GEOMATICS (CE20203)

Autumn 2022-2023

Chapter 2

Distance Measurement

Content

- Chain and tapes
- Basic measurements, Units of measurement
- Optical distance measurement, Electronic distance measurement
- Errors and corrections in Distance measurement
- Consideration of earth curvature and refraction

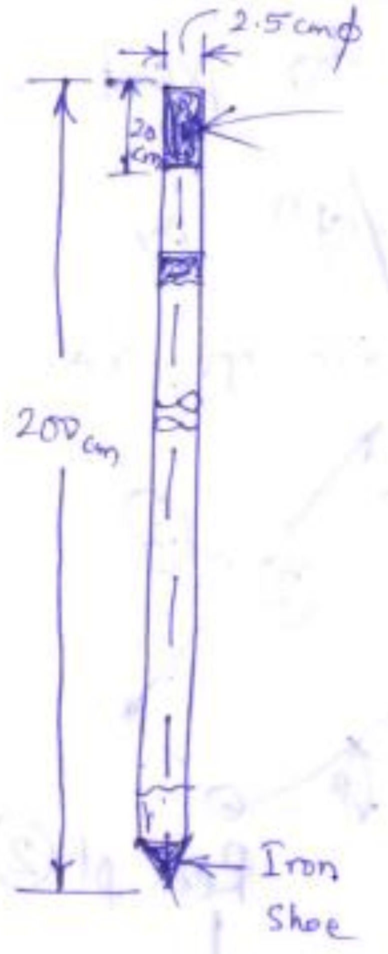
Introduction

Distance measurement can be done by

- Pacing/Stepping
- Passometer/ speedometer/ odometer
- Chain/Tape
- Optical Distance Measurement
- Electronic Distance Measurement

Linear Measurement Accessories

- Ranging Rod
- Chains
- Tapes
- Arrows
- Pegs
- Offset rod

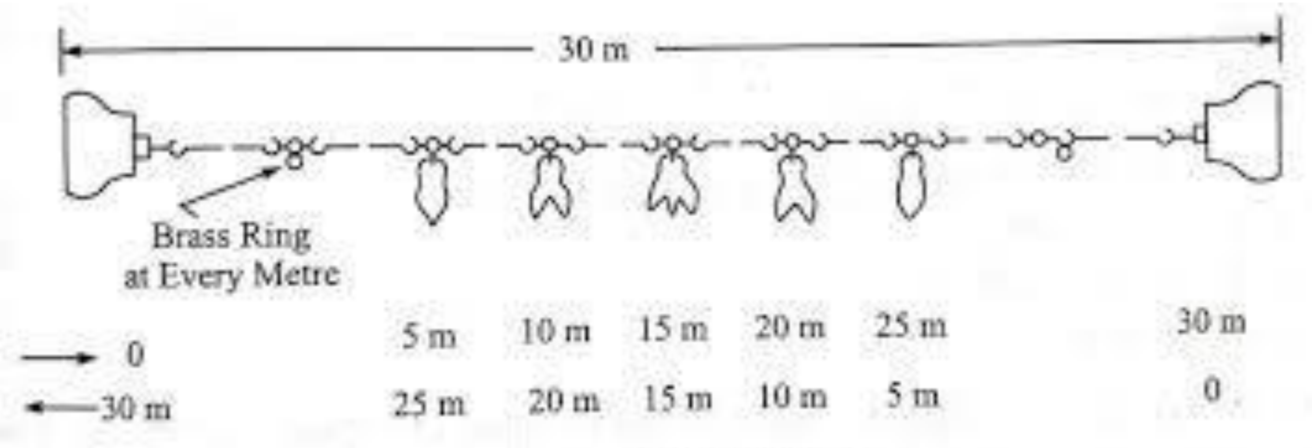


Principle of Chain Surveying

- The main principle of chain survey is surveying by **triangulation**
- In chain surveying, the area to be surveyed is divided into several smaller triangles
- The triangles sides are measured on the field directly above the location by the **survey chain**
- No angular measurement will be taken into it

Components of Chain

- Chain is made by **connecting 100 pieces of galvanized steel** wire 4 mm in diameter. The ends of each pieces are bent to connect with each other
- The pieces are then connected to each other with the help of three oval rings, which makes the chain flexible
- Two brass handles are connected at both the ends of the chain
- Tallies are provided at every 10 or 25 links for long-distance counting



30 m Chain

Chains

Chains:-

[Heavy in wt.]

- Metric Chain :- 20m long with 100 links / 30m —"— 150 —"— ; } tallies @ 5m spacing

For more accuracy ⇨ • Steel band :- 20m/30m long with 16mm wide Steel ribbon [graduations in m, dm, cm on one side & 0.2 links on the other]

- Engineers' Chain :- 100' long with 100 links [tallies @ 10' spacing]

