1.5 Surveying and levelling: Fundamentals of surveying; measurements (linear distance, vertical distance, and angle and directions); levelling; topographic survey (principles and applications); Simple circular curves, principles and applications of GPS/GIS. (ACiE0105)

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Prepared By
Mahesh Bhatta

Fundamental of Surveying

- The art of determining the relative positions of features on the surface of the earth by means of measurement of different parameters like distance, direction, elevation, etc.

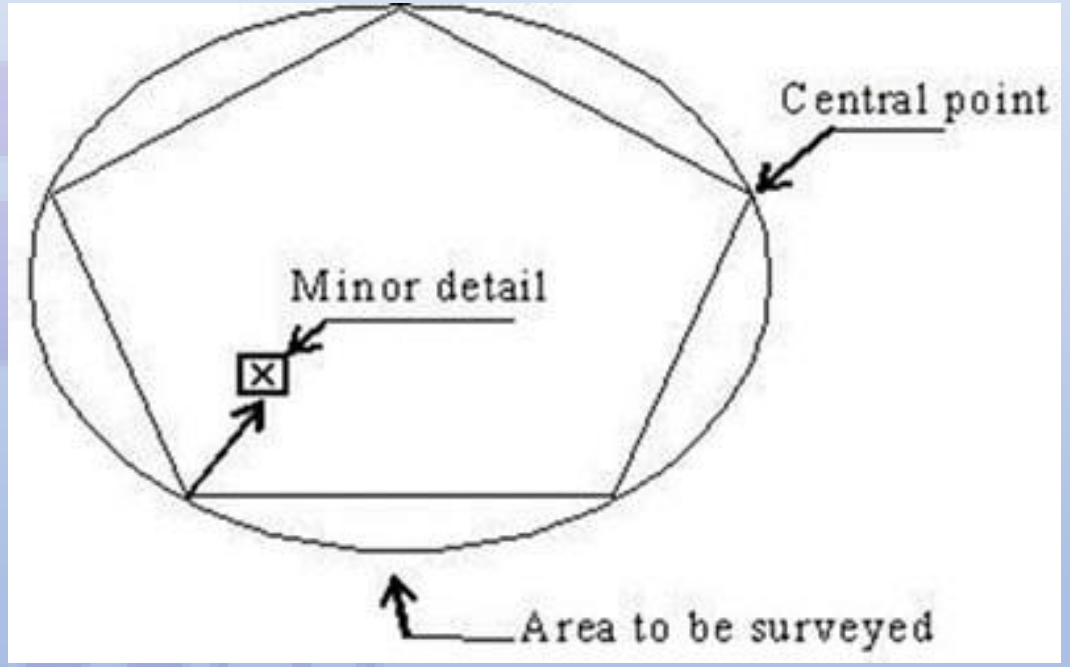
- The primary objective of surveying is the development of the **plan of an area.**

Principles of Surveying

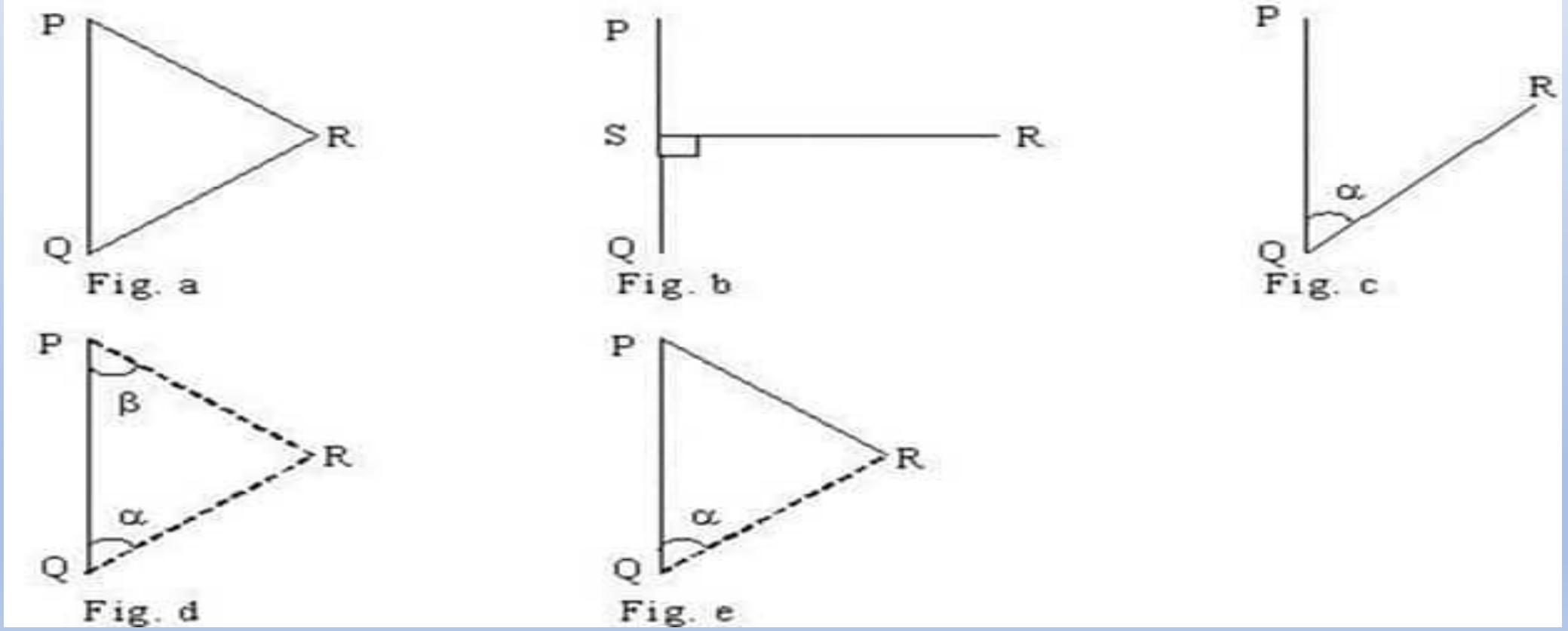
Cardinal or basic principles:

1. Working from whole to part

- Firstly, major control points are established in whole area with very high precision.
- Then minor details are located by less precise methods.
- To prevent accumulation of error.



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



Classification of surveying

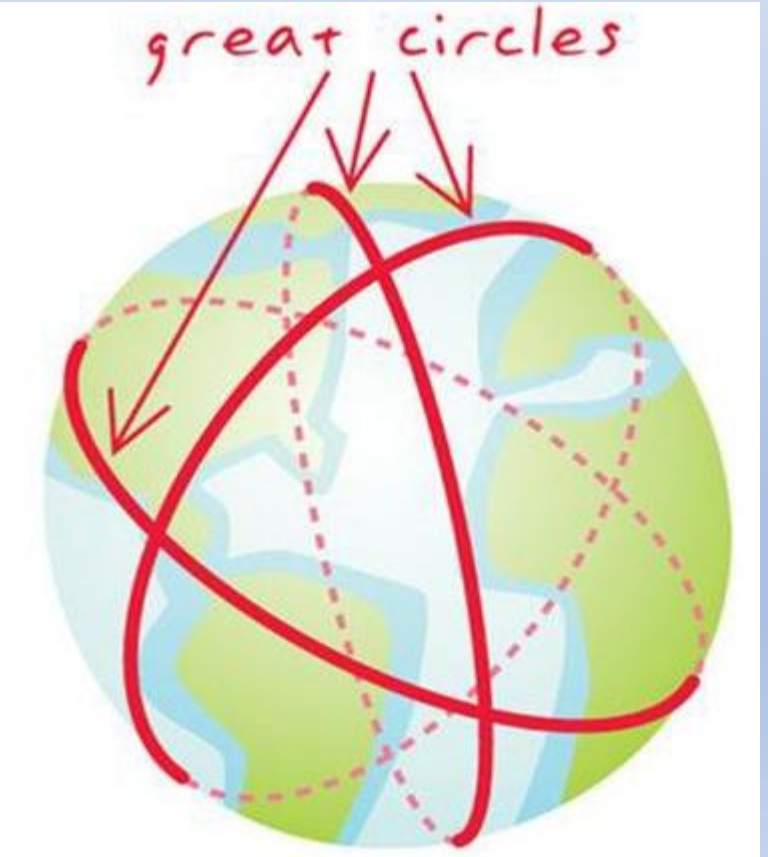
1. Primary classification
2. Secondary classification

Primary classification:

Plane surveying	Geodetic survey
Earth is considered as a plane.	Considers curvature of earth.
Plane surveying is done for area less than 250/260 km^2.	Area > 250/260 km^2.
Conducted by private agencies.	Used for national level survey. Conducted by survey department of Nepal.

