Koya University
Faculty of Engineering
Civil Engineering Department – 2nd Stage

Surveying (SUR5109)

Part 2:
Principles of Surveying

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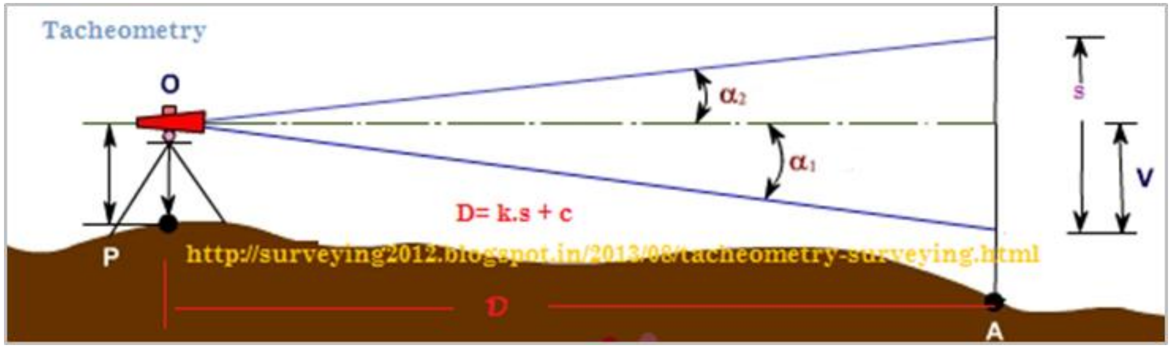
Types of Linear Distance Measurement

1. Indirect method (electronic): by using EDM, Stadia method, and Substance bar.



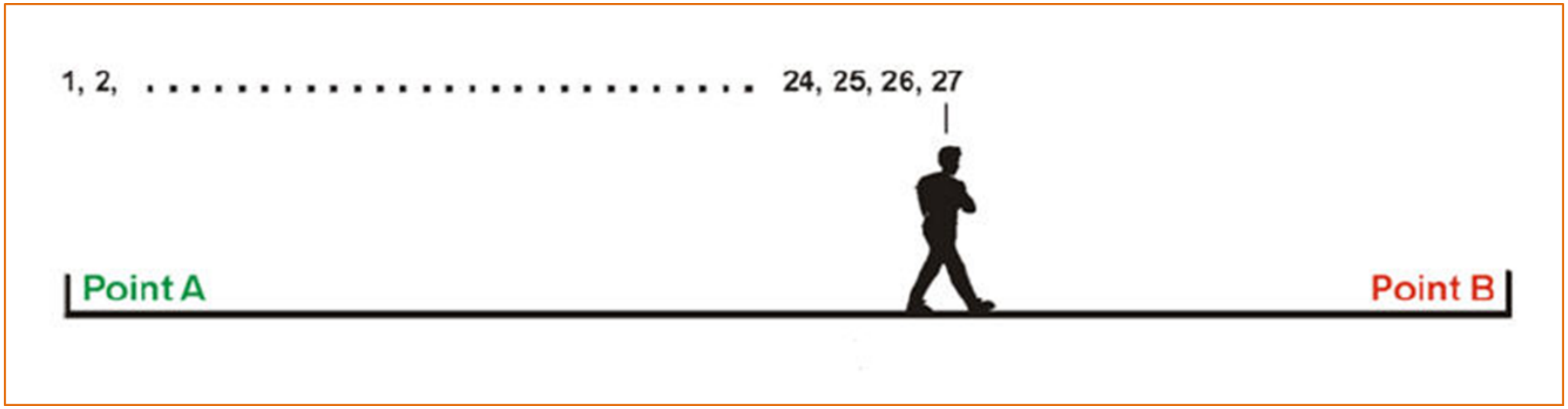
2. Optical Method: by Theodolite instrument.

3. Direct Method: Is very important and use in general:

Types of direct method:

1. Pacing measurement:

Pacing is a quick method for estimating distances. One simply walks from one point to another, counting steps. Knowing the length of one's step allows a quick estimation of the distance. With practice, pacing estimates will typically be accurate to within 2%. Pacing is most reliable on even terrain without obstructions. The more uneven or unstable the surface is the lower the accuracy. Pacing upslope tends to shorten the step and pacing down slope tends to lengthen the step. If better accuracy is required, use another method.