- Gunters' Chain :- 66' long with 100 links

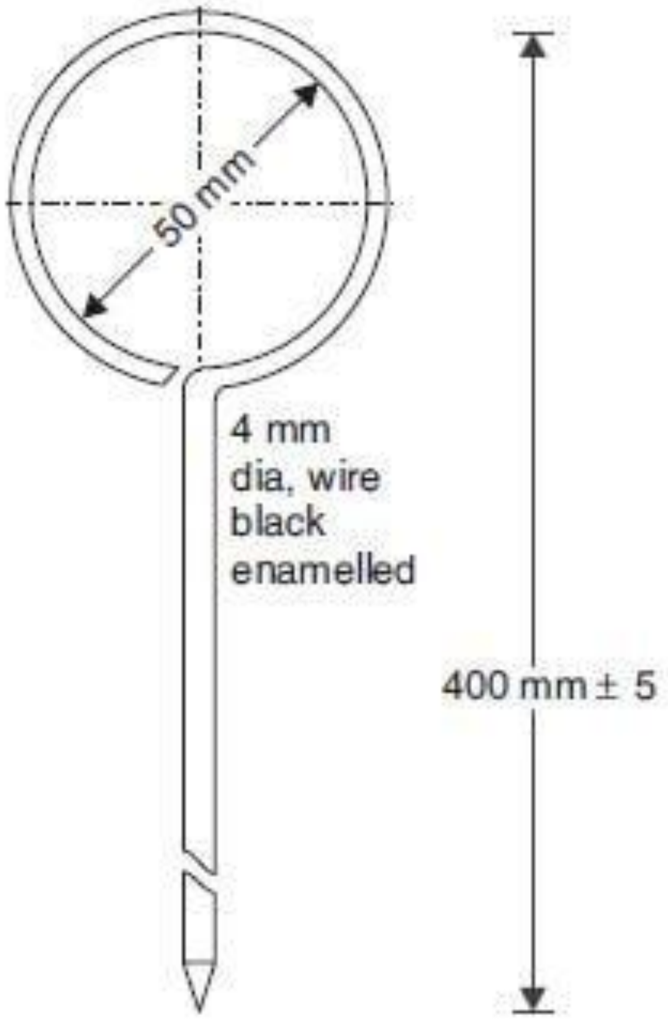
- Revenue —"— :- 33' long —"— 16 links

Tapes

Tapes :- [Light in wt.]

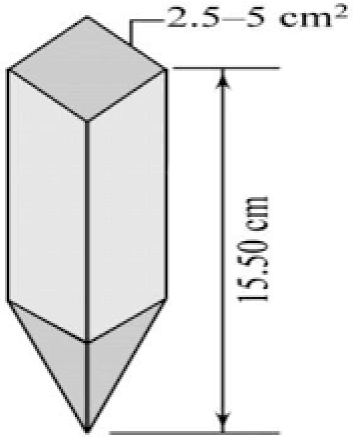
- Cloth/Linen Tape :- 10 m long / 15 m –"– { 15 mm wide & Varnished.
- Metallic Tape :- 15 m / 20 m / 30 m long
  [Reinforced with brass/copper wires]
- Steel Tape :- 10 m / 15 m / 20 m / 30 m / 50 m long & 6–16 mm
  Steel ribbon · ∥ to Steel Band.
- Invar Tape :- Made of a 6mm wide ribbon in an alloy with Steel & Ni
  [64%] [36%]
  30 m / 50 m / 100 m long.

Arrows



- An arrow is used to accurately mark the **end of a chain** and calculate the length of an entire chain when measuring length on a field
- It is made of soft steel wire of 4 mm diameter
- The upper edge of arrow is 5 cm and is rounded together
- While the lower end is pointed
- The total height is 400mm

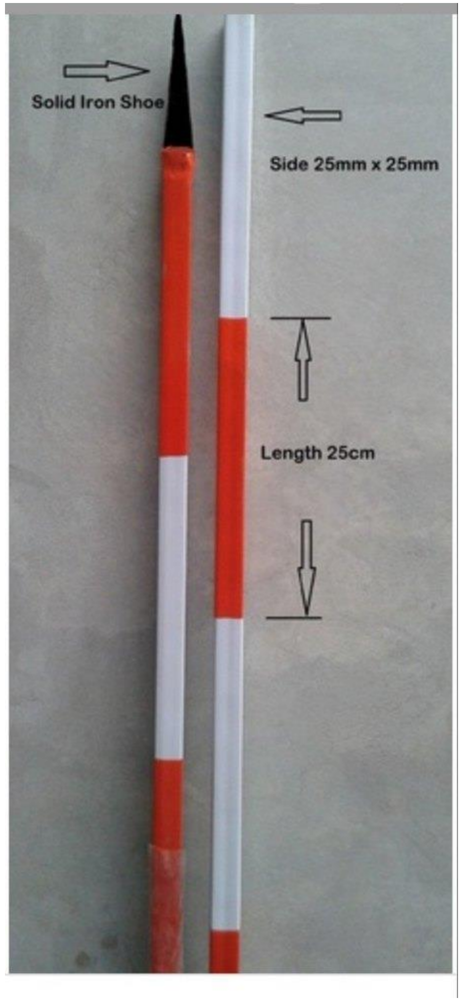
Pegs



- Used to mark the position of the survey point or the end points
- Generally made of solid wood
- Length of 15 cm
- The pegs are fixed to the ground by hammer so the head of wooden pegs is 4 cm above the ground

Offset Rods

- Offset rods are used to rotate the survey lines or take offset at right angles
- 3 m long and 3 cm in diameter
- Has groove or hooks at one end used to pull the chain