Great circle/Riemannian circle

- 12 km long arc on earth surface is only 1cm longer than the subtended chord.
- Total sum of angles in spherical triangles – that of plane triangles=1 second for 195 Km2 of area.



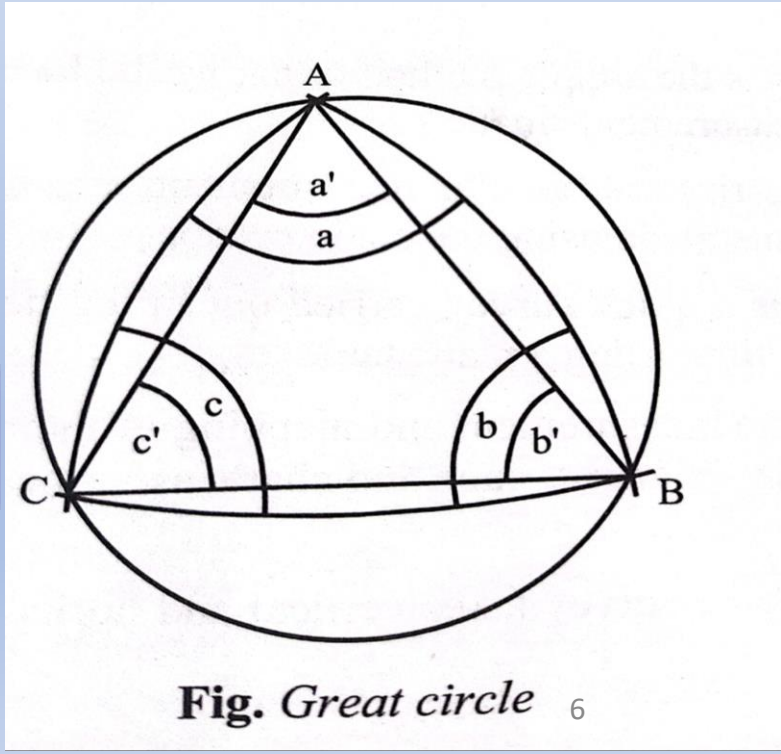


Fig. *Great circle*

Q. Hydrographic Survey deals with the mapping of

a) Large water bodies
b) Canal Systems
c) Cloud Movement
d) None of the above

Q. In the city for planning, the map used for plotting the details as well as the property line is

a) Topographical map
b) Cadastral map
c) Land use map
d) None of the above

Linear distance measurement methods:

- **Direct measurement method:** Chaining, taping, pacing.
- **Optical measurement methods:** Theodolite/Tacheometer.
- **Electro-magnetic distance measurement (EDM) methods:** Total station.

So, Linear Measurements can be done by:

- Pacing
- Passometer
- Pedometer
- Odometer
- Tape/chain
- Tacheometry
- EDM
- GPS

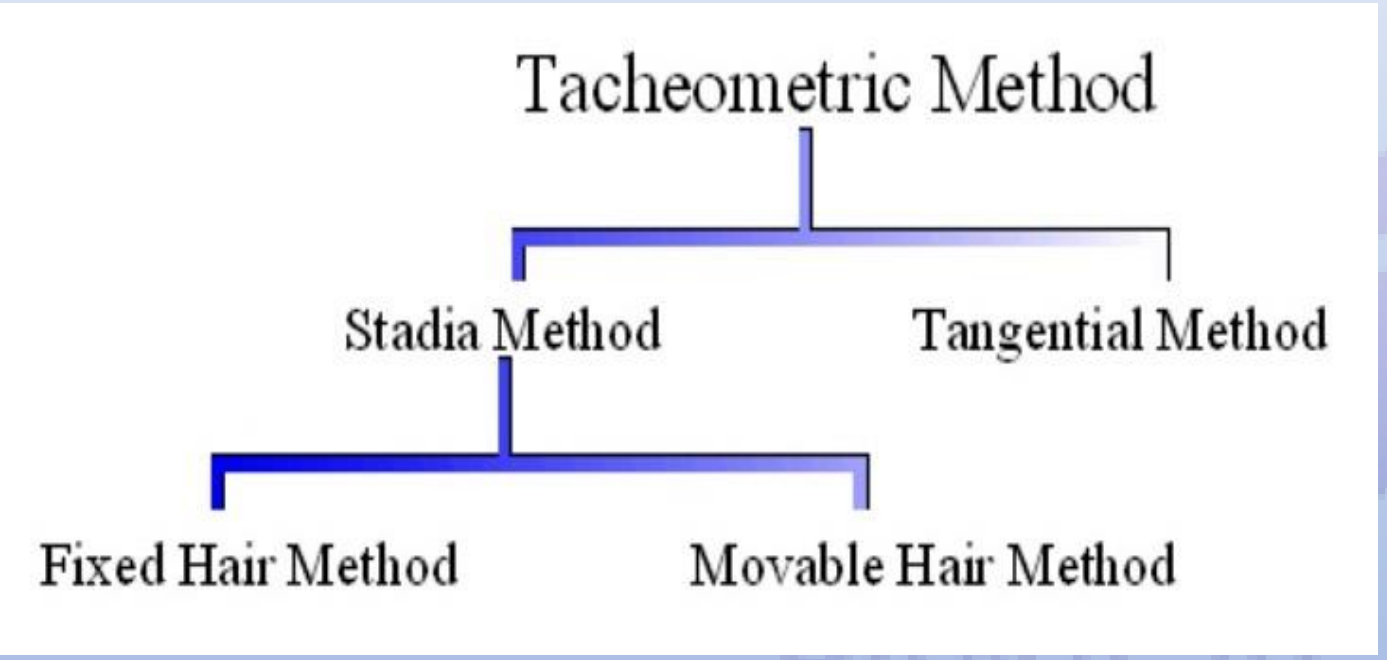
The method of measuring distance by approximate methods such as pacing is used for

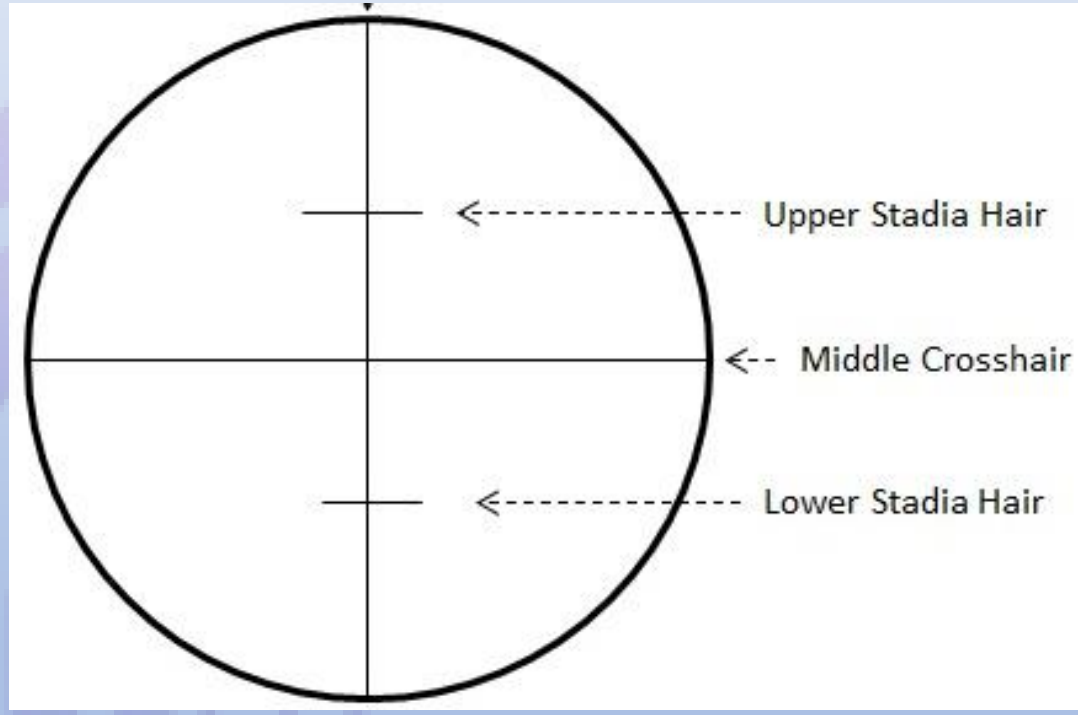
a) Reconnaissance
b) Preliminary survey
c) Location Survey
d) All of the above