Direct Method

2. Odometer and Speed measurement:

An Odometer converts the number of revolutions of a wheel of known circumference to a distance. Lengths measured by Odometer on a vehicle are suitable for some preliminary surveys in route-location work. Odometer wheels use different units on the odometers. Insure you know the measuring units before you start to use the wheel.

3. Chaining measurement: That needs some of tools and apparatus:

Apparatus used in chaining:

1. Chain or Tape: Cloth tape, Metallic tape, Steel tape, and Invar tape.

Note: Cloth tape is rarely used for making accurate measurement, because of the following reasons:

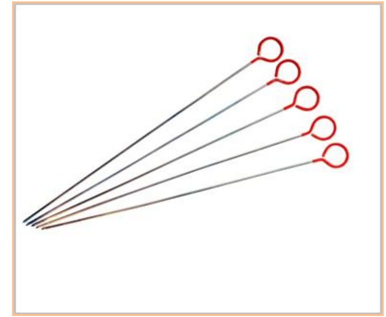
1. It's affected by moisture dampness and thus shrinks.
2. It's likely to twist.
3. It's not strong.

-The length of Tape is various, that (10m, 20m, 25m, 30m, 50m, and 100m).

-Standard conditions for the use of the steel tape:

Conditions	SI	FPS
Temperature	20 C°	68 F°
Tape pull or under a tension	50N	11 lb

2. Arrows: For transition measurement. The height is (400mm), Diameter of top is (50mm), and Ø for steel is (4 mm).



3. Pegs: The height is (15 cm).

4. Ranging rods: For temporary marking.

5. Plumb bob:

Chaining

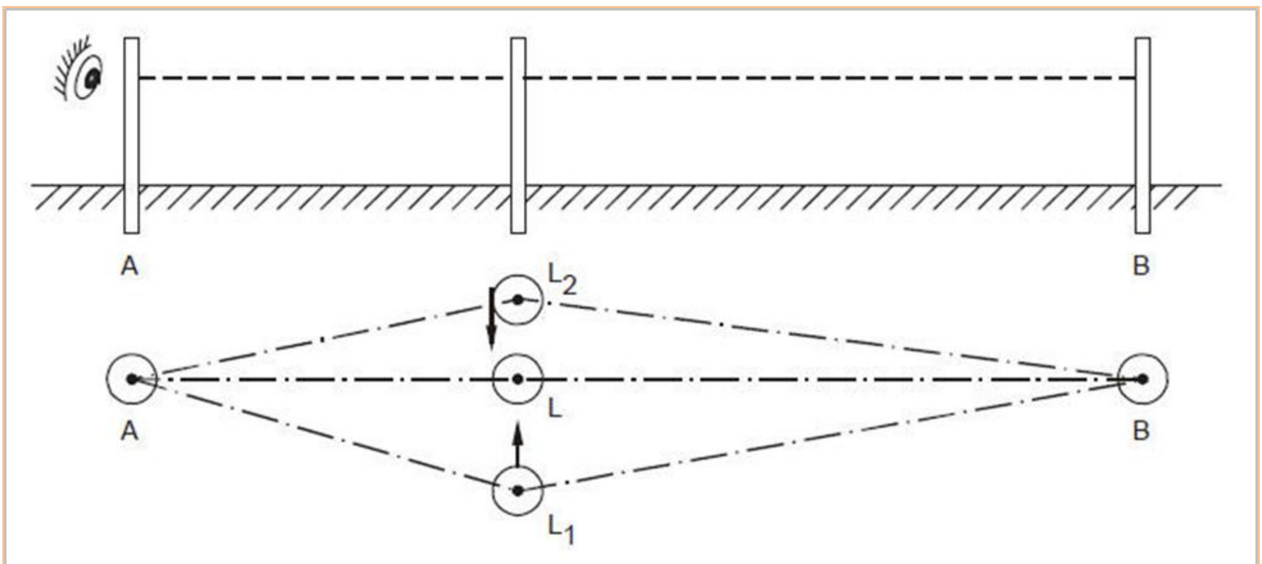
-There are two cases for measurement distance by Tape

