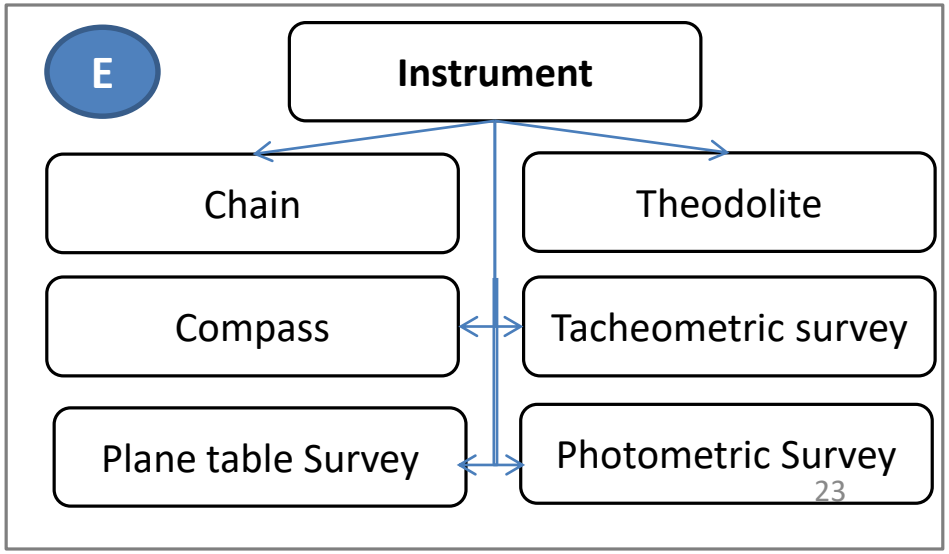
Classification based on Method used



Classification based on objective of survey



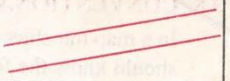
Classification based on instrument used

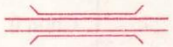


Plans and Maps

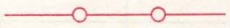
Plan	Map
1. Plans are a set of two-dimensional diagrams or drawings used to describe a place or object, or to communicate building or fabrication instructions 2. Plans are usually scale drawings, meaning that the plans are drawn at specific ratio relative to the actual size of the place or object. 3. Plans are large scale (1:10, 1: 20 etc)	1. A map is a visual representation of an area—a symbolic depiction highlighting relationships between elements of that space such as objects, regions, and themes 2. Many but not all maps are drawn to a scale, allowing the reader to infer the actual sizes of, and distances between, depicted objects 3. Maps are small scale (1:1000, 1:5000 etc)

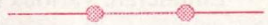
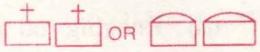
Conventional symbols

Sr. No.	Object	Symbol
1.	North line	
2.	Main stations or triangulation stations	
3.	Traverse stations or substations	
4.	Chain line	
5.	River	
6.	Canal	
7.	Lake or pond	
8.	Open well	
9.	Tube well	
10.	Footpath	
11.	Metalled road	
12.	Unmetalled road	

Sr. No.	Object	Symbol
13.	Railway line (single)	
14.	Railway line (double)	
15.	Road bridge or culvert	
16.	Railway brdige or culvert	
17.	Road & Rail level crossing	
18.	Wall with gate	
19.	Boundary line	
20.	Wire fencing	
21.	Pipe fencing	
22.	Wooden fencing	
23.	Building (pukka)	
24.	Building (katcha)	
25.	Huts	

Conventional symbols

Sr. No.	Object	Symbol
26.	Temple	
27.	Church	
28.	Mosque	
29.	Benchmark	
30.	Tree	
31.	Jungle	
32.	Cultivated land	
33.	Embankment	
34.	Cutting	
35.	(a) Telegraph line	
	(b) Telegraph post	

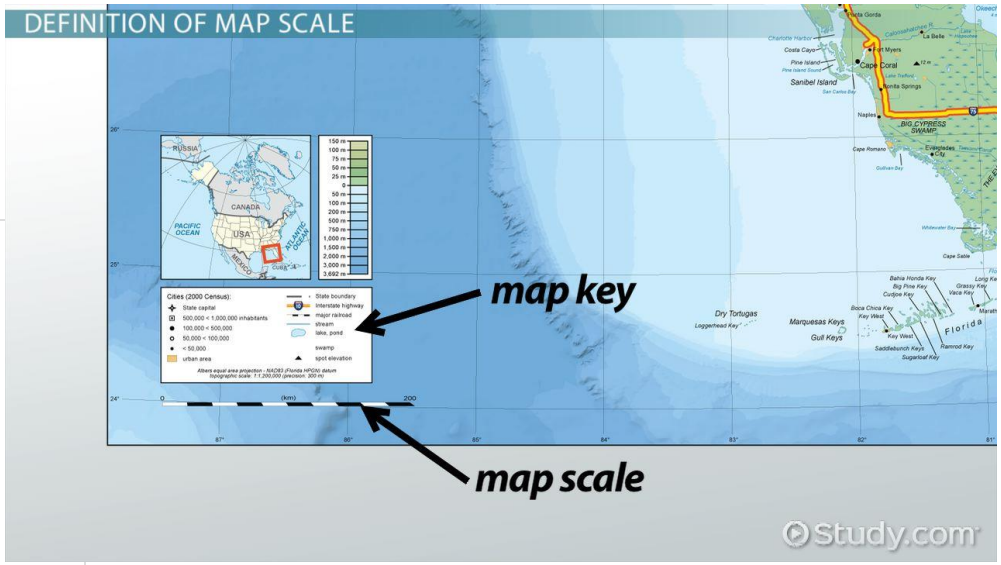
Sr. No.	Object	Symbol
36.	(a) Electric line	
	(b) Electric post	
37.	Burial ground or cemetery	

Scale

- Scale: Is the ratio of distance on the paper (Plan or map) to the distance on the ground

$$\text{Scale} = \frac{Plan\ distance}{Ground\ distance}$$

- Selection of scale depends on
  - Purpose
  - Size
  - Required precision
- Classification
  - Large scale: 1cm =10 m or less than 10m
  - Medium scale: 1cm = 10 m to 100 m
  - Small : 1 cm = 100m or more than 100m



- Type of scale
  1. **<u>Engineers scale:</u>**
     1. Indicated by a statement (1 cm= 5 m)
  2. **<u>Representative fraction</u>**:
     1. Indicated by a ratio of the distance on the plan to the corresponding distance on the ground (scale of 1cm=5m in RF is $\frac{1}{500}$)
     2. RF is unit less
  3. Graphical scale:
  4. Chord scale:
  5. Comparative scale

Scale

3. Graphical scale:

3. Scale which is drawn on the plan itself
   a) Types:
      a) Plain scale: Possible to measure units and its submultiple.
      b) Diagonal Scale: Possible to measure unit, submultiple and further submultiple
   b) Importance
      – Avoid the change in scale because of shrinkage of paper

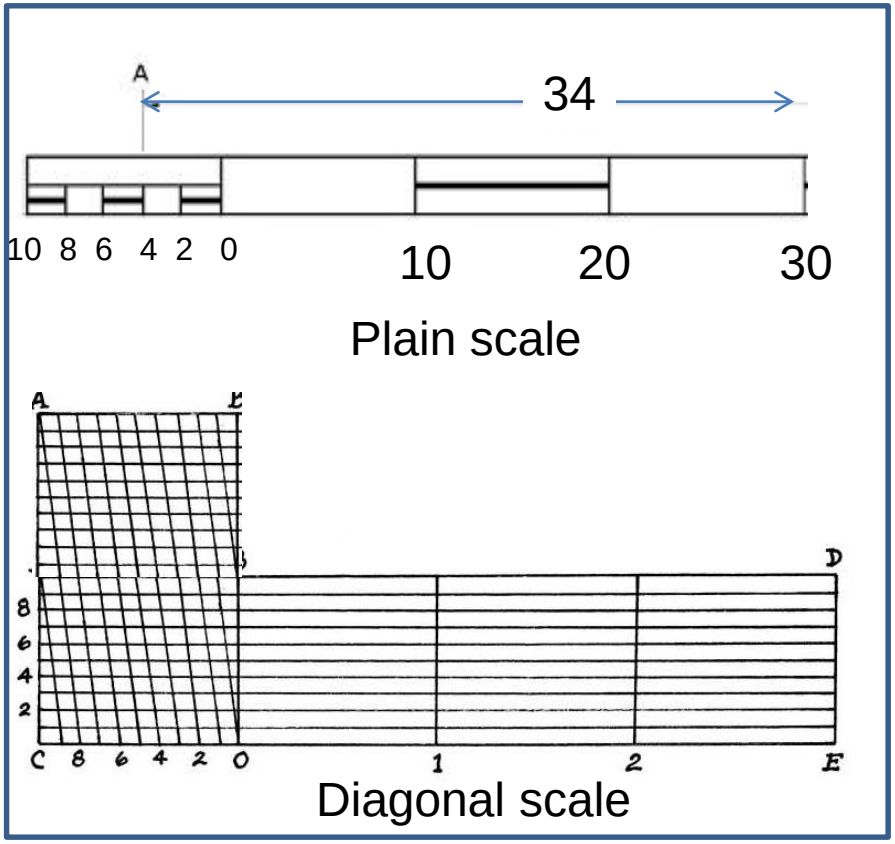
      Shrunk scale= Shrinkage factor x Original scale