Gunters Chain

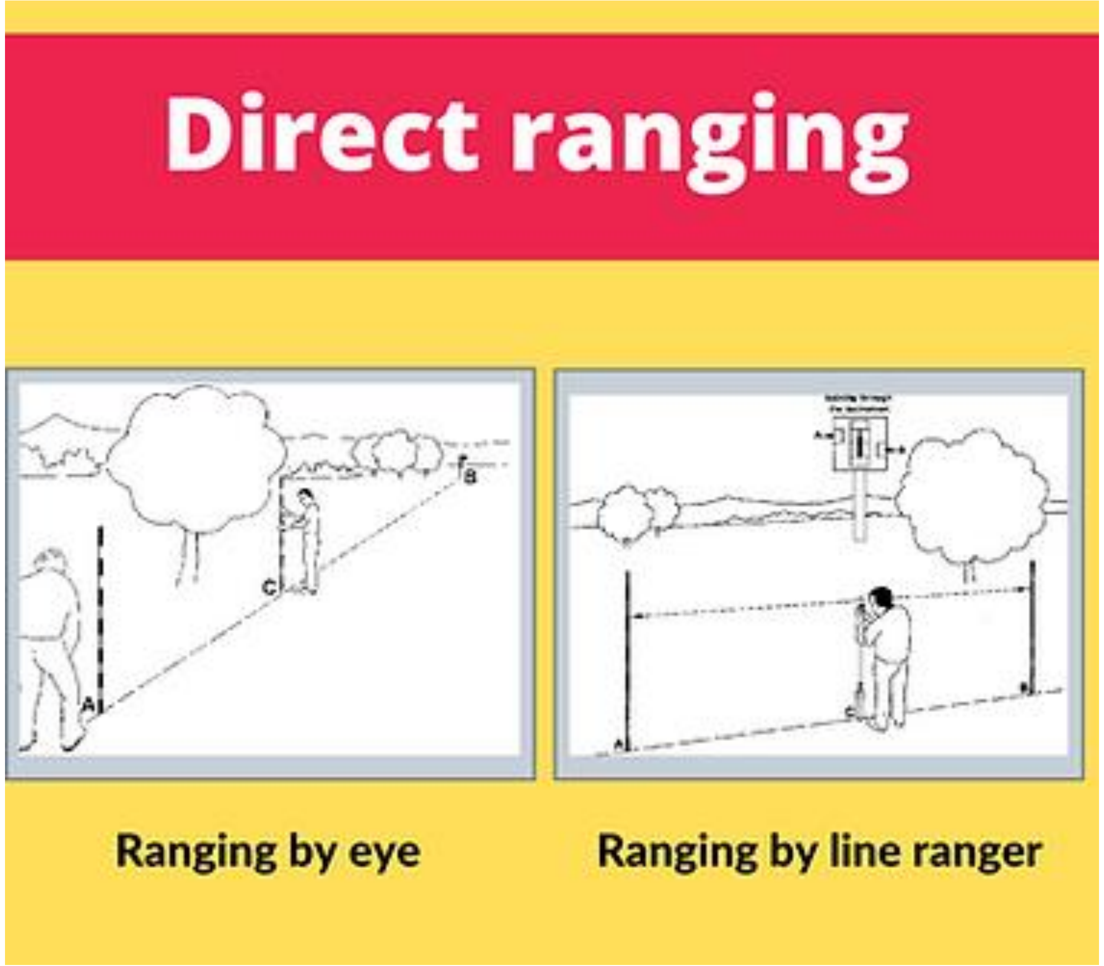
Steel Band

Ranging

- Ranging is the process of establishing many intermediate points to measure the survey lines in linear measurement
- When the length of the surveying line is longer than the length of the measuring chain, the line can be measured by using intermediate points along with it by ranging

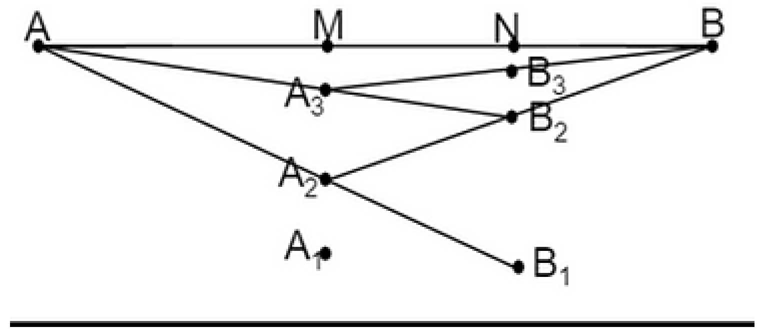
Direct Ranging

- Ranging by eye – The person is asked to stand in between the points A and B and his position is changed with respect to the given points
- Ranging by line ranger – Instrument is used precisely to locate the mid- point location

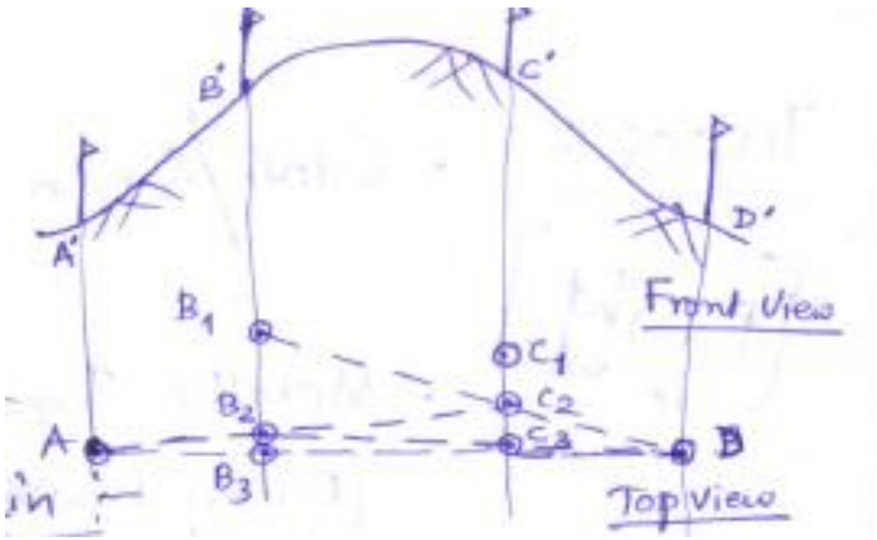


Indirect Ranging

- The points are not visible directly from each other
- Intermediate points are located in such a way, from that both the end points are visible



Indirect Ranging



Unfolding & folding a Chain :- B_3T

Top view

1st Chainman (follower) stationary

2nd Chainman (Leader) moving away

- 2nd Chainman (Leader) moves forward bringing both brass handles together, near Stationary & 1st Chainman (follower)
- 2nd Chainman (Leader) Starts folding from the middle of the chain, beginning with the pair of links there
- Finally 2 brass handles will appear @ the top. Then it is tied with a Strap.

Adjustment of Chain :-

When chain is too long:-
- Closing up the jts. of rings.
- Hammering elongated rings
- Replacing some old rings by new rings
- Removing some rings.