A. If the length is less than tape or chain length for horizontal ground length is easy.

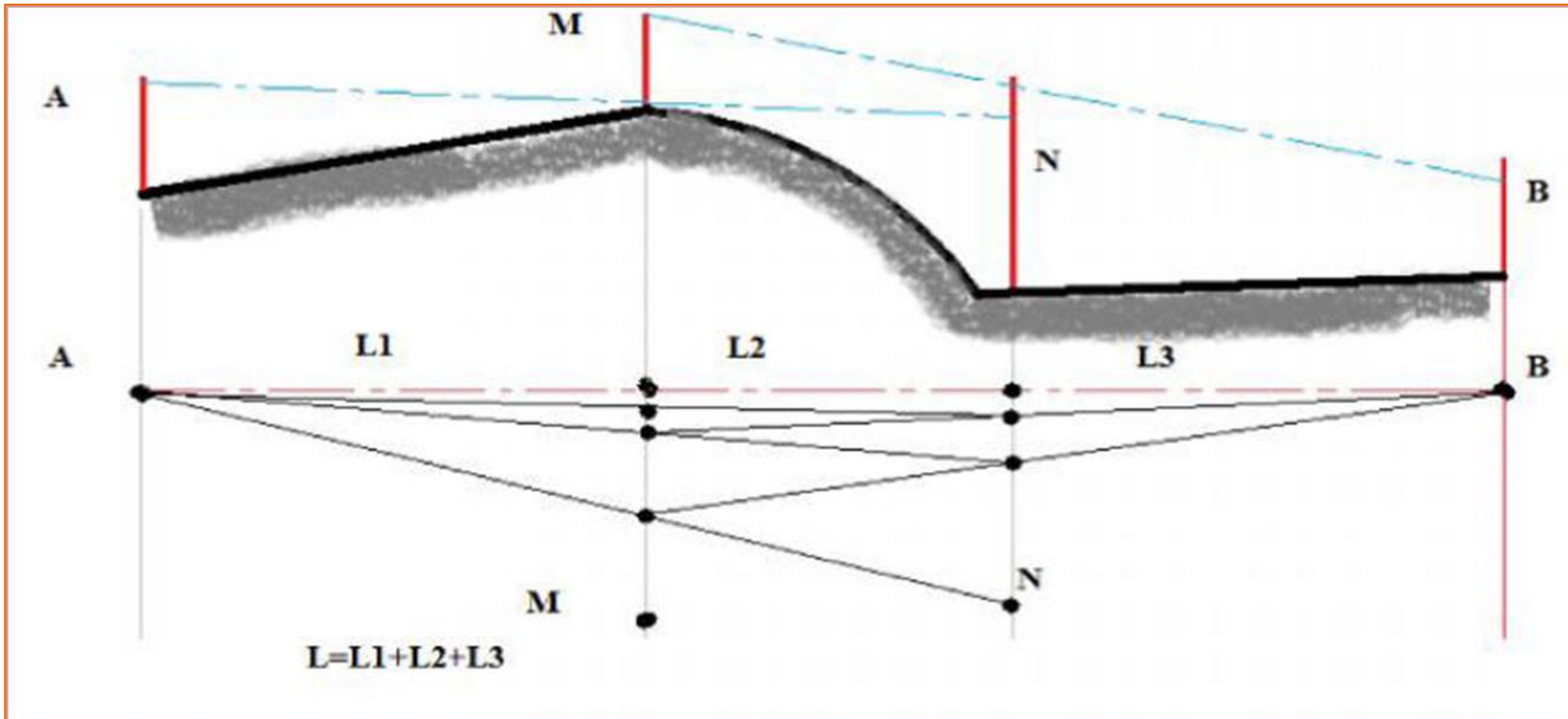
B. If the length is more than tape or chain length. In this case the ranging rod process is necessary.

-Ranging rod process:

1. Direct ranging: Direct ranging is done. When the two ends of the survey lines are inter-visible. In such cases, ranging can either do by eye or through some optical instrument.