Tacheometer

- A tacheometer is a theodolite fitted with stadia hairs in addition to the central cross-hair.

Methods of Tachometric Survey:

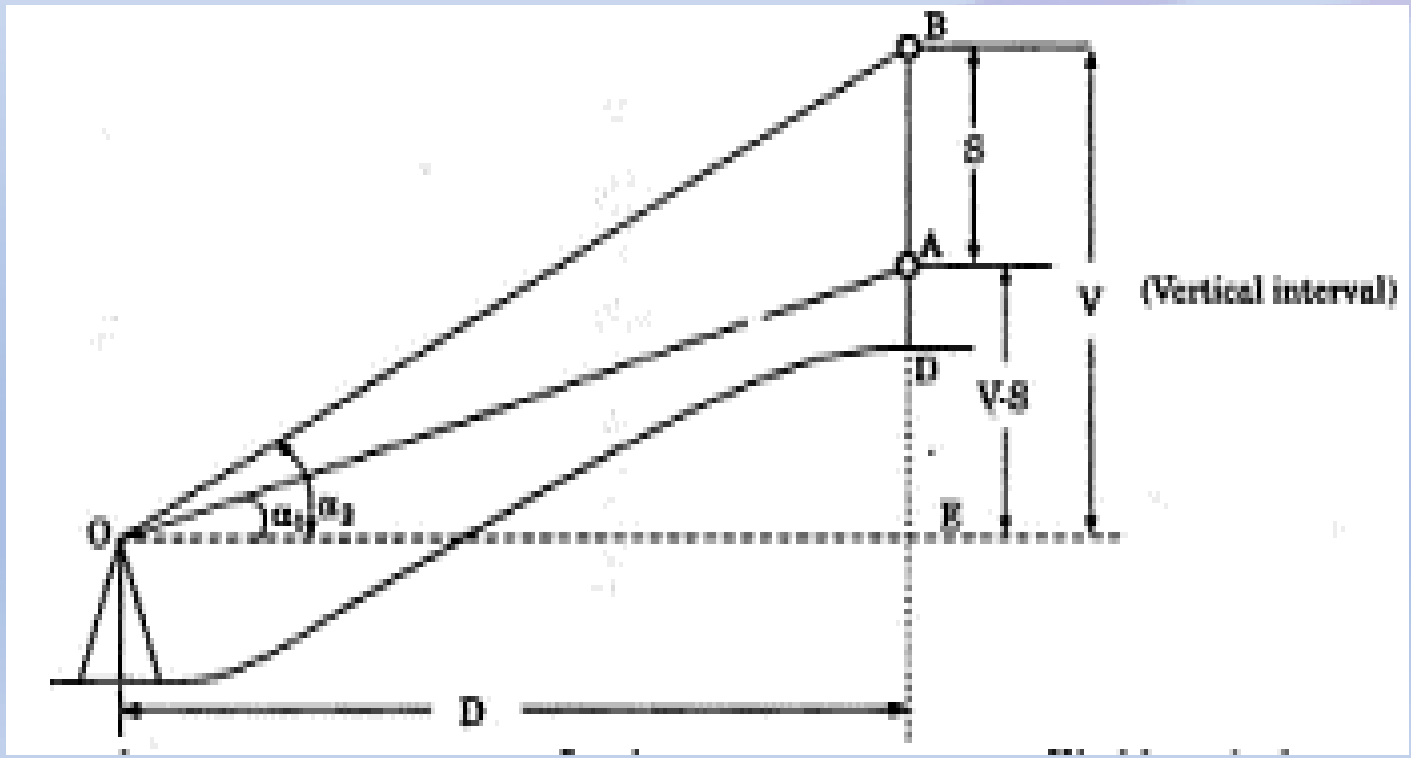




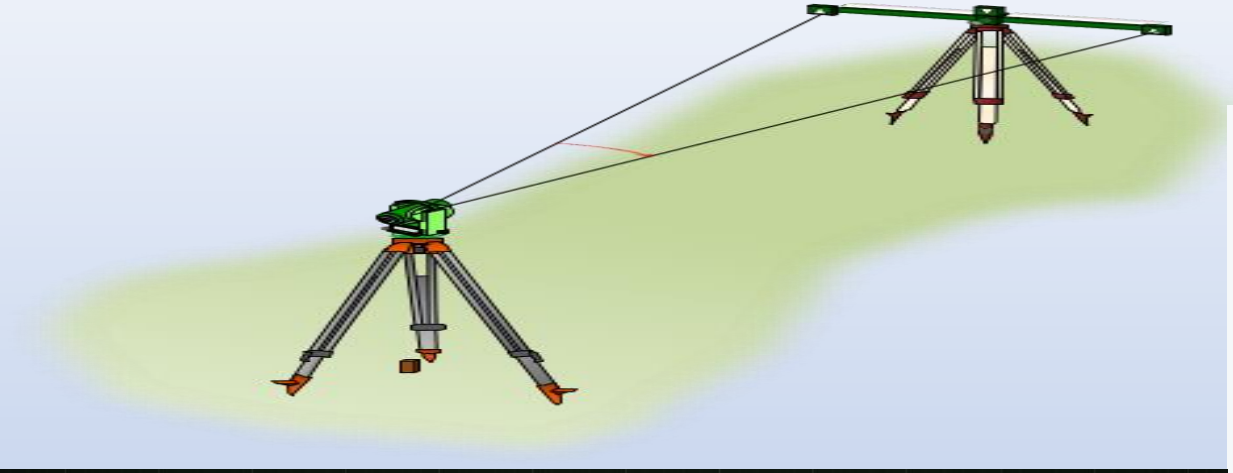
Note: *Out of the two methods mentioned above of tacheometric surveying, the "**fixed hair method** "is more used.*