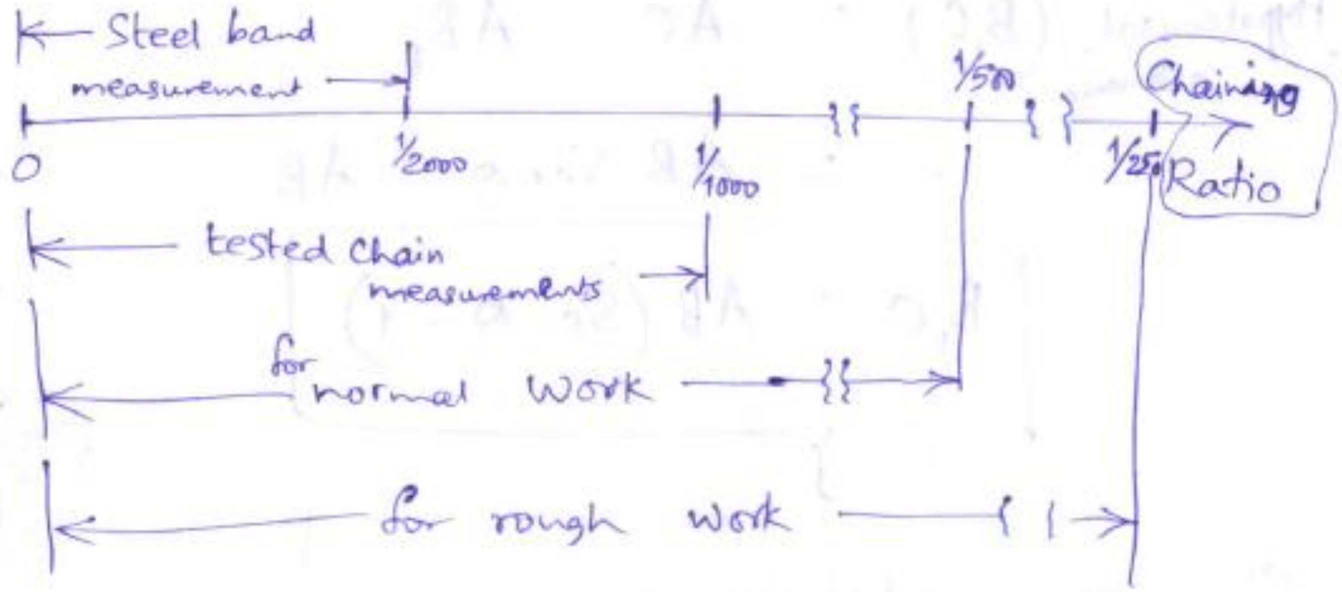
When chain is too short
- Straightening the bent links
- Opening the ring joints
- Replacing old rings by larger rings
- Inserting new rings where necessary.

4/25

Accuracy in chaining:

$$\text{Chaining Ratio} = \frac{\text{error in Chaining}}{\text{total length measured}}$$

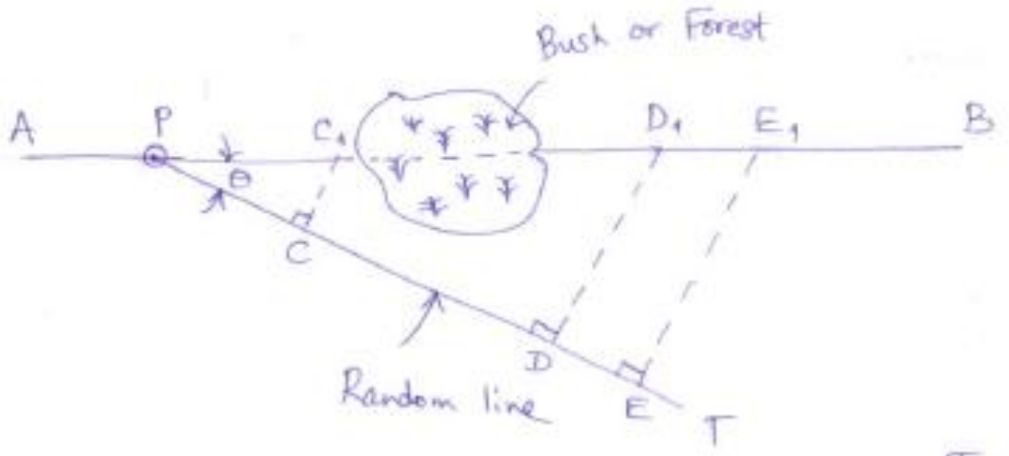
Permissible chaining error limits (i.e., Chainage Ratio)



Chaining methods on sloping grounds

- Direct method – Tapes lighter in weight are used
- Indirect method

1. Chaining free, Vision Obstructed



Top View

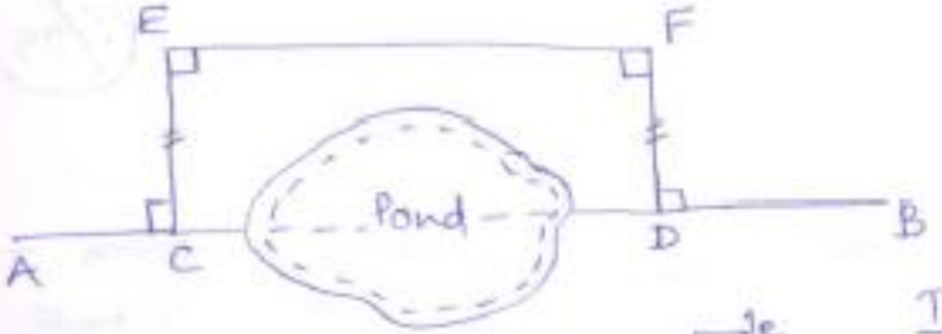
we have $\tan\theta = \dfrac{CC_1}{PC} = \dfrac{DD_1}{PD}$