<u>2. Indirect or reciprocal ranging:</u> This method is done when both the ends of the survey line are not inter-visible, either due to high intervening ground or due to long distance between them. We choose two points M1 and N1 where from N1 we can see M1 and A, also from M1 we can see N1 and B.



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Necessary precautions in using instruments in chaining:

1. After use in wet weather, chains should be cleaned, and steel tapes should be dried and wiped with an oily rag.

2. A piece of coloured cloth should be tied to arrow (or ribbon – attached) to enable them to be seen clearly on the field.

3. Ranging rods should be erected as vertical as possible at the exact station point.

4. The operating tension and temperature for which steel bands/tapes are graduated should be indicated.

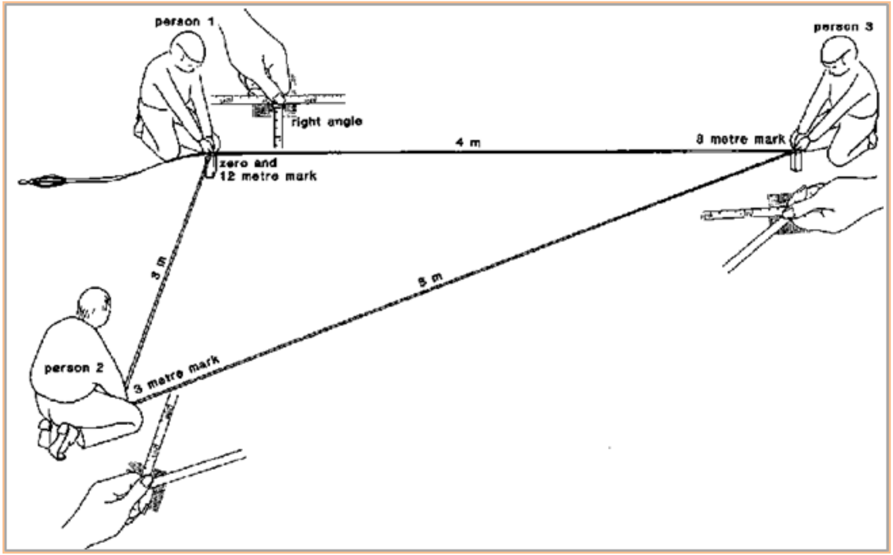
5. Linen tapes should be frequently tested for length (standardized) and always after repairs.

6. Always keep tapes reeled up when not in use.

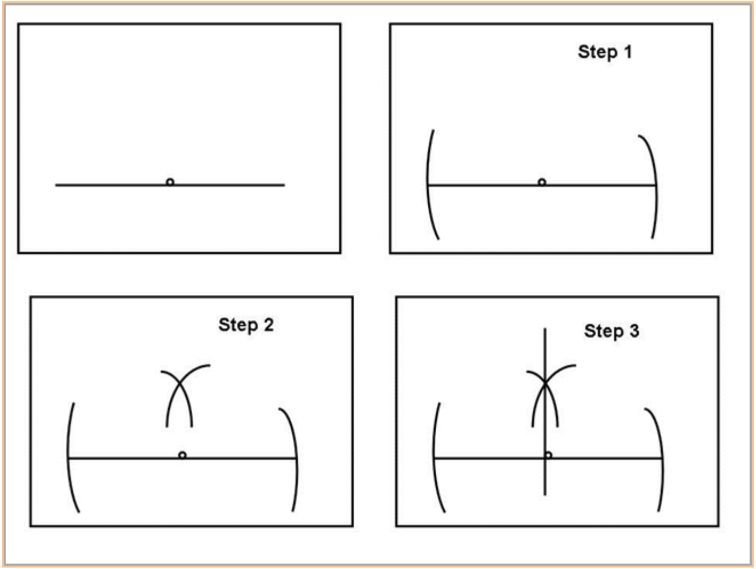
How to draw a perpendicular?