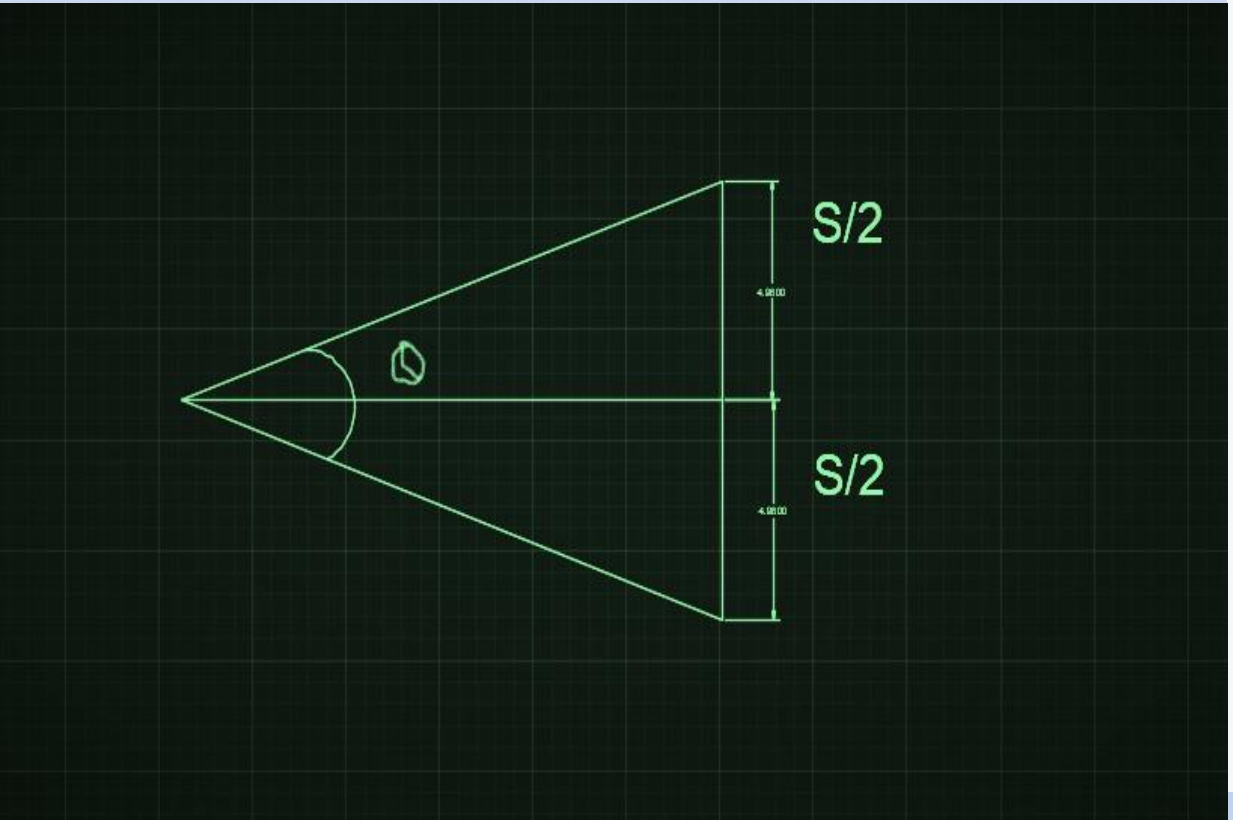
Tangential Method of Tacheometry:

- This method is used when the telescope is not fitted with a stadia hairs.
- Vertical angles at targets on the staff at a known distance (S). apart are taken.
- This method is quite **similar** to **trigonometrical levelling.**



Subtense bar method:





MCQ:

Subtense bar is used for:

1. Levelling
2. Measurement of horizontal distances in almost flat areas
3. Measurement of horizontal distances in undulated areas
4. Measurement of angles

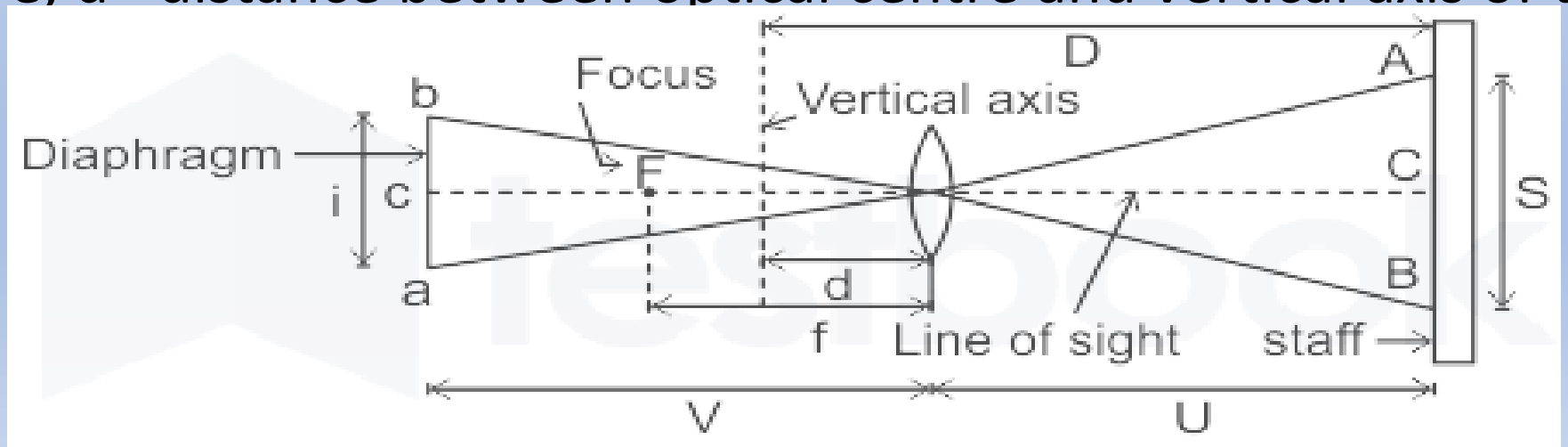
Distance by tacheometer::

- D=KS+C
- K is multiplying constant. K=100 for anallactic lens (convex lens)
- C is additive constant. C=0
- It makes distance measured directly proportional to staff intercept.
- Anallactic lens is used in external focusing type telescope only.

$$K = f/i$$

$$C = f + d$$

Where, d= distance between optical centre and vertical axis of tacheometer.



Principle of tacheometric surveying

Principle of tacheometric surveying is based on the property of an isosceles triangle i.e the ratio of the distance of the base from the apex and the length of the base is constant.

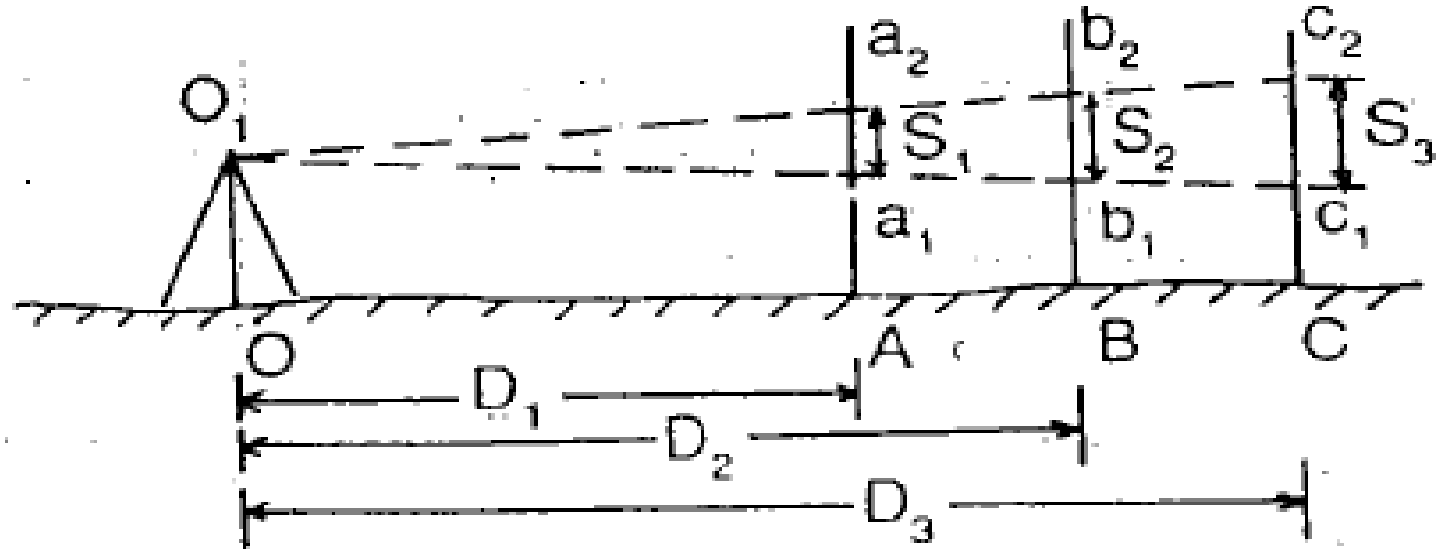


Fig. 11.2

So, according to the stated principle,

$$\frac{D_1}{S_1} = \frac{D_2}{S_2} = \frac{D_3}{S_3} = \frac{f}{i} \quad \text{(constant)}$$