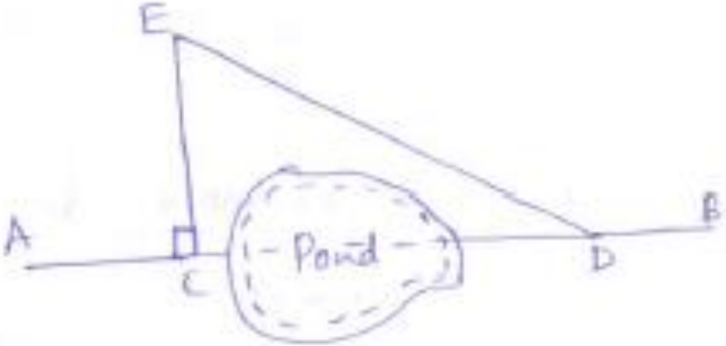
$$\therefore \boxed{DD_1 = \tan\theta \cdot PD = \frac{CC_1}{PC} \cdot PD}$$

$$|||^{ly} \quad \boxed{EE_1 = \frac{CC_1}{PC} \cdot PE}$$

$\therefore$ Vision obstructed distance $\boxed{(PE_1) = \sqrt{PE^2 + EE_1^2}}$

2. Chaining obstructed; Vision free





Top View

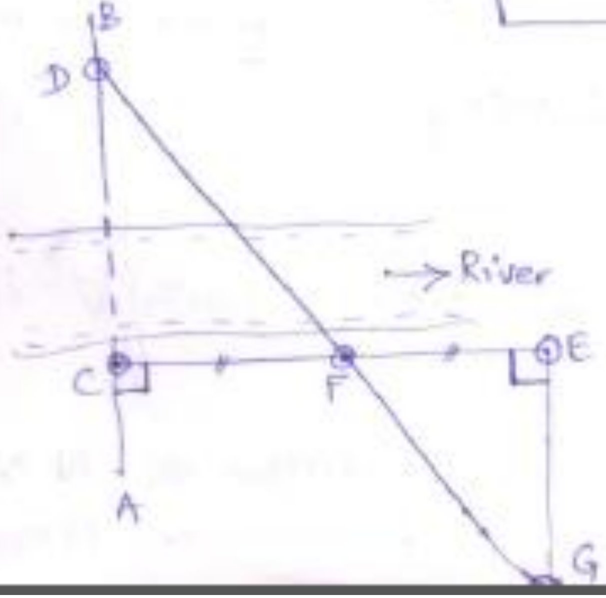
Since CDFE is a $\square^{le}$,

Obstructed chain length $\boxed{(CD) = EF}$

In rt. $\angle^{le}$ Δ^{le} CDE,

Obstructed chain length

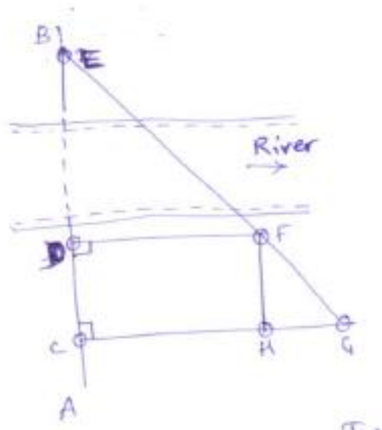
$$\boxed{(CD) = \sqrt{ED^2 - CE^2}}$$



In the congruent Δ^{les} CDF & EFG,

Obstructed Chain length $\boxed{(CD) = EG}$

Top view



Top view

In the $|||^r$ Δ^{les} EDF & FHG,

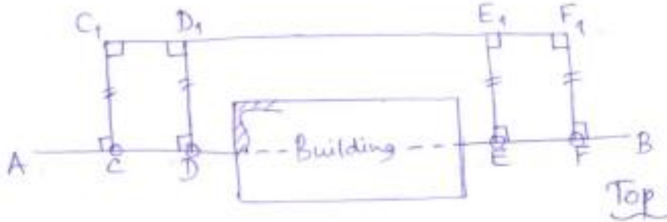
Obstructed Chain length

$$(ED) = \frac{FH}{HG} \cdot DF$$

i.e.,

$$\boxed{ED = \frac{CD}{CG-DF} \cdot DF}$$

Both Chaining & Vision obstructed

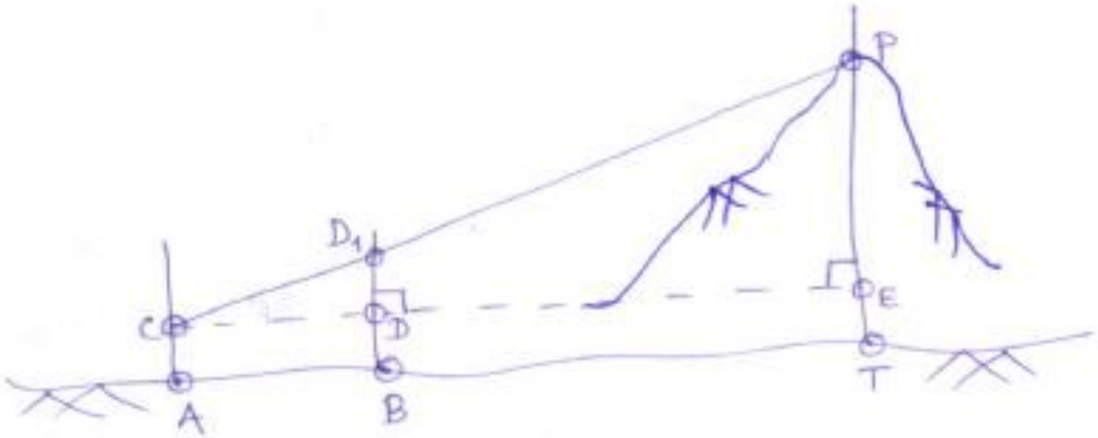


Top view

In the ▭le DD_1E_1E,

Chaining & Vision obstructed length $(DE) = D_1E_1$

To find the ht. of an object by using only tape & ranging rods



$$\frac{PE}{CE} = \frac{DD_1}{CD}$$

Here $CD = AB$ & $CE = AT$

$$\therefore \boxed{PE = \frac{DD_1}{AB} \cdot AT}$$

& $\boxed{\text{Tower Ht.} = PE + ET}$

Errors in Surveying :- → Compensating Errors → They have both +ve & -ve values. So, they get compensated eventually.