a. <u>Where the point is on the line:</u>

1. By 3-4-5 Method:



2. By arc method:

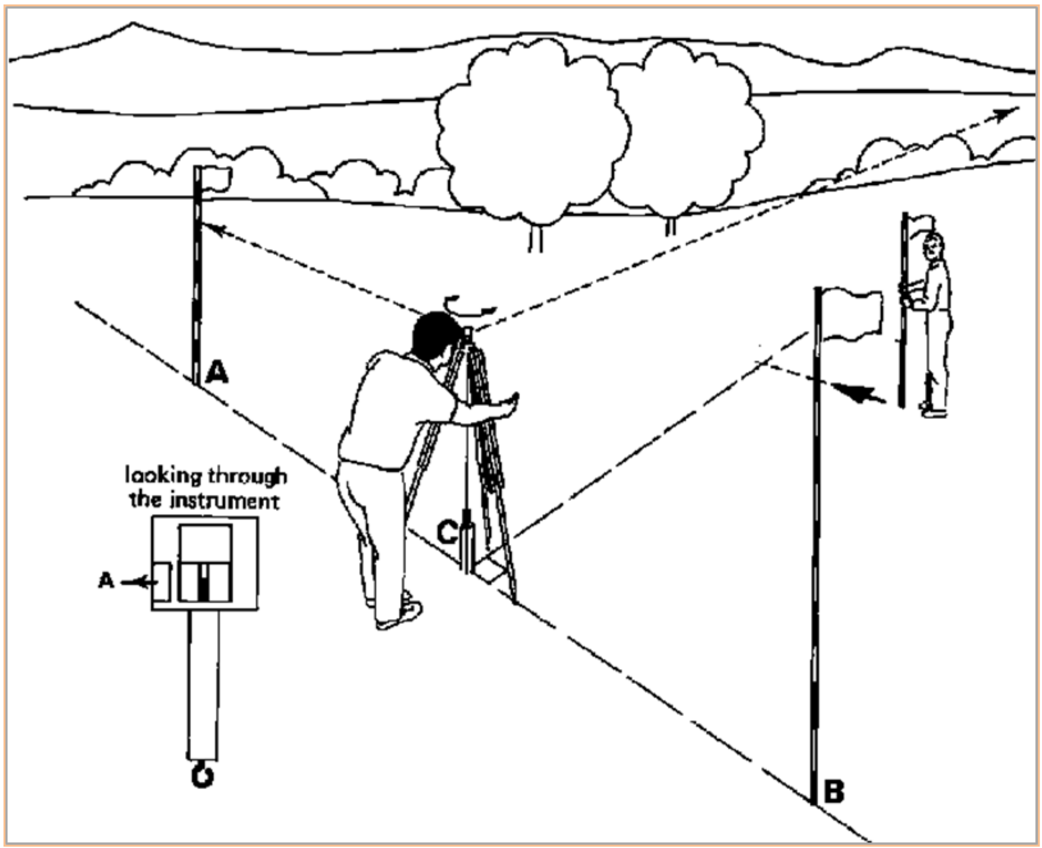


b. Where the point is outside the line:

1. by cord bisection method.

2. by optical square.

3. by prism.



Using optical square

Errors in Surveying:

Error is generally defined as the deviation of the measured value from the “exact” value of a quantity. The study of errors is important in surveying as it helps the surveyor understand the sources and exercise the necessary care and apply correction to minimize their effect so that an acceptable accuracy is achieved.

Error sources

Generally the errors in surveying measurements are classified as:

a) ***Personal***: the error that occurs due to lack of perfection in the surveyor’s sense of sight, touch, hearing etc. during survey activity. Also mistakes due to carelessness or fatigue of the surveyor are classed under this category. This type of error can be minimized with care and vigilance by the part of the surveyor.

b) ***Instrumental:*** it is the error type that occurs due to imperfection of the instruments in manufacture and during adjustments and due to wear and tear by usage. Also included are mistakes due to failure or damage of the instrument. This type of error can be minimized with careful handling, maintenance and adjustment and calibration of instruments and by applying corrections.

d) ***Natural***: included under this are errors due to effect of temp, pressure, humidity, magnetic variation etc. this type of error can be minimized by applying correction and by carrying out the survey when their effect is minimal.

Types of errors:

a. Mistake: These actually are not error because they usually are so gross in magnitude compared to the other two types. These are rather blunder made by surveyor or his equipment and can occur at any stage of the survey (during reading, recording computing and plotting).