      Shrinkage factor = $\frac{\text{Shrunk length of plain}}{\text{Actual lenth of plain}}$

      – Shrinkage factor will always less than 1

      – Corrected distance= $\frac{Measured\ distance}{Shrinkage\ factor}$

      – Corrected area = $\frac{Measured\ area}{(Shrinkage\ factor)2}$



4. Comparative scale:
   - Designed to read two units of measures which are interconnected.
   - Representative fractions for both measures are same and can easily computed
5. Chord scale:
   - Is used to measure angles or set off angles with considerable accuracy

Examples

- If scale is 1 cm = 10 m , RF is ???

$$\frac{1}{10\ x100} = \frac{1}{1000}$$ or 1 :1000

- If scale is 1 cm = 100 m , RF is ???

$$\frac{1}{100\ x100} = \frac{1}{10000}$$ or 1 :10000

Example

- A 10 km long road is indicated in a map by 10cm straight line. Calculate the scale and RF

10 cm on drawing sheet = 10 km on ground

$\therefore 1\ cm = 1\ km\ (Scale\ on\ map)$

RF = $\frac{1}{1\ X\ 1000\ X100}$ = $\frac{1}{100000}$ or 1 : 100000

Example

- An area of 49 cm^2 of a map represents an area of 2401 km^2. Find the scale and R.F. of Map?

ie. 49 cm^2 = 2401 km^2

$\therefore 1cm^2 = \frac{2401}{49} = 49\ km^2$

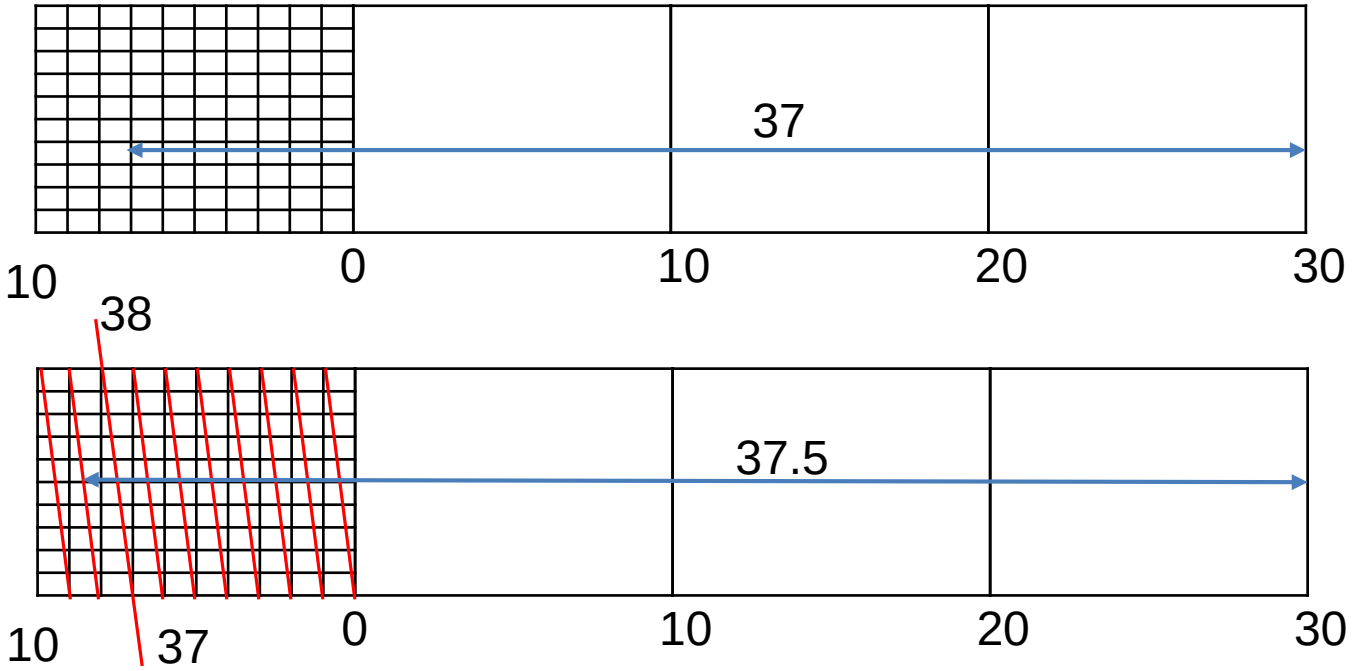
Or 1 cm = $\sqrt{49}$ = 7 km

$\therefore$ scale 1 cm = 7 km

RF = $\frac{1}{7\ X\ 1000\ X\ 100} = \frac{1}{700000}$

Example

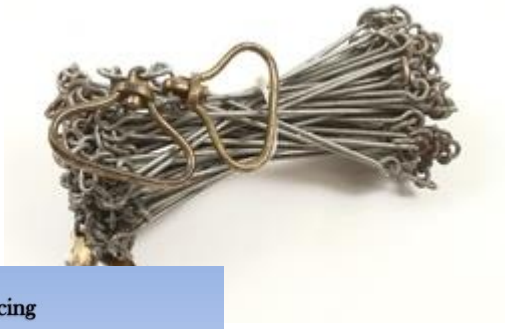
- Construct a plain scale of RF 1/500 to measure up to meters and represent 37 m on the scale.
- Construct a diagonal scale of RF 1/500 to measure up to meters and represent 37.5 m on the scale.



Units of Measurements

Linear Measurements

Determining the distance between various points on the surface of the earth is called linear measurements



Following methods are used

Direct method:

- In which the distance are actually measured on the ground
- Following are the way by which the distance can be measured directly
    - i. Chaining or taping
    - ii. Pacing
        - i. Chiefly used for reconnaissance survey
    - iii. Passometer:
        - i. Small pocket instrument
        - ii. Automatically count the steps
    - iv. Pedometer
        - i. Similar like passometer
        - ii. But can adjust the pace length and gives the distance directly
    - v. Odometer:
        - i. Measure the number of resolution made by a wheel
    - vi. Perambulator
        - i. Measure the distance directly
    - vii. Speedometer

Indirect method:

- In which the distance in not actually measured on ground
- Following are the types
  - Optical Method
    - Different principles of optics are used
  - EDM method
    - Electromagnetic distance measurements
      - Electro optic instruments
      - Microwave instruments

Chaining and Ranging & Offsetting

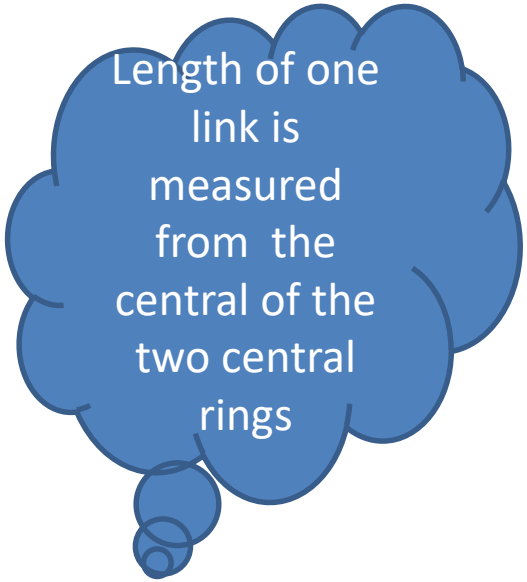
- Chaining:
  - Chain survey is the method of land survey in which only linear measurements are made and no angular measurements are taken.
- Ranging
  - Ranging the process of fixing intermediate points to maintain the direction during the chaining
- Offsetting
  - Distance measured from object to chain line is termed as offsetting
    - Perpendicular offset
    - Angular offset

Instruments used in Chaining

1. Chain:
2. Tape:
3. Ranging rod:
4. Offset rod:
5. Cross staff/Optical square:
6. Plumb Bob:
7. Field book:
8. Miscellaneous items
    1. Hammer
    2. Pegs
    3. Nails
    4. Arrow etc

Chains

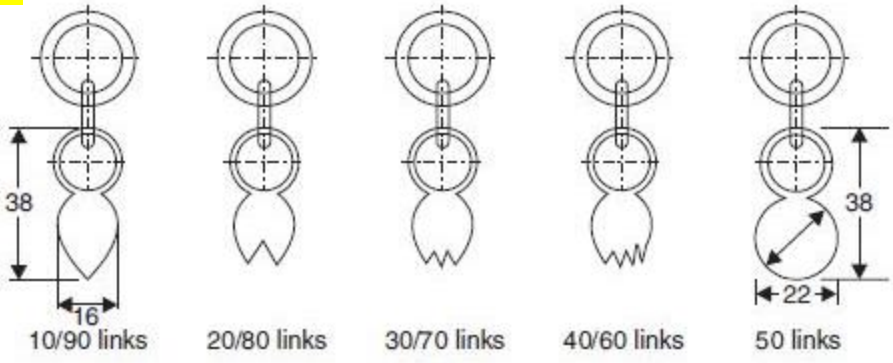
- Survey chain is commonly used for measurement of distance where high accuracy is not required
- Consists of
  - Link:
    - Galvanized mild steel wire of 4mm diameter
    - Each end of the link is bent in to loops
  - Connecting links
    - Small circular or oval shaped rings connecting the links
    - Consists of three rings
    - Outer rings are oval in shape and central are circular
  - Brass handles
    - With swivel joints