→ Cumulative —"— → +ve or → -ve

Cumulative errors get accumulated, due to a particular sign of their magnitudes.

Compensating Error Sources :-

1. Incorrect holding of chain;
2. Horizontality / Verticality of steps not being properly maintained during stepping operation;
3. Fractional parts of chain/tape not being uniform thru'out its length;
4. Inaccurate measurements of rt. $\angle$les with chain & tape.

[i.e, when the measured length is more than actual length]
+ve Cumulative Error Sources :-

1. Chain/tape length is shorter than Std. length;
2. Slope correction is not being applied;
3. Sag ———— " ————;
4. Measurement being taken with a faulty alignment; &
5. ———— " ———— in high winds with tape in suspension.

-ve Cumulative Error [i.e. when measured length is $<$ actual length] Sources :-

1. When the Opening of ring joints in chain;
2. When the applied pull is $>$ std. pull;
3. —"— temperature during measurement is $>$ Std. temperature;
4. When there is wearing of connection rings &
5. When there is elongation of links due to heavy pull.

Tape Corrections :-

1. Temperature Correction [in m]

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

thermal expansion Coeff. (α)

Std. Temperature (T_0)

tape length [m] (L)

Measurement Temperature (T_m)

2. Pull correction [in m]

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

Applied pull during measurement [kg] (P_m)

Std. pull [kg] (P_0)

Tape length [m] (L)

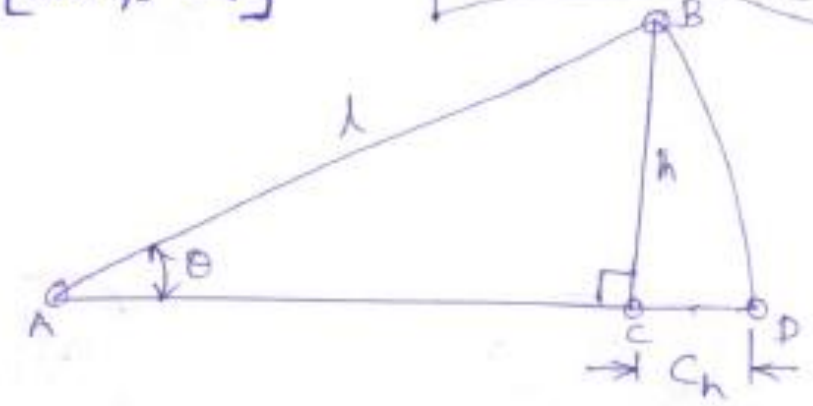
Elasticity Modulus [kg/cm²] (E)

Tape c/s area [cm²] (A)

3. Slope Correction

[always -ve]

$$(C_h) = l - \sqrt{l^2 - h^2} = l(1 - \cos\theta) \quad \Big\}\ \text{Exact}$$



$$\boxed{C_h \simeq \frac{h^2}{2l}}$$

4 Sag Correction (C_s) [always -ve]

[i.e., st. length - Curved length]

$$[\text{in m}] = \frac{L W^2}{24 n^2 \cdot P_m^2}$$

W – Total Tape Wt. [kg]

P_m – Pull applied during measurement [kg]

n – no. of spans

L – Tape/Chain length [m]

Wherein pull effect is neutralized by sag effect

5. Normal Tension (P_n) is obtained by the Eq^n

$$\boxed{(P_n - P_o)\,P_n^2 = \frac{W^2 \cdot AE}{24}}$$

Total wt. of Tape

C/s^tal Area of Tape [cm^2]

Elasticity Modulus [kg/cm^2]

Std. Tension

normal Tension [kg]