Errors and Corrections

b) Systematic errors: These are error types with relatively small magnitude compared to mistakes, and are result of some systems whose effect can be expressed in mathematical relations; hence their magnitude and sign can be estimated (determined). In most cases, the system causing the systematic error can be personal, instrumental or physical and environmental conditions or may be result of choice of geometric or mathematical model used.

c) Random errors: These are types of errors that remain after elimination of mistakes and systematic errors. They occur because neither the surveyor nor his instruments are perfect. They are random in their nature and are thought to have normal probability distribution. Their effect can be greatly decreased by exercising care and vigilance by the part of surveyors and by using high precision instruments.

Systematic Errors in Taping and Corrections:

1. Tape is not of standard length: a tape may be too short or too long when compared to a standard tape under specific conditions of tension, temperature and method of support. When the tape is too short the surveyor will actually measure a distance less than that shown on the graduations. Hence, a negative correction is needed. Similarly, when the tape is too long, a distance greater than that shown on the graduations is measured, hence a positive correction is applied.

The correction can be done by using the following formulas:

- For measuring length: $\frac{Actual\ length}{Measured\ length} = \frac{Length\ of\ used\ tape}{Length\ of\ standard\ tape}$
- For measuring area: $\frac{Actual\ area}{Measured\ area} = \left(\frac{Length\ of\ used\ tape}{Length\ of\ standard\ tape}\right)^2$
- For measuring volume: $\frac{Actual\ volume}{Measured\ volume} = \left(\frac{Length\ of\ used\ tape}{Length\ of\ standard\ tape}\right)^3$

2. Variation due to temperature: this causes expansion or contraction of the material of which the tape is made.

$$C_t = \alpha * L * \Delta T$$

$C_t = correction\ due\ to\ temperature,\quad \alpha = temperature\ expansion\ factor$

$L = distance\ measured,\ \Delta T = difference\ in\ temperature\ (°C)\ or\ (°F),\ \ °F = 32 + (1.8 * °C)$

$$\alpha = \frac{0.00000645}{unit\ length\ * °F} \quad , \quad \alpha = \frac{0.000064}{unit\ length\ * °C}$$

3. Variations in tension/pull: if the tension force that is used for pulling the tape is greater than the standard, tension errors exist which can be found by using the following formula:

$$C_p = \frac{(P - P_s)}{A * E} * L$$

$C_p = correction\ due\ to\ tension,\quad P = Applied\ tension,\quad P_s = standard\ P$

$A = cross\ sectional\ area,\quad E = elastic\ modulus\ (200\ Gpa, or\ 29\ Mpsi)\ , L = length\ of\ tape$

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4. Sag Correction:

$$C_s = \frac{-w^2L^3}{24 * P^2} = \frac{-W^2L}{24 * P^2}$$

$C_s = Sag\ correction\ per\ length\ (m\ or\ ft),$

$w = weignt\ of\ tape\ per\ unit\ length\ (N\ or\ lb)$

$W = weignt\ of\ tape\ (N\ or\ lb),$

$L = length\ of\ tape,\qquad P = Applied\ tension\ (N\ or\ lb)$

5. Slope correction:

$$\cos\alpha = \frac{Horizontal\ distance\ (H)}{Sloped\ distance\ (S)} \Rightarrow H = S * \cos\alpha$$

Example (1): Find the horizontal distance, when a slope rise from one points a distance of (156.77 m) to another point at a rate of (+1.5%)?

Solution:

$$\tan\alpha = \frac{1.5}{100}$$

$$\alpha = \tan^{-1}\frac{1.5}{100} = 0.85937^o$$

$$H = S * \cos(0.85937^o)$$

$$H = 156.77 * \cos(0.85937^o)$$

$$\Rightarrow H = 156.759\ m$$

Example (2): A measurement was recorded as (171.278 m) with a (30m) Tape length, that was only (29.996m) under standard conditions. What is the correct measurement?

Solution:

$$\frac{\textit{Actual length}}{\textit{Measured length}} = \frac{\textit{Length of used tape}}{\textit{Length of standard tape}}$$

$$\frac{\textit{Actual length}}{171.278} = \frac{29.996}{30}$$

$$\therefore \textit{Actual length} = 171.255$$

Example (3): You must layout two points in the field that will be exactly (100m) a part. Fields condition indicate that the temperature of the tape (27°C). What distance will be layout?