Chains cont……

1. Metric chain
   - Are available in lengths of 5m, 10m, 20m and 30m
   - Length of chain is engraved on both the brass handles
   - Tallies are fixed at every meter length for 5m and 10m length chain
   - Tallies are fixed at every 5 meter length for 20m and 30m length chain
   - Small brass rings are provided at every 1 m length for 20m and 30m chains
   - In metric chain length of one link is 20cm
2. Steel band/band chain:
   - Ribbon of steel with brass handles at ends
   - Available in length of 20m and 30m
   - Width varies from 12mm to 16mm
   - Graduations will be at two ways
     a) Brass studs at every 20cm and numbered at every 1m. Last and first links are subdivided in to cm and mm
     b) Graduations at every meter, decimeter and centimeters on one side and 20cm link on another side. Brass tallies are fixed at every 5m of band

Tags for metric chain



3. Gunter's/Surveyors chain
   - 66 feet long and consists of 100 links
   - Each link is 0.66 foot long
   - Measurements
     - 10 Gutenberg's chain = 1 furlong
     - 8 furlong = 1 mile
     - 10 X (Gutenberg's chain)^2= 1 acre
4. Engineers chain
   - Available in 100 feet and 50 feet length
   - Divided in to 100 or 50 link respectively
   - Each link is 1 feet
5. Revenue chain
   - 33 feet long chain
   - Divided in to 16 equal parts
   - Each link is 2.0265 feet I length

Tape

1. Tapes are used for more accurate measurements
2. Tapes are classified as the material by which it is made

Type of tapes

1. Cloth or linen tape:

- Used to measure offset
- Closely woven linen or cloth varnished to resist moisture
- Available in 10m, 20m, 25m and 30m and also 33feet, 50 feet and 100 feet
- 12 to 15 mm in width
- Not used when accurate readings are needed because of
  1. Easily affected by moisture
  2. Stretching gets altered the length
  3. Likely to twist and tangle
  4. Not strong
  5. Light and flexible, don't remain straight in strong wind
  6. Continues use gets the calibration indistinct

2. Glass fiber tape

- Made up of glass fibres
- Advantage
  - Flexible
  - Strong
  - Non-conductive
  - Don’t stretch or shrink
  - Available in varies length

3. Metallic tape:

- Made up of water proof fabric or glass fibres in which metallic wires are interwoven
- Strands of copper wires generally used for interweaving
- Available in 1,2,10m,20m,30m,50m
- Advantage
  - Strong and do not stretch easily
  - Light and flexible
  - Do not break easily

4. Steel tape

- Made up of steel or stainless steel stripe
- Width of 6mm, 9.5mm, 13mm and 16mm are common
- Available in 1m,2m,10m, 15m, 20m 30m and 50m
- Advantage
  - More accurately graduated than metallic tape
- Disadvantage
  - Cannot withstand rough usage
  - Need to be cleaned and dried before winding to avoided rusting

5. Invar tapes:

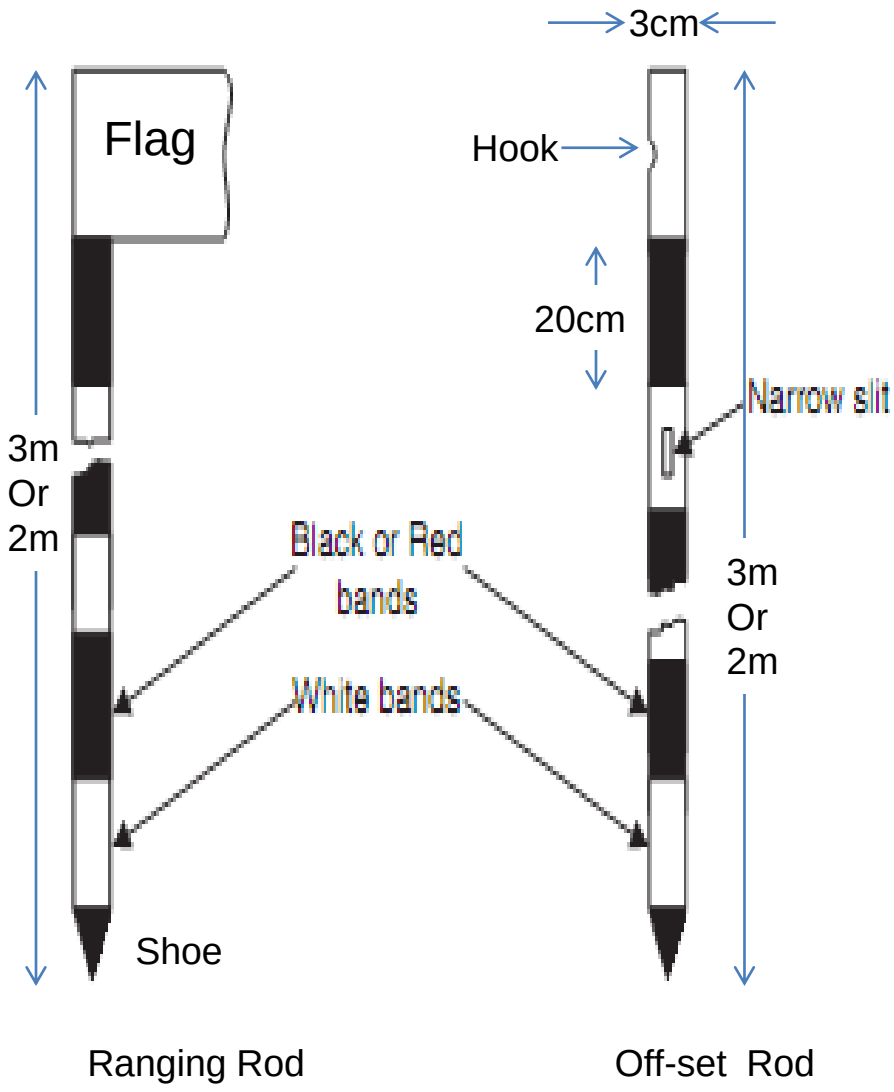
- Made up of alloy of steel (64%) and Nickel (36%)
- Low coefficient of thermal expansion
- Available in 20m, 30m and 60m
- Used for very high precision and rapid
- Costly and delicate

Ranging rod

- Used to fix the intermediate station
- Made up of good quality seasoned timber
- Provided iron shoe at the bottom
- Also made with light steel tubes
- Circular in cross section with diameter of 30mm
- Available in two lengths 2m and 3m
- Divided in to equal parts and alternate parts being painted in black or white Colour
- Flags at the top for better visibility

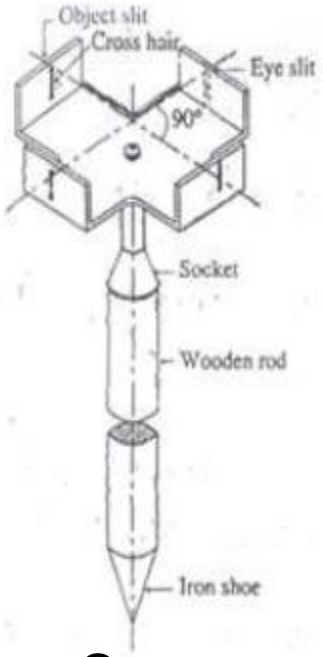
Offset rod

- Similar to ranging rod
- 3m length and divided in to 20cm length
- Provided a hook and narrow slit