Types of chain

Depending upon the length of the chain, these are divided into following types,

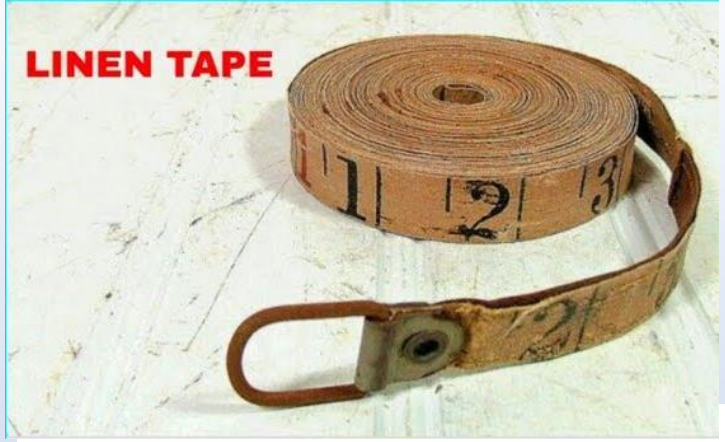
- Metric chains 5/10/20/30 m: made of galvanized mild steel
- Steel band or Band chain: 20/30 m: stainless steel
- Gunter's chain or surveyor’s chain: Land survey
- Engineer’s chain: Construction
- Revenue chain: *cadastral survey.*

Summary

Type	Length	No. of links
Gunter's chain	66 feet	100
Revenue's chain	**33 feet**	**16**
Engineer's chain	100 feet	100
Metric chain	30m and 20m	150 for 30m; 100 for 20m

Types of tape.

- Cloth/Linen Tape
- Woven Metallic Tape
- Steel Tape
- Synthetic Tape
- Invar Tape (36% Nickel+64%steel)



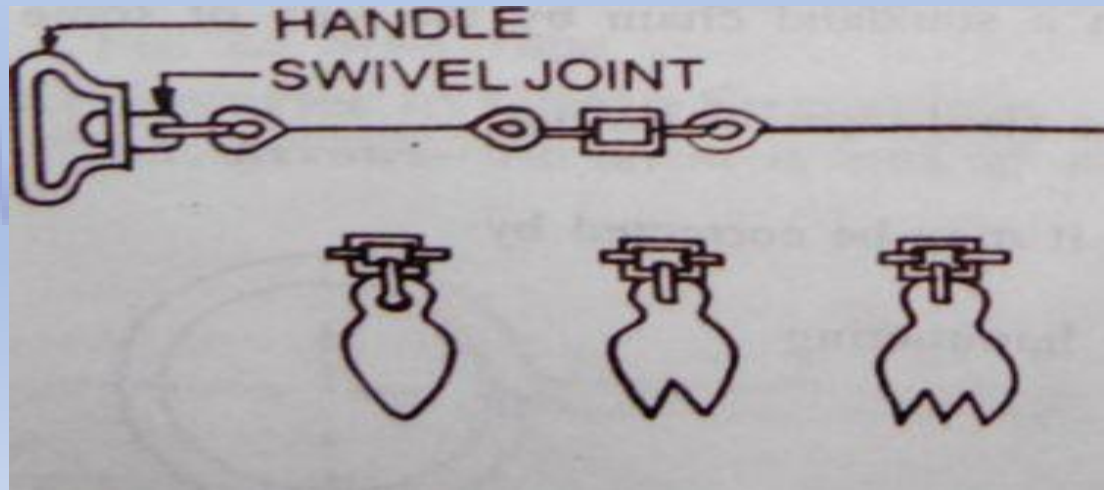
MCQ:

1. The accuracy of chain surveying depends more upon

A. Leader
B. Follower
C. Both of the above
D. None of the above

3. Handles are connected to link by

A. Flexible joint
B. Swivel joint
C. Rigid joint
D. All the above



Tape corrections

1. Tape Correction for Standardization :

- ***Correction per tape length (C) = l' – l***

  Here,

  l' = actual length of tape.

  l = nominal length of tape.

- The correction is positive when the actual length is greater than the nominal length and vice versa.

Q. Numerical

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

a) 251.25 m

b) 252.25 m

c) 225.25 m

d) 221.25 m

True length= measured length* (corrected tape length/designated tape length)

2. Correction for Temperature:

- $C_t = \alpha(t_m - t_o)L$

where,

α = coefficient of linear expansion
t_m= Mean temperature of the tape
t_o = Standard temperature

3. Correction for Sag

- $C_s = \frac{W2L3}{24P2}$

Where,

W = Weight of tape per unit length.
P = applied pull.
L = length of the tape suspended between the supports.

4. Correction of Pull

$$C_p = \frac{P - P_o}{AE} L$$

Where,

P = pull applied during measurement.
Po = Standard pull
L = Measured length
A = Cross- sectional area of the tape
E = Young's modulus of material of tape

What is Normal tension?

- Pull required to neutralize the sag correction.

  Sag correction = Pull correction

  Solve to get,

$$P_n = \frac{W\sqrt{AE}}{\sqrt{24(P - P_o)}}$$

5. Correction for slope

Distance measured is > horizontal distance, so *error +* and correction for slope is *always negative*.

$$C_s = h^2/2L$$

6. Correction for msl.

Que. 10 Determine correction for MSL if measured length of the line is 1000 m and Average elevation of the line from MSL is 300 m. if R = 6370 km.

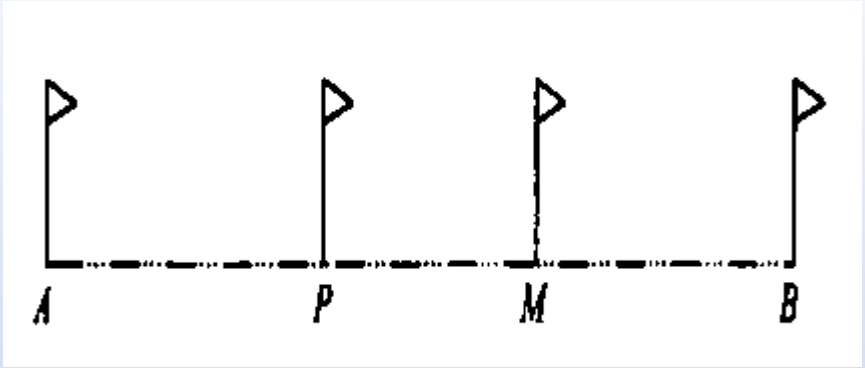
$$C_{MSL} = -\frac{hL}{R}$$

$$= -\frac{300 \times 1000}{6370 \times 10^3}$$

Ranging

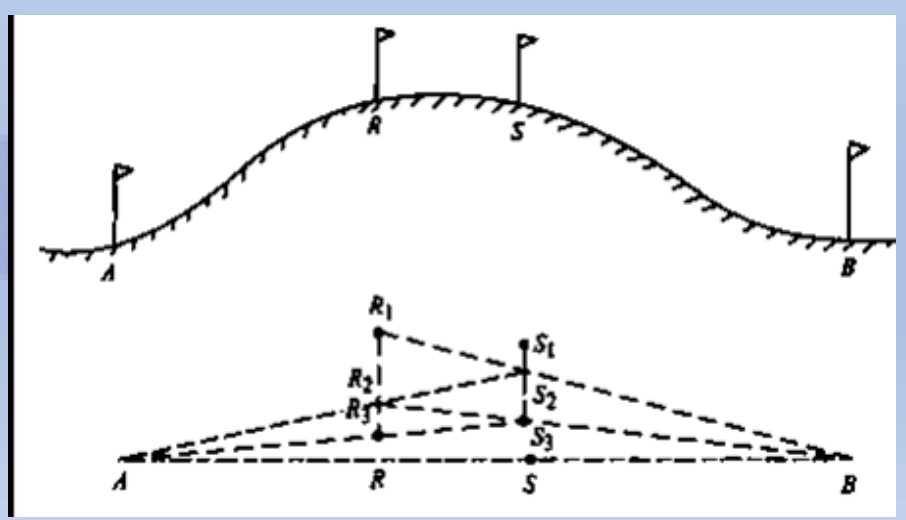
1. Direct Ranging

- End points are inter-visible.
- Minimum no. of ranging rods= 3



2. Indirect Ranging

- End points are not inter-visible due to hill, pond etc.
- Minimum no. of ranging rods= 4