Solution:

$$C_t = \alpha * L * \Delta T$$

$$C_t = 0.000064 * 100 * (27 - 20)$$

$$\Rightarrow C_t = 0.0448\, m$$

Example (4): A (30m) steel tape is used with a (100 N) force, instead of standard tension (50 N). If the X-sectional area of the tape is (0.02 cm^2). What is the tension error per tape length?

Solution:

$$C_p = \frac{(P - P_s) * L}{A.E} = \frac{(100 - 50) * 30}{0.02 * 10^{-4} * 200 * 10^9}$$

$$\therefore C_p = 3.75\, mm\, (+)$$

Question 2 / Semester 1 / (2014-2015)

A (20m) standard tape was used for measuring line AB and measured (679.88m) while the actual length is (681.24m) at temperature (40C°). Use ∝=0.0002m/m/C°

1. Find the used tape length.

$$\frac{Actual\ length}{Measured\ length} = \frac{Length\ of\ used\ tape}{Length\ of\ standard\ tape} \rightarrow \frac{681.24}{679.88} = \frac{Length\ of\ used\ tape}{20}$$

$$Length\ of\ used\ tape = 20.04m$$

$$C_t = \propto L\ \Delta T = 0.0002 * 20 * 20 = 0.08$$

$$\therefore Actual\ Length\ of\ the\ tape = 20.04 - 0.008 = 19.96m$$

2. At which temperature should the tape be used so that the error approaches to zero?

$$C_t = \propto L\ \Delta T \rightarrow\ 0.0002 * 20 * (T2 - 20) = 0.04$$

$$\therefore T2 = 30$$

Obstacles in chaining: there are three types:

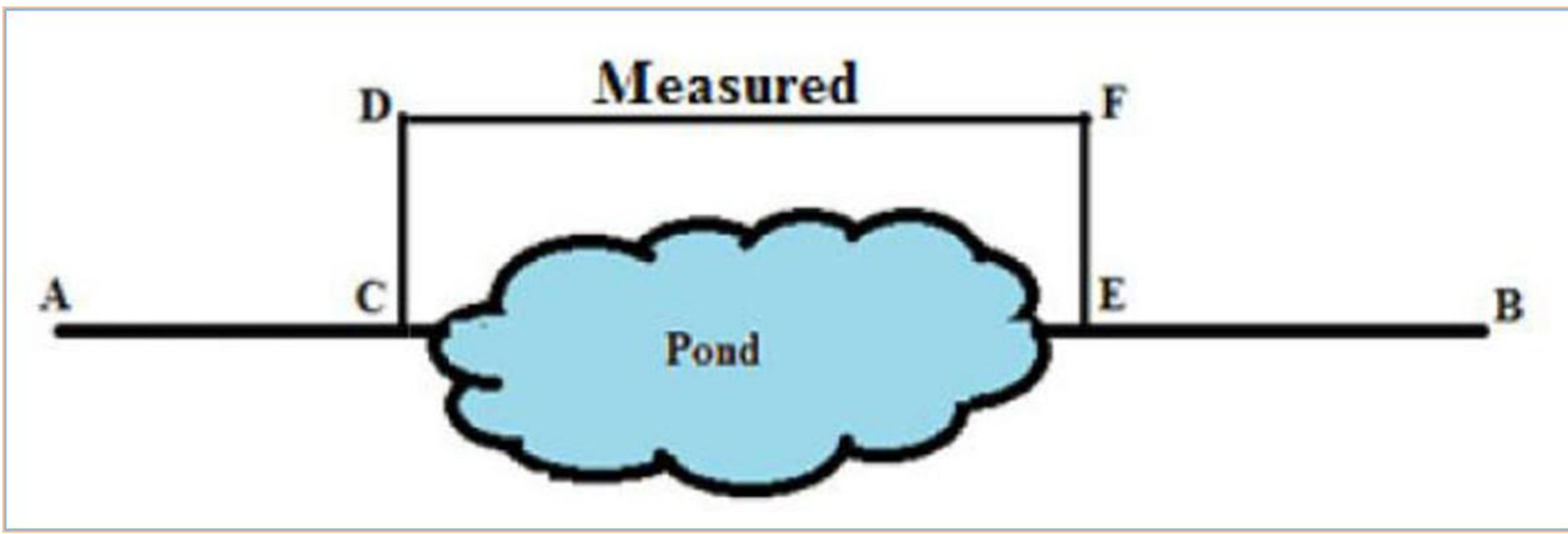
1. Obstacles to ranging: Solution by (Ranging rod) process, that illustrate in the past.