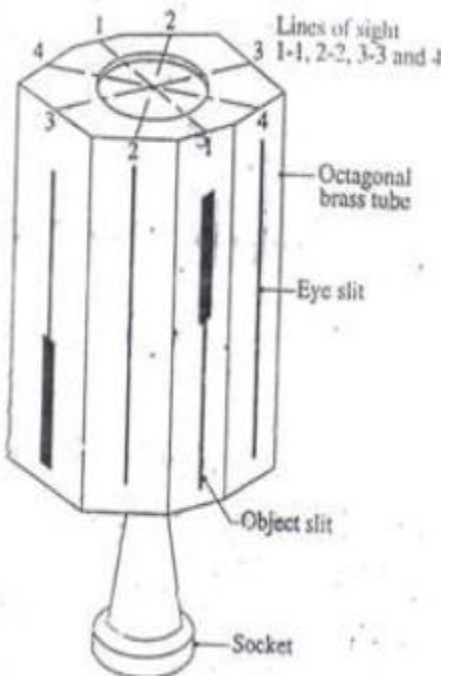


Cross staff

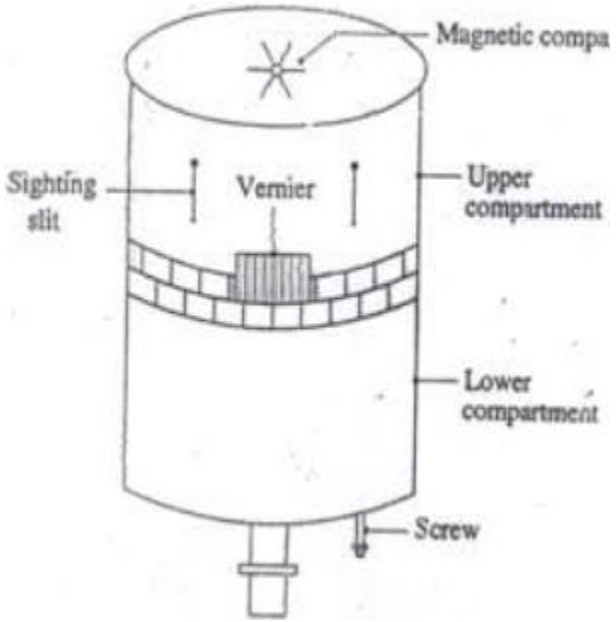
- Simple instrument used for setting out right angle
- Types
  - Open cross staff
  - French cross staff
  - Adjustable cross staff



Open



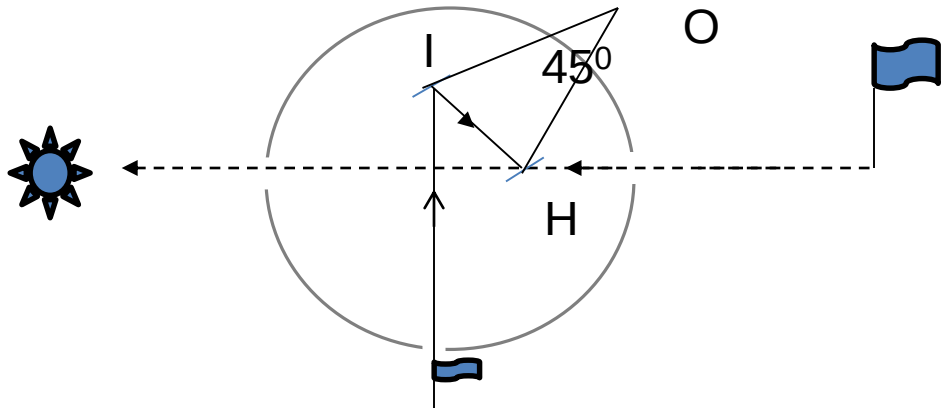
French



Adjustable

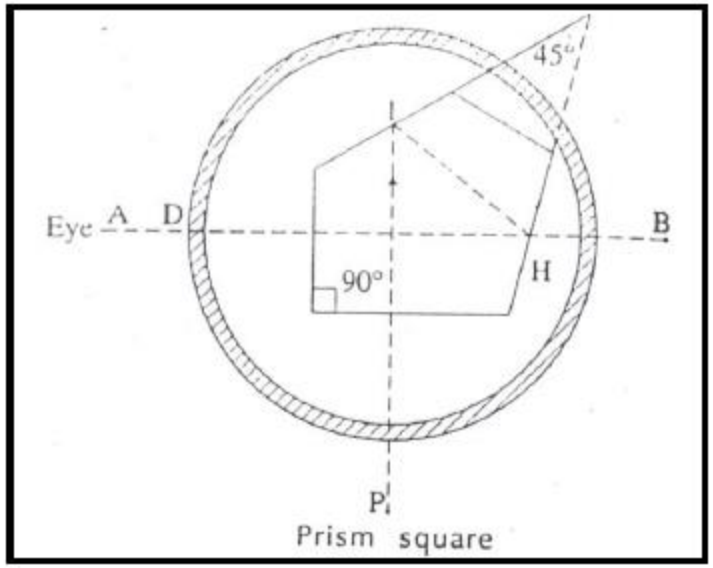
Optical Square

- Used to set up right angle with great accuracy
- Parts
  - Circular box of about 50mm diameter and 12.5 mm depth
  - Hole: A small circular hole is provided for inserting the key at the time of adjustment of instrument
  - Mirror : two mirrors (Horizontal mirror and Index mirror. Horizontal mirror is half silvered and half plain. The index mirror is fully silvered
  - Openings: A pinhole for eye or sight hole (b) Small rectangular hole exactly opposite to pinhole (c) Large opening for index site
- Principle
  - "If a ray of light undergoes two successive reflections in a plane at right angle to each of the two plane mirror, the angle between the incident ray and the reflected ray is twice the angle between the mirrors"



Prism Square

- Worked with the same principle
- Principle
  - "If a ray of light undergoes two successive reflections in a plane at right angle to each of the two plane mirror, the angle between the incident ray and the reflected ray is twice the angle between the mirrors"
- Instead of two mirrors a prism is used which has two reflecting surfaces

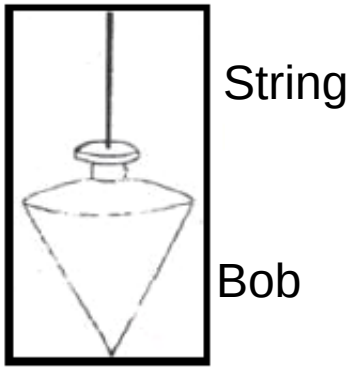


Indian optical Square

- Principle is same as of optical square
- Brass wedge shaped hallow box 5cm sides and 3 cm deep
- Two mirrors are fixed at an angle of 45^0
- Two rectangular openings at the mirror above

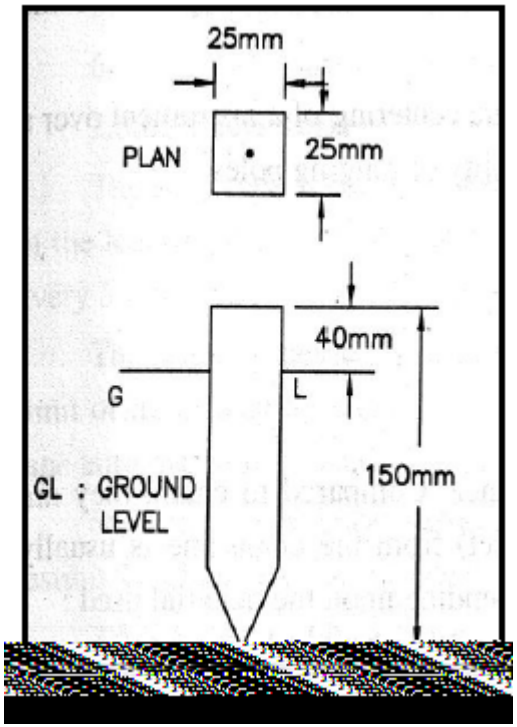
Plumb bob

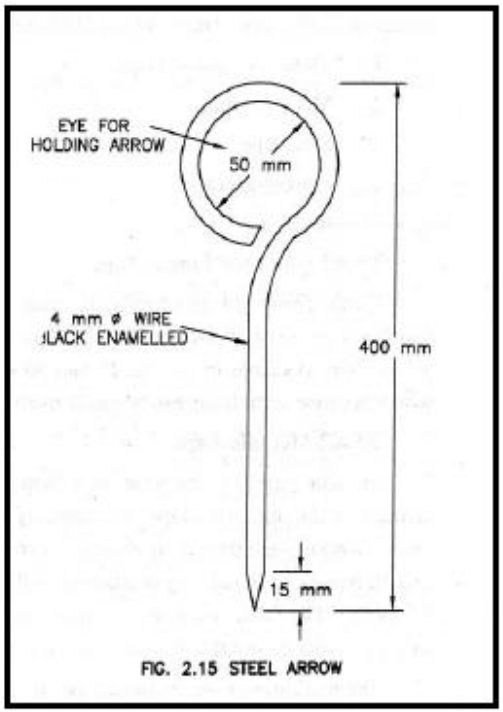
- Consist of a string and Bob
- It shows the direction of the vertical line



Miscellaneous

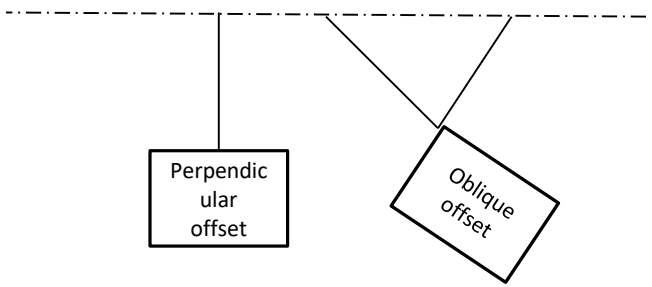
1. Hammer:
2. Pegs:
   - Wood with square section of 25mm to 30mm
   - Length varies from 15 cm to 45 cm
   - Used to mark the position of station
3. Arrow:
   - Hardened steel wire of 4mm diameter