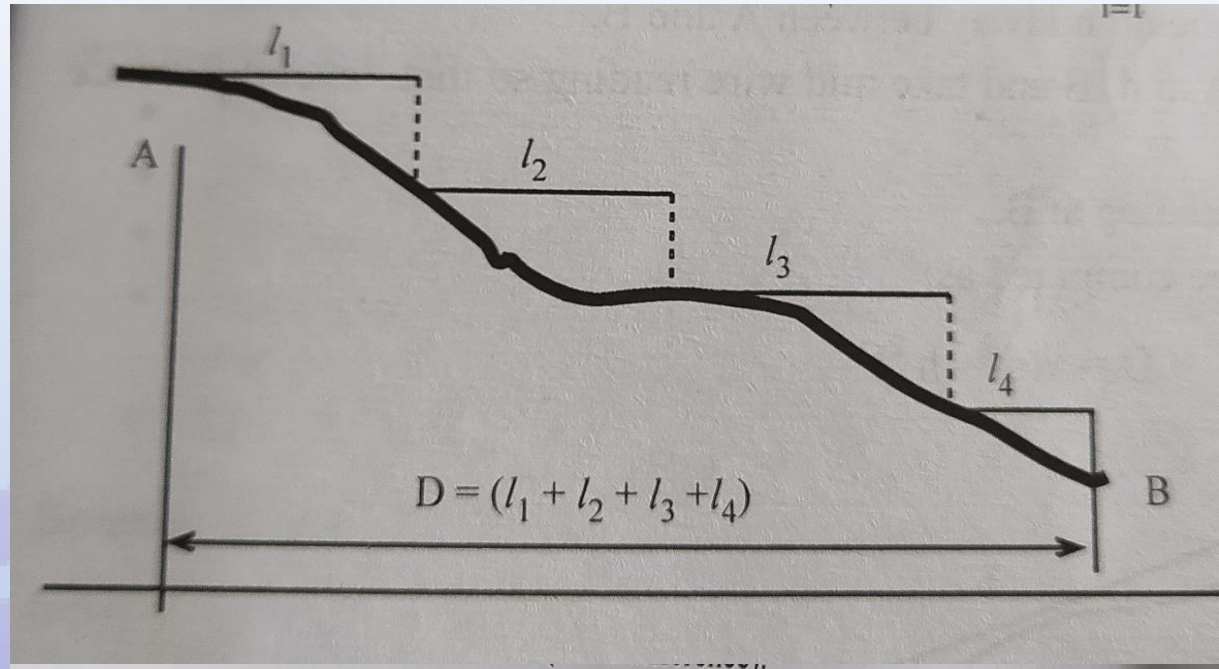
Taping on sloping ground: Methods

1. Direct/ stepping method

- When ground is very steep.

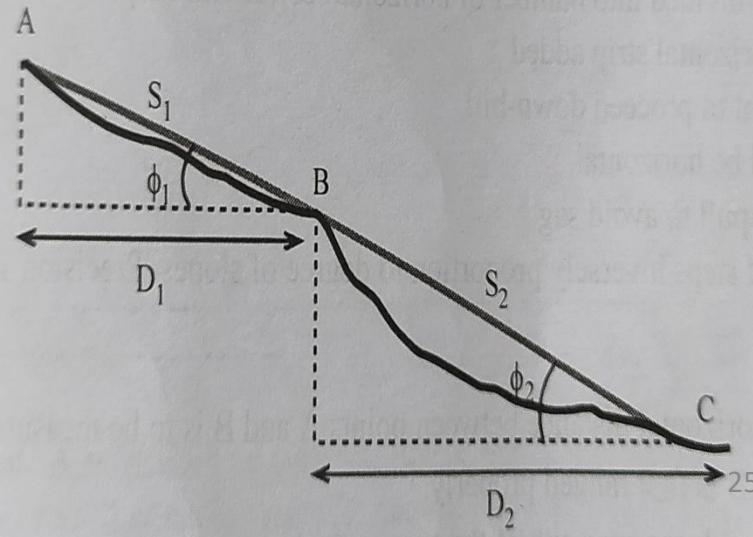
2. Indirect method.

- Vertical angle is measured.
- Suitable for long and gentle slope as stepping method is not suitable.
- Abney level is used.



$D_1 = s_1 \times \cos\Phi_1$

The required horizontal distance $(D) = \Sigma s \cos\Phi$



Too short and too long condition in tape/chain

Error= measured value- true value

❖**Too short condition:**

Measured distance is more than true, so **error** is positive and **correction negative.**

❖**Too long condition:**

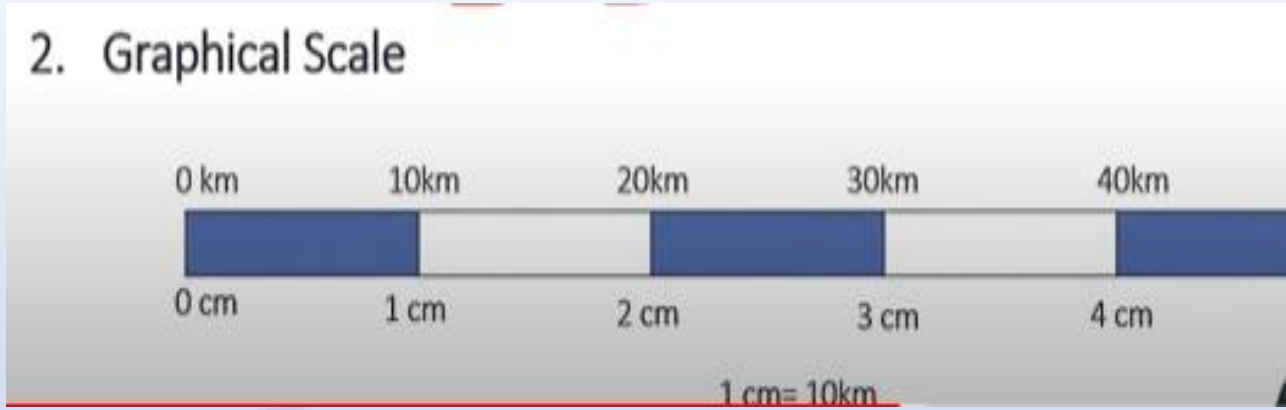
Measured distance less than true, so error negative, **correction. +.**

Scales:

1. Numerical Scale

I. Engineer's scale: eg. 1 cm=5m

II. Fraction scale: eg. 1:500



Representative fraction

- ***The ratio of distance on the map to distance on the ground*** .

Q. Find representative fraction(R.F) of given scale: 1 cm= 5 m

1cm=5*100 cm =500cm

So,

RF= 1/500.

MCQ.