Chain Corrections :-

1. Correction applied to incorrect chain length

Measured chain length

Measured Length

$$\text{True length of Line } (TL) = \left(\frac{L'}{L}\right) ML$$

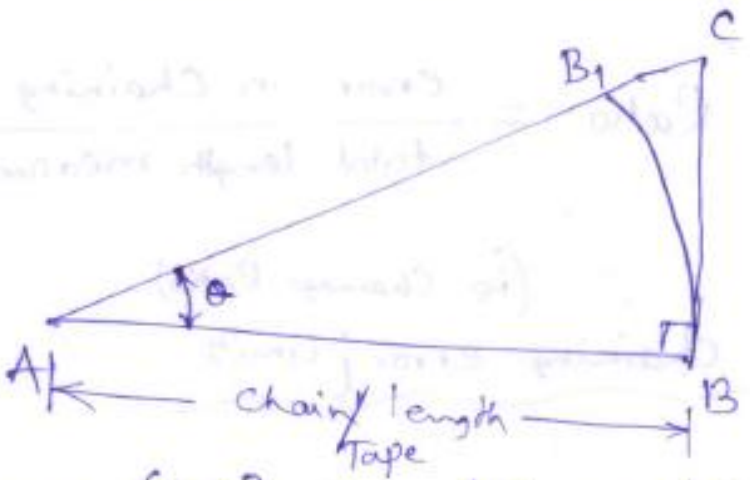
True length of Chain

2. Correction for incorrect area :-

$$\text{True Area} = \left(\frac{L'}{L}\right)^2 \cdot \text{Measured Area}$$

3. Hypotenusal Allowance

Indirect Method of Measurement along a Sloping ground



Hypotenusal allowance $(B_1C) = AC - AB_1$

$$= AB\ \sec\theta - AB$$

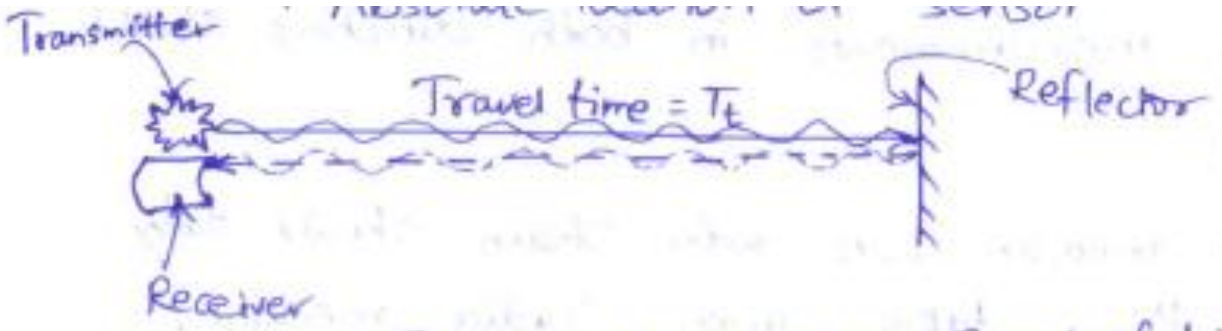
$$\boxed{B_1C = AB(\sec\theta - 1)}$$

Chain length or Tape

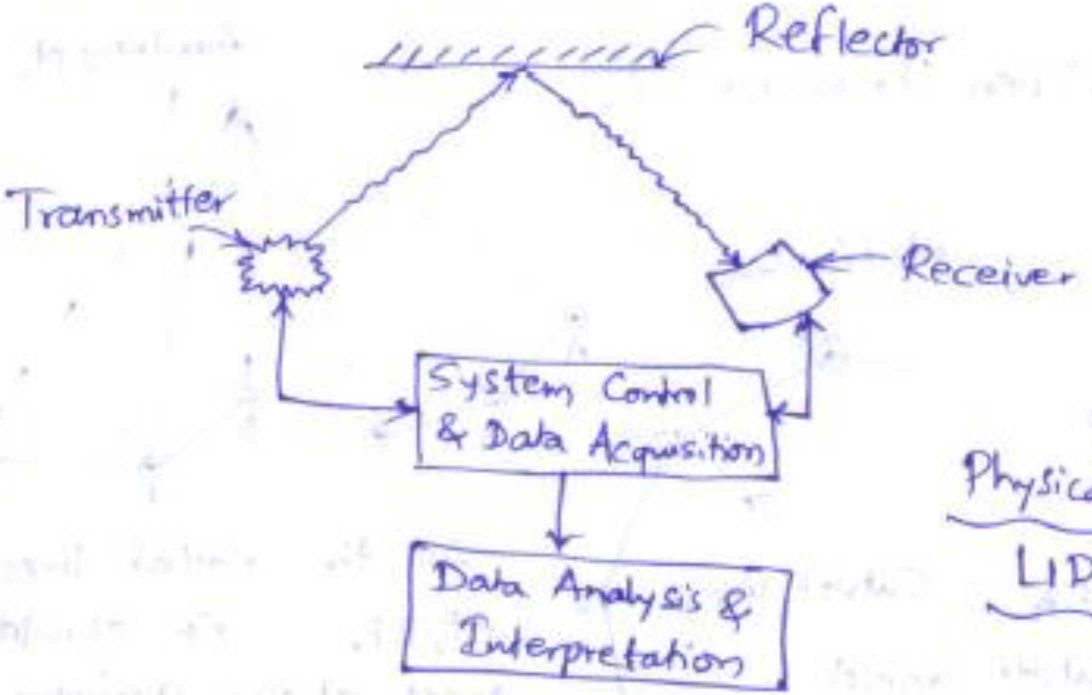
Optical Distance Measurement using LIDAR (i.e. Light Detection and Ranging)

<u>Working Principle of LIDAR</u>

- Laser generates an optical pulse signal
- Pulse is transmitted, reflected and received back
- Returned pulse is collected and processed to obtain the target property
- Receiver accurately measures the travel time
- X,Y,Z coordinates of target are computed from
  - Laser Range
  - Laser scan angle
  - Absolute location of sensor



$$\text{Distance travelled} = \text{Speed of Light} * \frac{T_t}{2}$$



Physical picture in LIDAR remote sensing

LIDAR Disadvantages

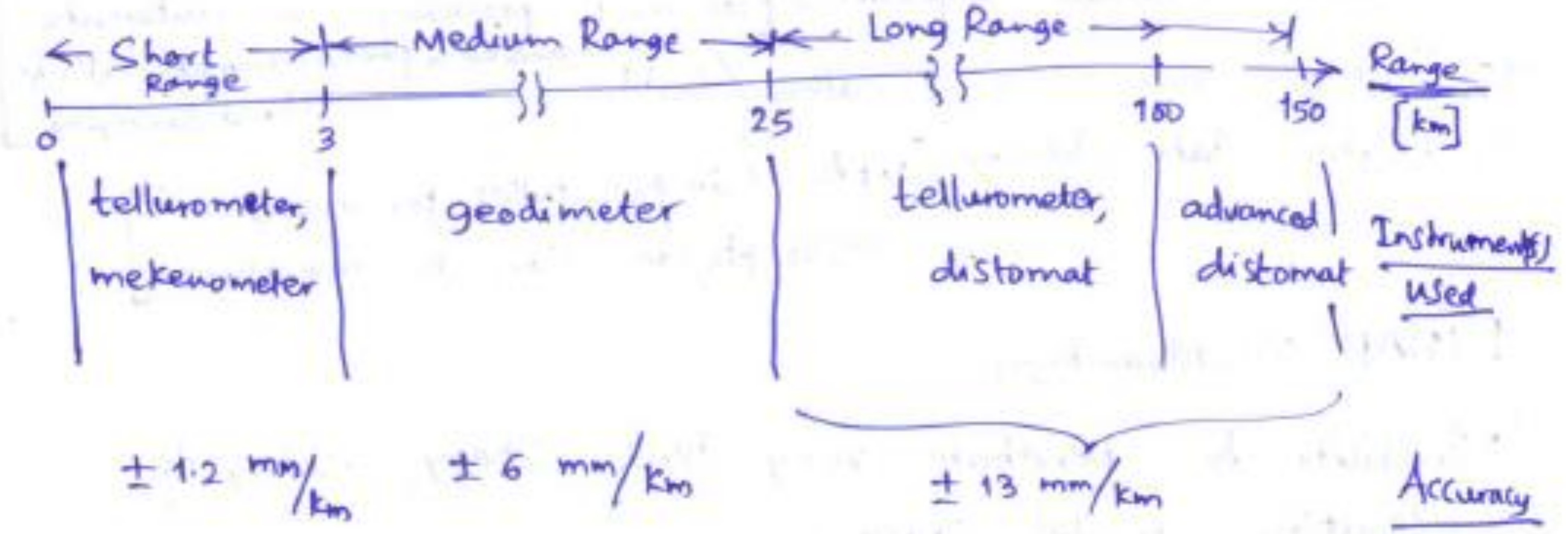
- Inability to penetrate very dense canopy, leading to elevation model errors
- Ineffective during heavy rain
- High operational cost