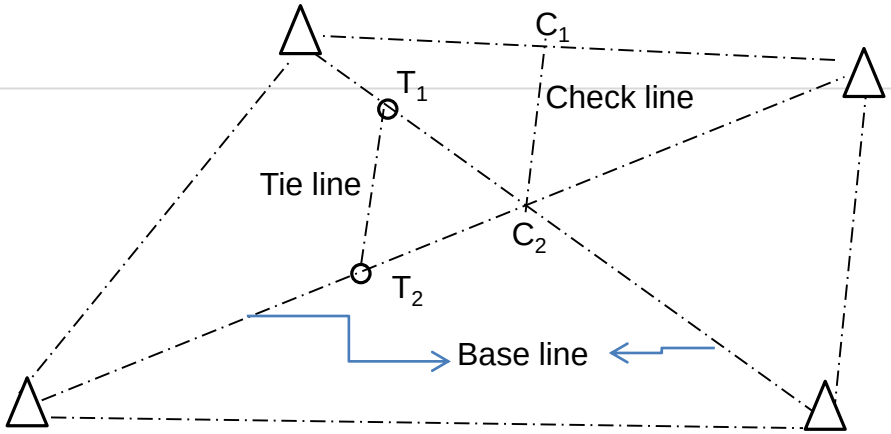




Chaining and ranging

- Terms used in Chain surveying
  1. Survey station
     - I. Main survey station: Survey station taken along boundary of area
     - II. Subsidiary survey station: Stations on main survey line or any other line
     - III. Tie station: Stations taken on main survey line
  2. Survey line
     - I. Base line: Line joining main stations
     - II. Check line: Apex of a triangle some fixed point on the base to check the accuracy
     - III. Tie line: Line connecting tie stations
  3. Offset
     - I. Perpendicular offset
     - II. Oblique offset
  4. Location sketches
  5. Well conditioned triangle



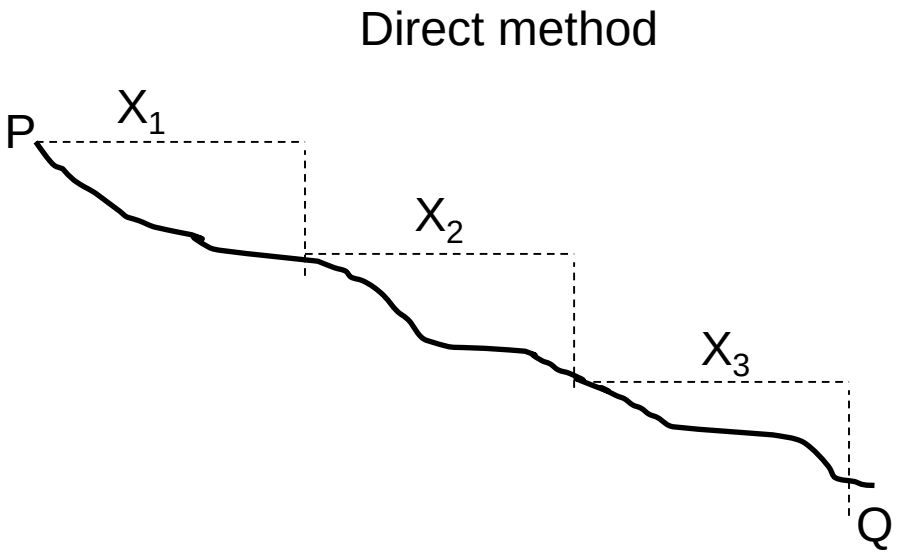


Chaining on Plain Ground

- Number of person required is 4
  - Leader
  - A follower
  - Two assistant
- Process

Chaining on Sloping Ground

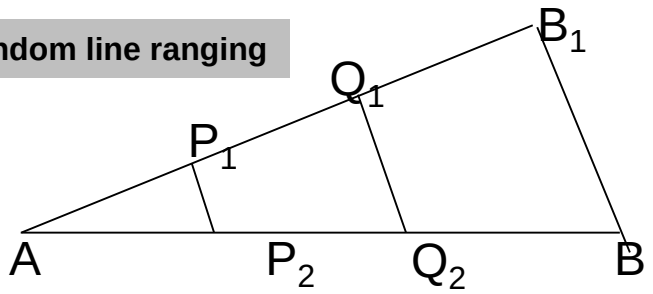
- Ground has a slope of 3^0 degree threated as plain ground
- More then 3^0 or 1 in 20 treated as sloping
  - Direct method
  - Indirect method
    - By measurement of Angle
    - By measurement of elevation
    - By Hypotenusal allowance



Ranging

- The process of establishing intermediate points on a straight line is known as ranging
- **Direct ranging**: Intermediate points are fixed by direct observation
  - Eye ranging
  - Ranging by a line ranger
  - Ranging by a theodolite
- **Indirect Ranging**: Intermediate points are fixed by indirect observations
  - Random line ranging
  - Reciprocal ranging

Random line ranging

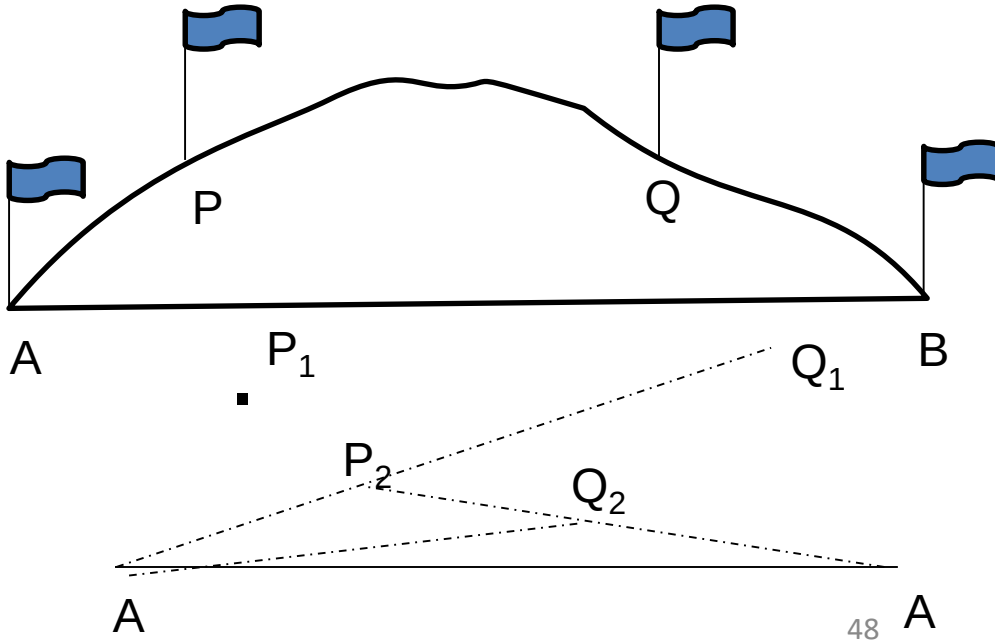


For similar triangle

$$\frac{AP_1}{AB_1} = \frac{P_1P_2}{BB_1} \text{ and } \frac{AQ_1}{AB_1} = \frac{Q_1Q_2}{BB_1}$$

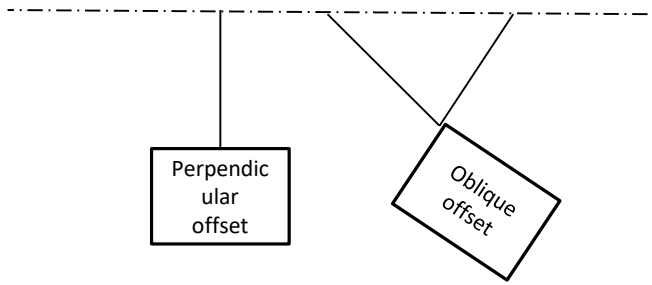
Sr. No.	Signals Given by the Follower	Meaning of the Signal
1	Rapid sweep with right hand	Move considerably to the right
2	Rapid sweep with left hand	Move considerably to the left
3	Slow sweep with right hand	Move slowly to the right
4	Slow sweep with left hand	Move slowly to the left
5	Right arm extended	Continue to move to left
6	Left arm extended	Continue to move to left
7	Right arm up and move to the right	Plumb the rod to the right
8	Right arm up and move to the left	Plumb the rod to the left
9	Both hands above head and brought down	Ranging is correct
10	Both arms extended forward horizontally and the hands brought down quickly.	Fix the ranging rod

Reciprocal line ranging



Offsetting

3. Offset
   I. Perpendicular offset
   II. Oblique offset



Errors in Linear Measurement

- Source of Errors
  - **Instrumental Error:** Wrong calibration or faulty adjustment
  - **Personal Error:** Due to human limitation
  - **Natural Error:** Error due to variation in natural phenomena. Eg. Temperature, wind, humidity etc
- Nature of errors
  - **Cumulative error/ Systematic error:** errors that are the same condition will always be of the same nature and amount
  - **Compensating error/ accidental error:** errors are random in nature
- Type of errors
  1. Error due to incorrect length of chain
  2. Error due to bad ranging
  3. Error due to bad straightening of chain
  4. Error due to non-horizontality of chain
  5. Error due to sag in chain
  6. Error due to variation in temperature
  7. Error due to variation in pull