1. Discrepancy means difference between

A. True value and error

B. Measured value and actual value

C. Two measured value of same physical quantity

D. Any of the above

2. If the smallest division of the vernier is shorter than smallest division of main scale, then the vernier is known as

A. Direct vernier

B. Simple vernier

C. Double vernier

D. Retrograde vernier

Types of Errors in Surveying

Mistakes:

- Due to inexperience, carelessness and poor judgment or confusion in the observer's mind.
- Also known as **gross errors/blunders**, and they cannot be measured.
- *Example: reading a 6 as 9 in staff.*

Systematic or Cumulative Errors:

- Due to surveying equipment, observation methods, and certain environmental factors.
- A systematic error always follows some definite mathematical or physical law, and correction can be applied.

Examples:

- Using an imperfectly adjusted instrument.
- if a tape is P cm short and is stretched N times, the total error in the length measurement will be P*N cm.

Compensating Errors:

This type of surveying error tends to occur in both directions, i.e., the errors may sometimes be positive and sometimes negative, thereby compensating each other.

Example:

- Too much Sag at one time is compensated by too much pull at second time.

- A person observes a reading one time higher and other time lower than what it is.

Accidental/random Errors:

- due to unavoidable circumstances like variations in atmospheric conditions.

- due to imperfection in measuring instruments and even imperfection of eyesight fall in this category.

- They are random and thus cannot be accounted for.

MCQ.

1. Which of the following error relies on Theory of probability?

A. Cumulative error
B. Curvature error
C. Compensating error
D. Accidental error

2. A surveyor made an error which is despite his skill and vigilance. Which type of error this surveyor has committed?

A. Mistake
B. Random error
C. Systematic error
D. None.

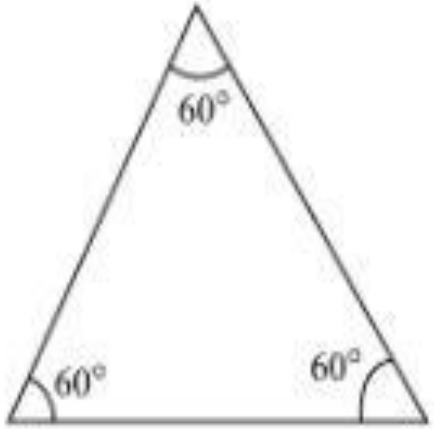
- **Error:** The difference between measured value and the true value is called error.
- **Discrepancy:** The difference between the two measured values of a quantity is called discrepancy
- **Residual error:** The difference between the measured value and the most probable value is called residual error

Chain surveying

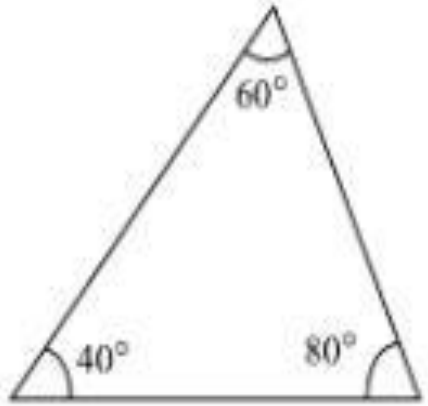
- Principle: Triangulation

Possible Network of triangles:

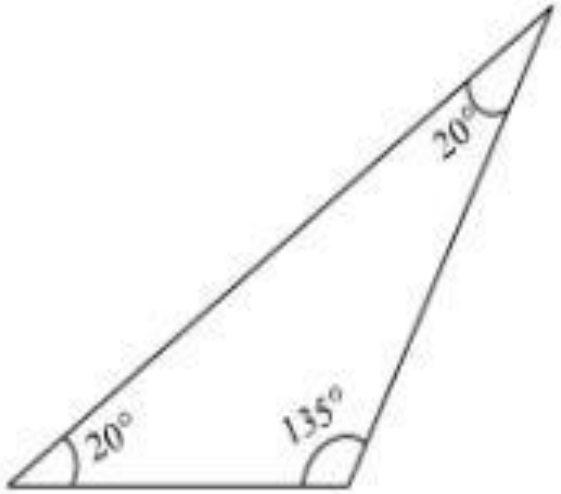
- *Well conditioned*
- *Ill conditioned*
- *ideal*