Electronic Distance Measurement [EDM]

- In EDM, the instruments [i.e, geodimeter, tellurometer, mekenometer, distomat etc] rely on propagation, reflection and subsequent reception of light/radio waves
- An EDM instrument performs the following basic functions
  - Generation transmission of carrier wave & measuring the transmitted wave frequencies
  - Modulation & demodulation of the carrier wave
  - Measurement of phase difference between transmitted and received waves
  - Display of measurement results

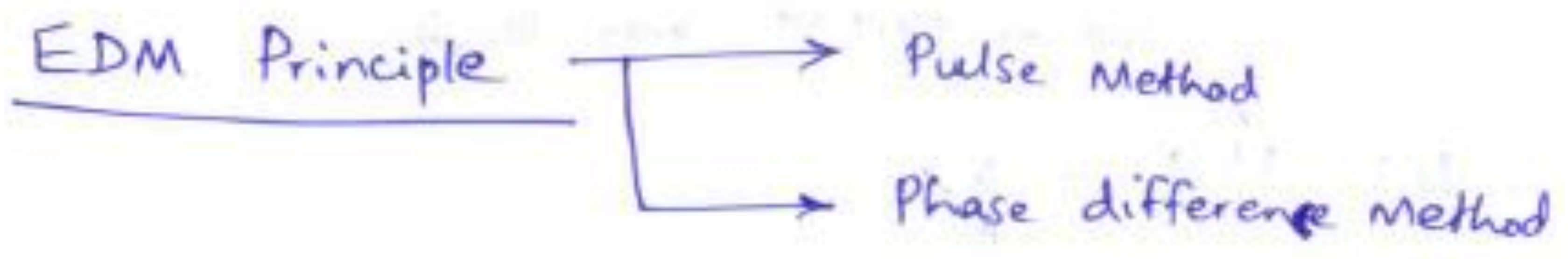
Electronic Distance Measurement [EDM]

EDM Instrument classification based on Range



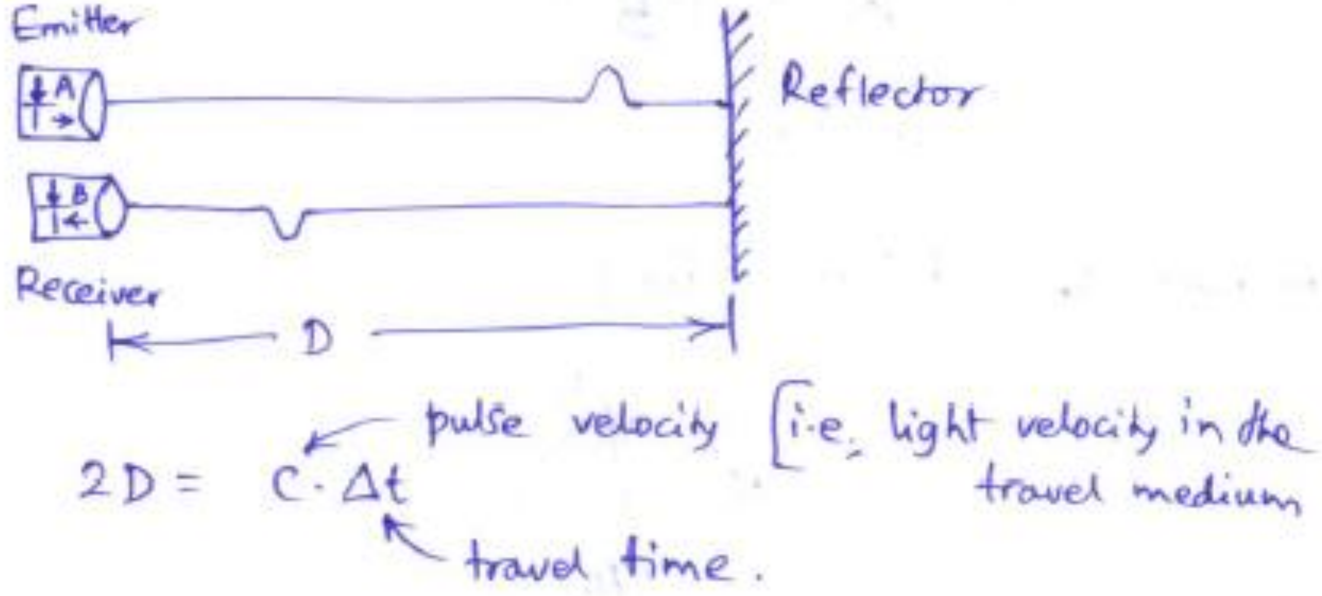
Electronic Distance Measurement [EDM]

- EDM Instrument classification based on signal
  - Microwave EDM instruments (generally use radio waves of 30mm wavelength)
  - Electro-optical EDM instruments (generally use visible & near infrared (NIR) radiation)



Electronic Distance Measurement [EDM]

- In pulse method, distance is measured as the product of pulse velocity and the travel time



Electronic Distance Measurement [EDM]

- In phase difference method [used in majority of EDM instruments] the phase difference is estimated and its product with wave length gives the distance.