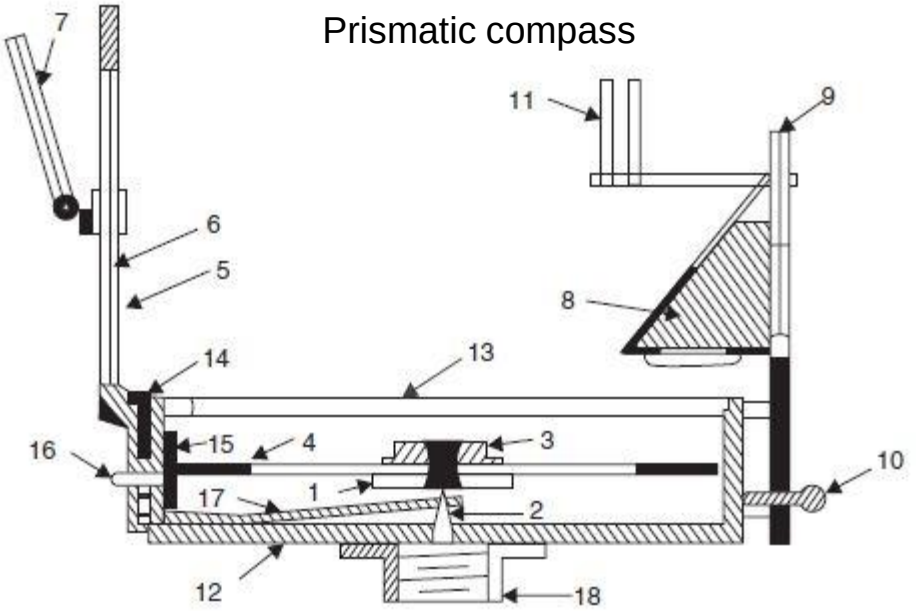
Compass Survey

1. Compass: Type and Use
2. Meridian
3. Declinations and Dip of needle
4. Bearing
   A. Whole Circle Bearing
   B. Reduced bearing
5. Computation of Angle
6. Local attraction

Compass:

1. Is a small instrument essentially consist of Magnetic needle, Graduated Circle and line of sight
2. Type:
   1. Prismatic compass
   2. Surveyor compass
3. Use:

Prismatic compass



1. Cylindrical Metal Box,
2. Pivot,
3. Lifting Pin and Lifting liver,
4. Magnetic needle,
5. Graduated circle,
6. Prism,
7. Object vane,
8. Eye vane,

9. Glass cover,
10. Sun glass,
11. Reflecting mirror,
12. Spring break and break pin

Comparison between prismatic compass and Surveyor compass

No	Prismatic compass	Surveyor Compass
1	Graduated ring is attached to magnetic needle	Graduated ring and needle are free to move
2	Graduated ring remain stationary	Graduated ring rotate with rotation of box
3	Prism is provided to take reading	No prism
4	Graduations are marked 0-360	Graduations are marked 0-90 on four quadrant
5	0^0 marked at south, 180^0 at North 90^0 at west and 270^0 at East	In this compass east and west are interchanged
6	Tripod may or may not be provided	Cannot be used without tripod
7	Gives whole circle reading	Gives quadrant bearing
8	Sighting and reading can be done simultaneously	Sighting and reading can not be done simultaneously

Meridian

- Meridian is the fixed reference line or the direction.
  1. Magnetic meridian: Direction shown by freely suspended magnet
     - Magnetic bearing: Horizontal angle formed by a line and the magnetic meridian
  2. True meridian: Line which passes through the true north and south.
     - True bearing: Horizontal angle formed by a line and the true meridian
  3. Arbitrary meridian: Any direction or line taken as reference line for small survey works
     - Arbitrary bearing: Horizontal angle formed by a line and the arbitrary meridian

Declination and Dip

- Horizontal angle between true north and magnetic north at a place at the time of observation is called magnetic declination.
  1. Isogonic and Agonic lines: Line passing through equal declination is known as Isogonic lines and line passing through zero declination is said to be Agonic lines
  2. Variations of Declination:
     1. Secular variation: Due to the swinging of magnetic meridian
     2. Annual variation: Change produced at a place due to one year
     3. Diurnal variation: Change produced at a place due to two year
     4. Irregular variation: Due to earthquake or volcanic eruption

Dip

- Dip: Angle between the magnetic needle and horizontal plane

Bearing

- Bearing of a line is the horizontal angle make with a reference line (Meridian)
  - **True bearing:** Horizontal angle between the true meridian and the survey line
  - **Magnetic Bearing:** Horizontal angle with reference to the magnetic north
  - **Grid Bearing:** Horizontal angle with reference to the grid meridian
  - **Arbitrary bearing:** Horizontal angle with reference to the arbitrary meridian

Calculation of True Bearing

- For declination towards East
  - True Bearing= Magnetic Bearing + Magnetic Declination
- For Declination towards west
  - True Bearing= Magnetic Bearing - Magnetic Declination

Designations of Bering

- **Whole circle bearing (W.C.B):** Bearing of a line measured with reference to the magnetic meridian in clock ways
- **Quadrantal Bearing (B.B.) / Reduced Bearing :** Bearing of survey line are measured with reference to N or S. Which ever is nearer.

W.C.B.	Quadrant	Rule for Conversion	Quadrant
0-90	I	RB= WCB	N-E
90-180	II	RB=180-WCB	S-E
180-270	III	RB=WCB-180	S-W
270-360	IV	RB=360-WCB	N-W

Fore Bearing and Back Bearing

- **Fore Bearing**: Bearing of a line measured in the forward direction of survey is called the Fore Bearing.
- **Back Bearing**: Bearing of a line measured in the direction opposite to the direction of the progress of survey is called the Back Bearing.

In W.C.B. the difference between FB and BB is 180^0.

BB= FB ± 180^0 + Sign is applied when FB is < 180^0

- Sign is applied when FB is > 180^0

In Q.B. the difference between FB and BB are equal but opposite quadrant.

Eg. If FB is N 60^0 E then BB is S 60^0 W

Problem

LEVELLING

- Levelling
  - The art of determining the relative heights of different points on or below the surface of the earth is known as levelling
- Objective:
  - The aim of levelling is to determine the relative heights of different points on or below the surface of the earth and determine the undulations of the ground.
- Use:
  1. To prepare the contour map
  2. To determine the altitude of different points
  3. Prepare the cross section of an area
  4. Prepare layout map for water supply, sewage or drainage scheme

- Terms used
  1. Level surface:
     A. A level parallel to the mean spheroidal surface of the earth.
     B. Such surface is curved
     C. Water surface in a still lake is considered as a level surface
     D. Normal to the plumb line
  2. Level line
     1. Line lying on a level surface
     2. Normal to plumb line
  3. Horizontal plane
     1. Plane tangential to the level surface
     2. Perpendicular to Plumb line
  4. Horizontal Line
     1. Line lying on the Horizontal plane
  5. Vertical Line
     1. Line perpendicular to the level surface
  6. Vertical plane
     1. Plane passing trough the vertical line
  7. Datum Surface
     1. Level surface, whose elevation is known or assumed
  8. Reduced level/Elevation
     1. Vertical distance of a point above or below the datum surface

- Terms used

1. Level surface:
   A. A level parallel to the mean spheroidal surface of the earth.
   B. Such surface is curved
   C. Water surface in a still lake is considered as a level surface
   D. Normal to the plumb line
2. Level line
   1. Line lying on a level surface
   2. Normal to plumb line
3. Horizontal plane
   1. Plane tangential to the level surface
   2. Perpendicular to Plumb line
4. Horizontal Line
   1. Line lying on the Horizontal plane
5. Vertical Line
   1. Line perpendicular to the level surface
6. Vertical plane
   1. Plane passing trough the vertical line
7. Datum Surface
   1. Level surface, whose elevation is known or assumed
8. Reduced level/Elevation
   1. Vertical distance of a point above or below the datum surface
9. Bench mark
   1. Fixed point above Datum, whose elevation is known
10. Mean Sea level
    9. Average height of the sea for all stages of the tides.
    10. Taken as averaging the hourly tide heights over a long period of 19 years.