Ideal Triangle



Well-Conditioned Triangle



Ill-Conditioned Triangle

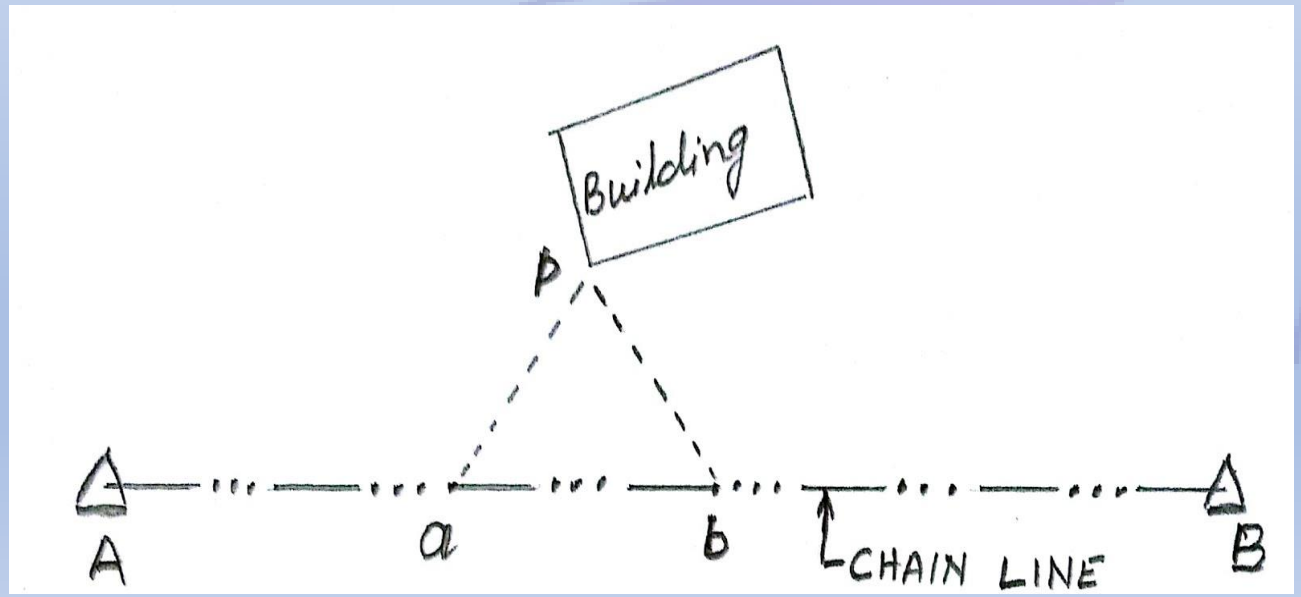
Offsets

Short offsets: < 15 m

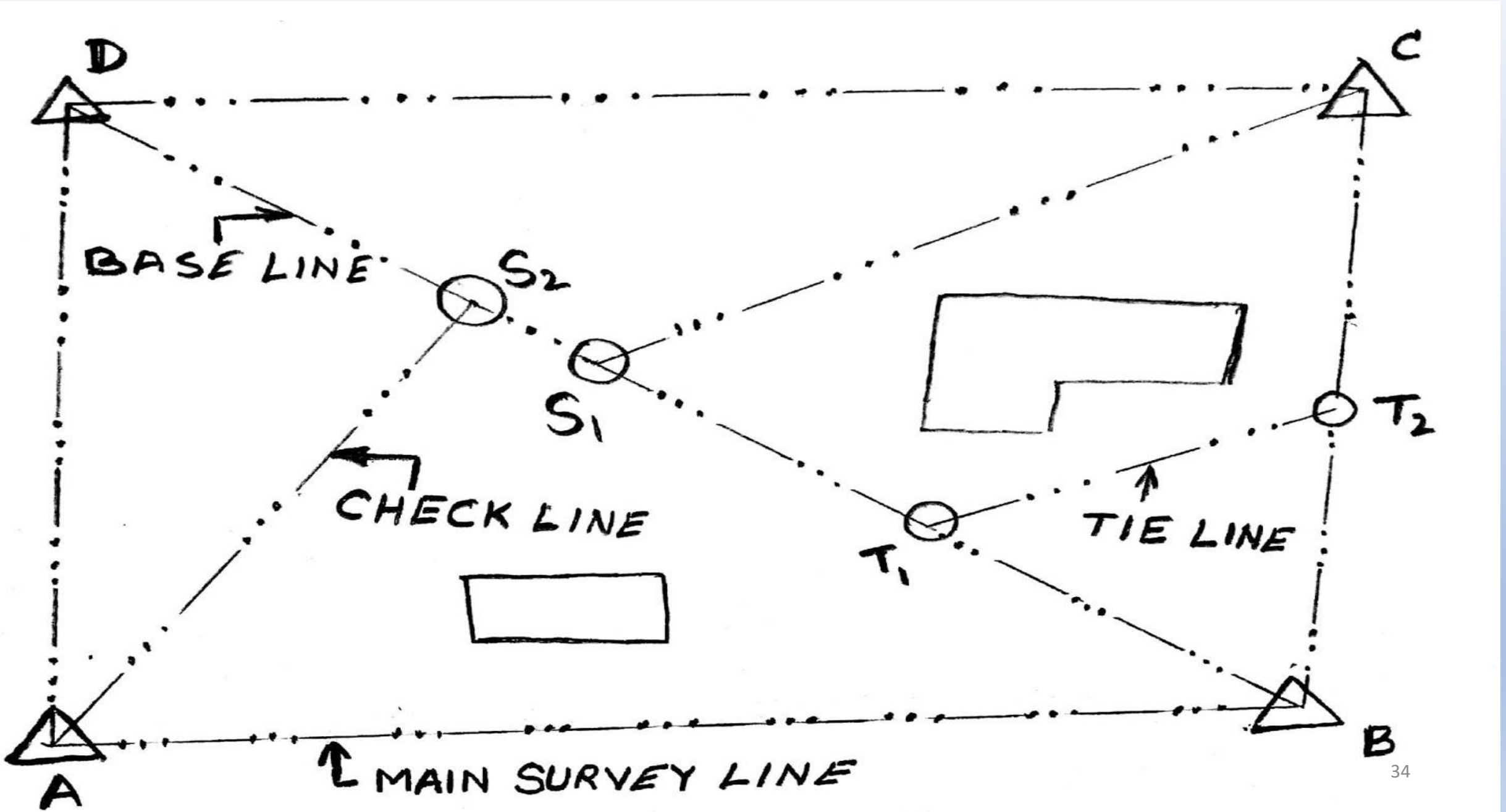
Long offsets: >15 m length.

Methods of taking offsets:

1. Perpendicular: When there is no obstruction,
2. Oblique offsets : used for long distant objects.



Lines in chain survey



MCQ:

In chain surveying tie lines are primarily provided

a) to check the accuracy of the survey

b) to take offsets for detail survey

c) to avoid long offsets from chain lines

d) to increase the number of chain lines

Q. Every 20 m chain should be accurate to within

a)± 5 mm

b)± 3 mm

c)± 8 mm

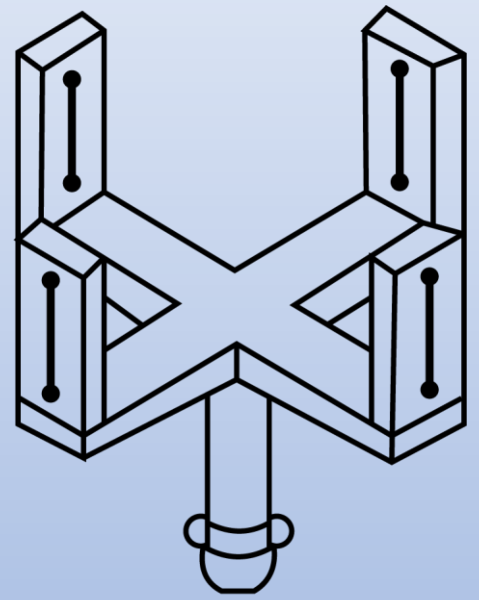
d)None of these

Accessories in Chain surveying

Cross staff

Cross staff:

1. Open cross staff → Δ angles
2. French cross staff → 45°
3. Adjustable cross staff → Any ang



Open cross staff

French cross staff

- The French Cross Staff has Eight Faces on it.
- Each Face is connected to the other with a 45 Degree Angle.

Optical square and prism square

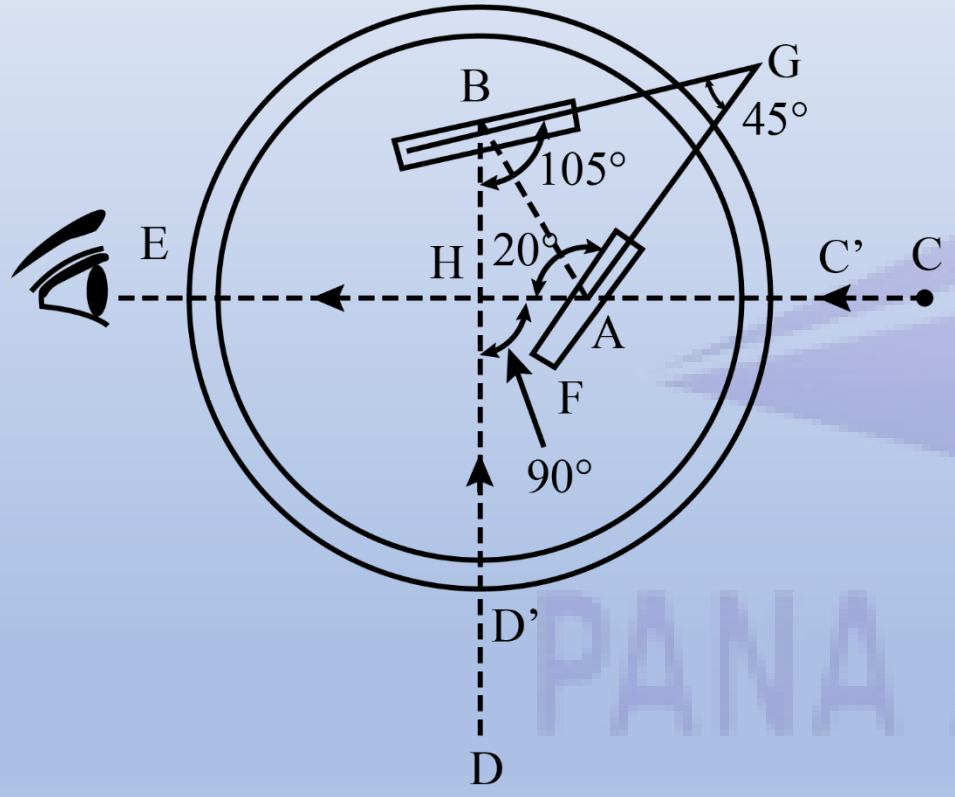
- To set out right angle to a chain line.

Optical Square:

- It is more accurate than cross-staff for setting out right angles.

- Consists of two mirrors making a 45° with each other.

Optical square ctd…



MCQ. ***The construction of optical square is based on the principle of***

A. Refraction

B. Reflection

C. Double refraction

D. Double reflection

Line Ranger

It is an optical instrument used for locating a. point on a line and hence useful for ranging. It consists. of two isosceles prisms placed one over the other and. fixed in an instrument with handle

It is used in the process of locating an intermediate point in a straight line between two endpoints of the survey line.

A. It eliminates the requirement of two persons in range. (A single person can easily perform ranging work with this instrument.)

Obstacles in chain survey

- **Obstacle to ranging**
- Hill/raised ground.
- These obstacles can be overcome by reciprocal ranging.
- **Obstacle to chaining**
- Ponds, lakes.
- **Obstacle to both chaining and ranging**
  Building.

Correct/limiting length of offset

$L = 0.025n \operatorname{cosec}\alpha°$ ..... in m.

Where,

Scale of plan 1cm=n metre