Levelling Instruments

1. A level
2. A levelling Staff

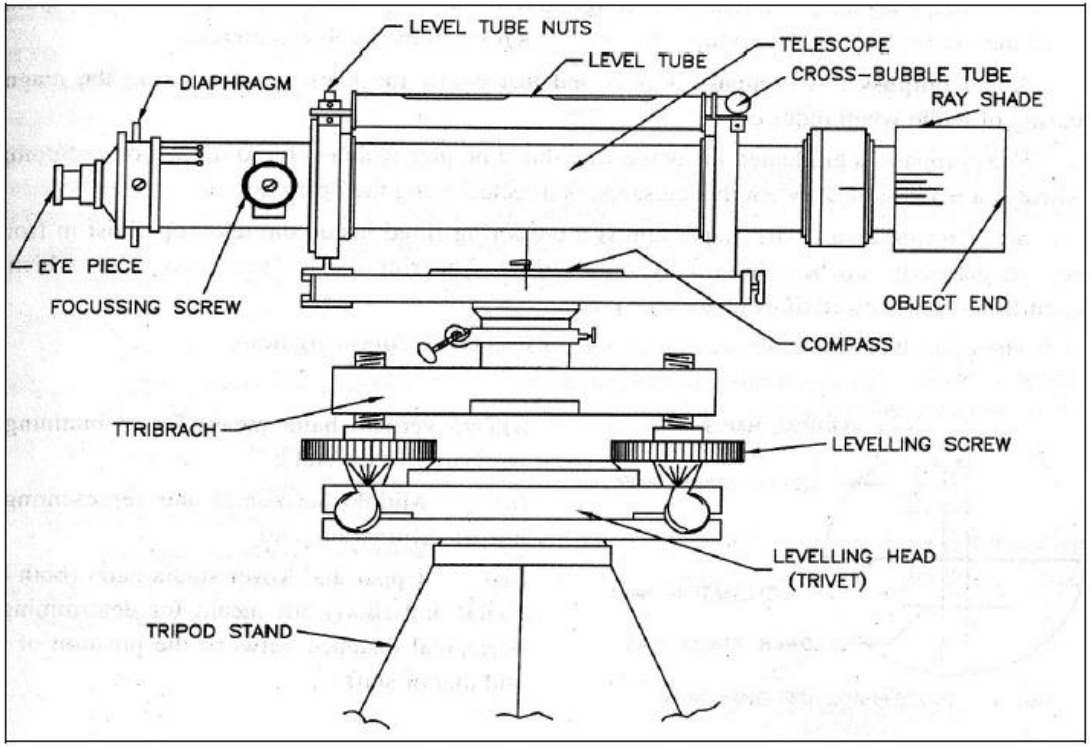


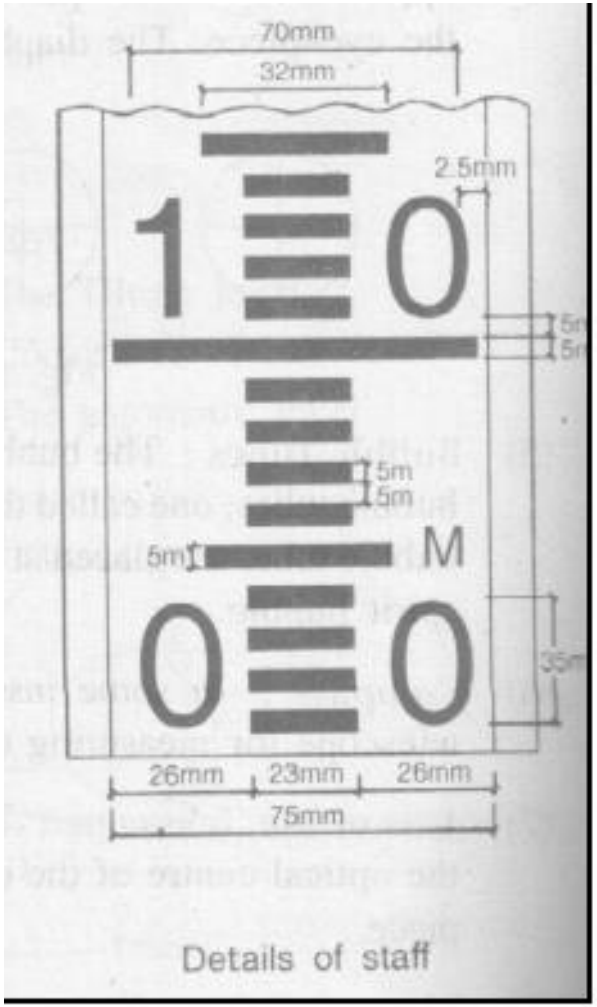
Figure: Dumpy Level

1. Dumpy Level
    1. **Tripod Stand**
        1. Three legs (Solid or Telescopic)
        2. Made up of wood or aluminum
        3. Lower end is fitted with iron shoes
    2. **Levelling Head**
        1. Two parallel plates having three grooves to support the foot screws
    3. **Foot screw**
        1. Screws provided between Trivot and Tribrach , used for levelling
    4. **Telescope**
        1. Consist of two metal tubes, one moving within another
        2. Object Glass ,Eye glass ,Eye piece, Diaphragm with Cross wire

5. **Bubble tube**
6. **Compass**
7. **Axis of Telescope**
8. **Line of Collimation/Sight**

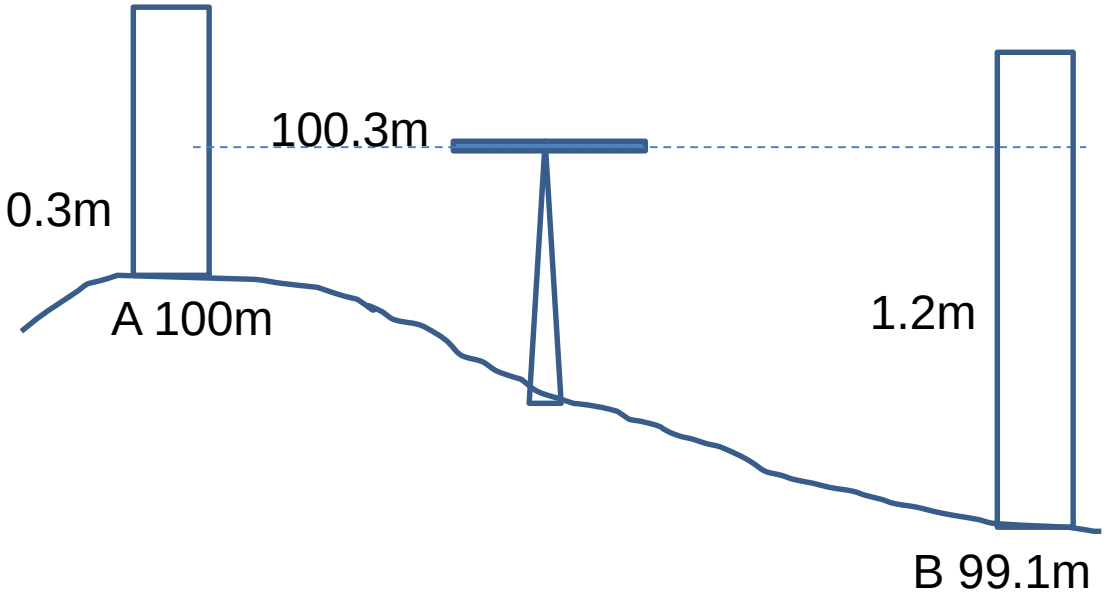
Levelling Staff

- Levelling stuff is used to measure the vertical distance between the points on the ground and the line of collimation.
- Types of Levelling staff
  - Self Reading
    - Solid staff:
      - 3m long, 75 mm wide, 25 mm thick
      - Metal shoes in the bottom
      - Graduated on one phase
    - Telescopic staff
    - Folding staff
  - Target staff
    - Sliding target equipped with vernier

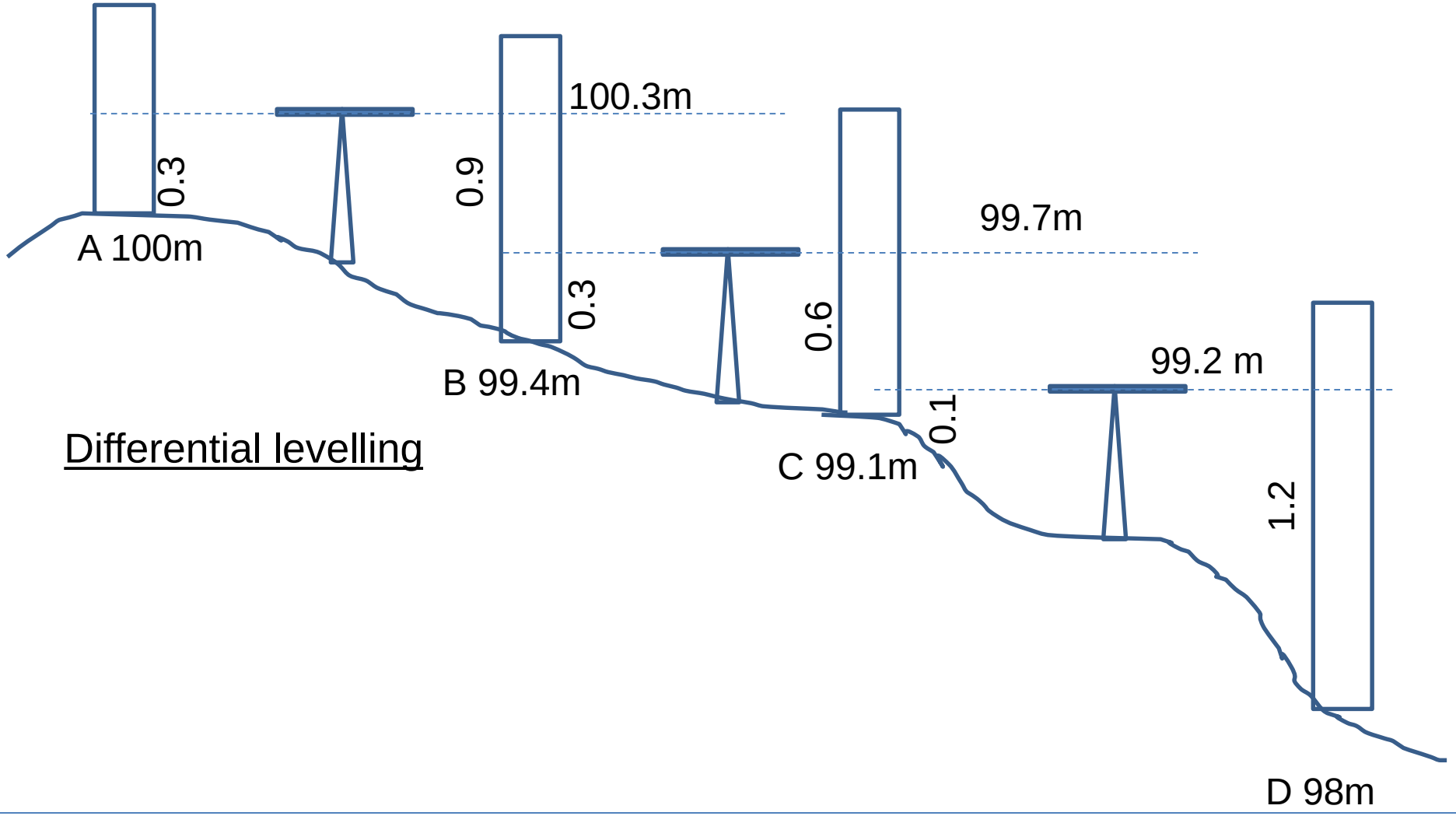


Classification of Levelling

- Direct levelling
  - Simple levelling
  - Differential levelling
  - Reciprocal levelling
  - Profile levelling
  - Fly levelling
  - Check Levelling
  - Precise levelling
  - Cross section levelling
- Indirect Levelling
  - Trigonometric levelling
  - Barometric levelling
  - Hypsometric levelling



Simple levelling



Differential levelling

Reciprocal levelling

$$h = \frac{(a1 - b1) + (a - b)}{2}$$

Special terms and Abbreviations

- Station:
  - station is the point where the staff is held and not the point where the level is set up
- Back sight (BS):
  - First reading taken after setting up the instrument.
  - Reading is taken on a point of known elevation.
  - BS is also known as plus sight because it is always added.

  Height of instrument = Known elevation +BS
- Foresight reading (FS):
  - It is the last staff reading in any set up.
  - FS is used to determine the elevation of the staff station.

  RL of station = RL of HI - FS
- Intermediate station:
  - Any other staff reading between the BS and FS is the same setup of the instrument.

  RL of station = RL of IH- IS

- Change point (CP):
  - Point indicating the shifting of the instrument
- Height of instrument (HI):
  - Is the RL of line of collimation/line of sight.

  When staff on the bench mark

  RL of HI = RL of BM +BS

  When staff on change point

  RL of HI: RL of CP+BS
- Balancing of sight:
  - The distance of the point where BS is measured and the FS is measured should be approximately equal

Type of Bench marks

- GTS (Great triangulation Survey) bench mark
- Permanent bench mark
- Arbitrary bench mark
- Temporary bench mark

Point to be followed by a level man

1. The level should be kept at a position, so that number of readings can be taken. It should not be placed in the centre line
2. The height of the instrument should not be too short or too long
3. Temporary adjustment should be done perfectly
4. Eye piece cross wire should be adjusted properly
5. Shaft should be bisected by pointing telescope towards it.
6. The parallax should be eliminated
7. Verticality of the staff should be checked
8. Take care in inverted image while reading

Points to be followed By Staff man

- The staff should be held carefully while moving from one station to another
- Staff should be held vertical on firm ground by holding it with both the arms
- Telescopic staff should be properly stretched
- Instruction given by the level man should be followed

Recording and Reducing

- The collimation or height of instrument method
- The rise and fall method

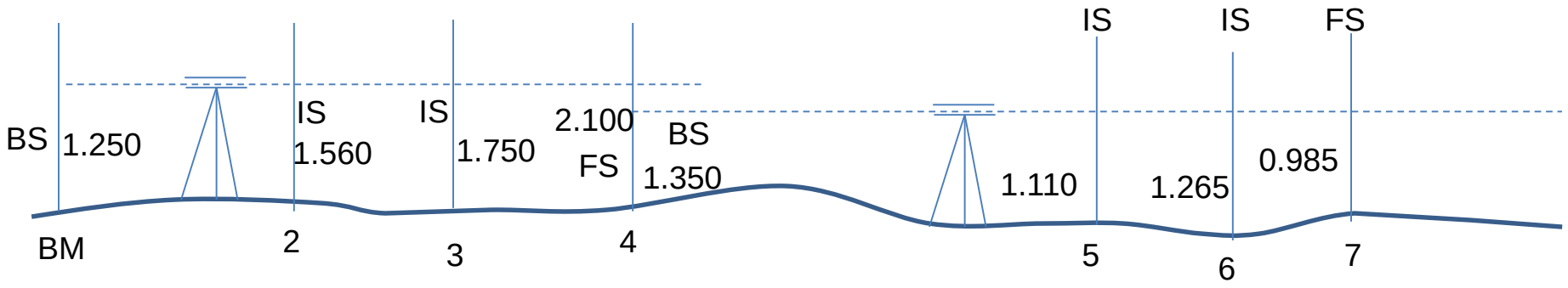
The collimation or height of Instrument method

- The height of instrument is calculated by adding the back sight reading (BS) to RL of BM

Height of instrument = Known elevation +BS

- Before shifting the instrument, the RLs of intermediate

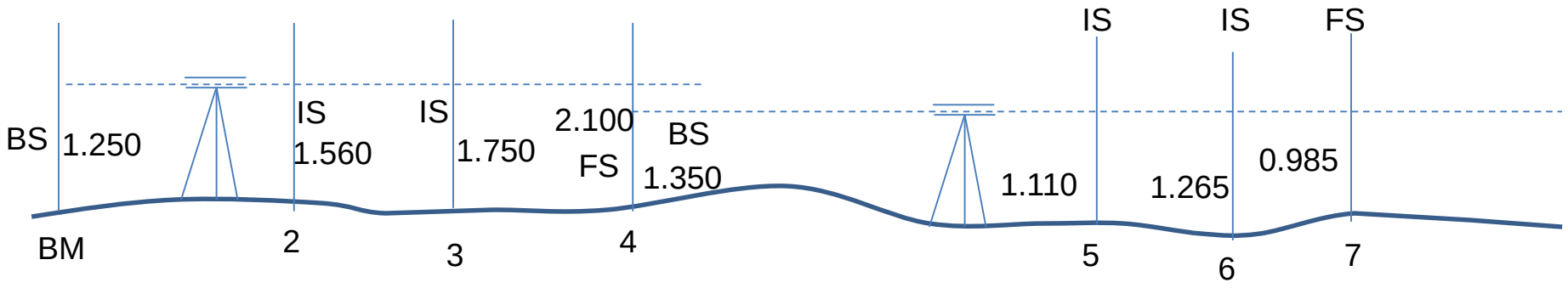
Height of instrument method



Station	BS	IS	FS	HI	RL	Remark
BM	1.250	-	-	101.250	100.000	BM
2		1.560			99.690	
3		1.750			99.500	
4	1.350		2.100	100.500	99.150	CP
5		1.110			99.390	
6		1.265			99.235	
7			0.985		99.515	
	ΣBS=2.600		ΣFS=3.085			

ΣBS-ΣFS= Last RL - First RL

Rise and Fall Method



Station	BS	IS	FS	Rise	Fall	RL	Remark
BM	1.250	-	-			100.000	BM
2		1.560			0.310	99.690	
3		1.750			0.190	99.500	
4	1.350		2.100		0.350	99.150	CP
5		1.110		0.240		99.390	
6		1.265			0.155	99.235	
7			0.985	0.280		99.515	
	ΣBS=2.600		ΣFS=3.085	Σ= 0.52	Σ=1.005		

ΣBS-ΣFS= ΣRise-ΣFall =Last RL - First RL

-0.485 = -0.485 = -0.485

Difference between two methods

Hi method

1. More rapid and save time
2. No check for RL ‘s of intermediate stations
3. Error in intermediate Rl cannot be detected
4. ΣBS-ΣFS= Last RL - First RL
5. Suitable for profile levelling when there is more stations

Rise and Fall method

1. It is laborious, involve several calculations
2. Check on RL s of intermediate stations
3. Error in intermediate stations can be detected
4. ΣBS-ΣFS= ΣRise- ΣFall =Last RL - First RL
5. Suitable for fly levelling