2. Obstacles to chaining but not ranging: there are some cases and illustrated below:

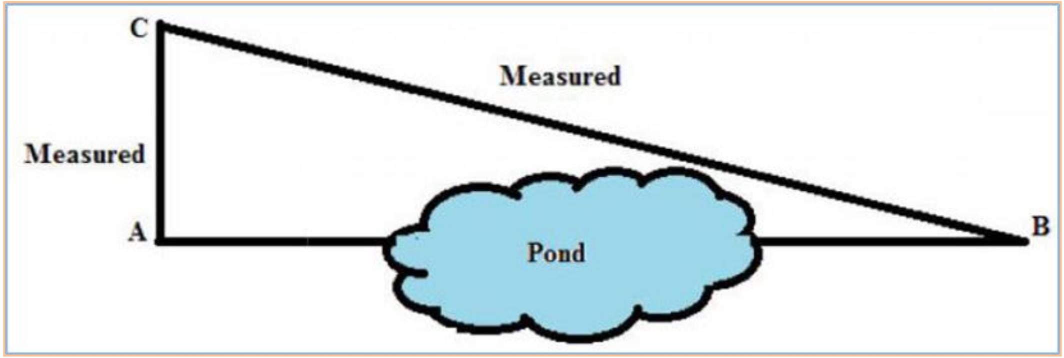
Case 1: When it is possible to chain round the obstacle, like (a pond).

a.

$$L = AC + DF + EB$$



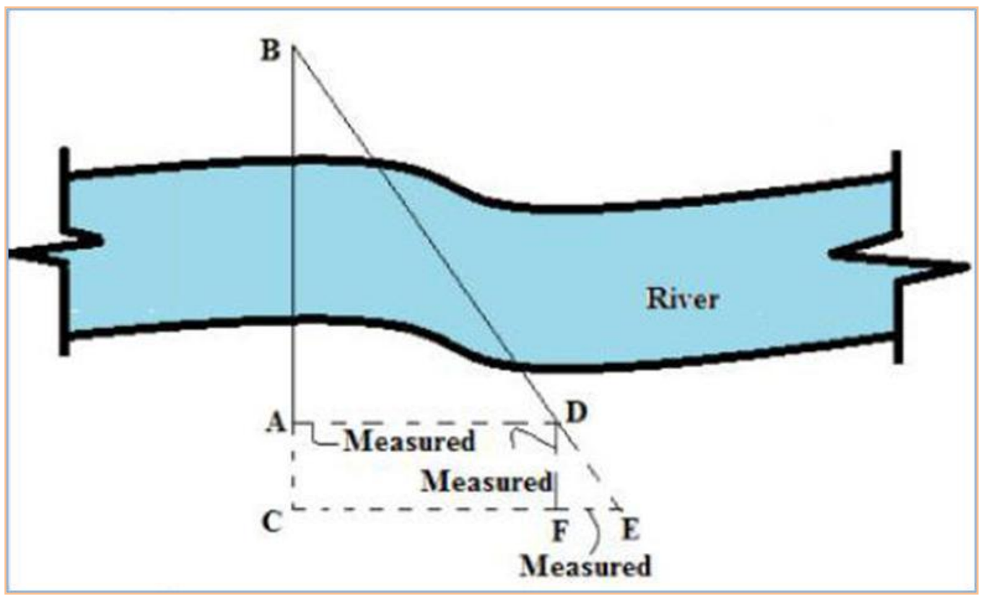
$$AB^2 = CB^2 - CA^2$$



Case 2: When it is not possible to chain round the obstacle, like (a river).

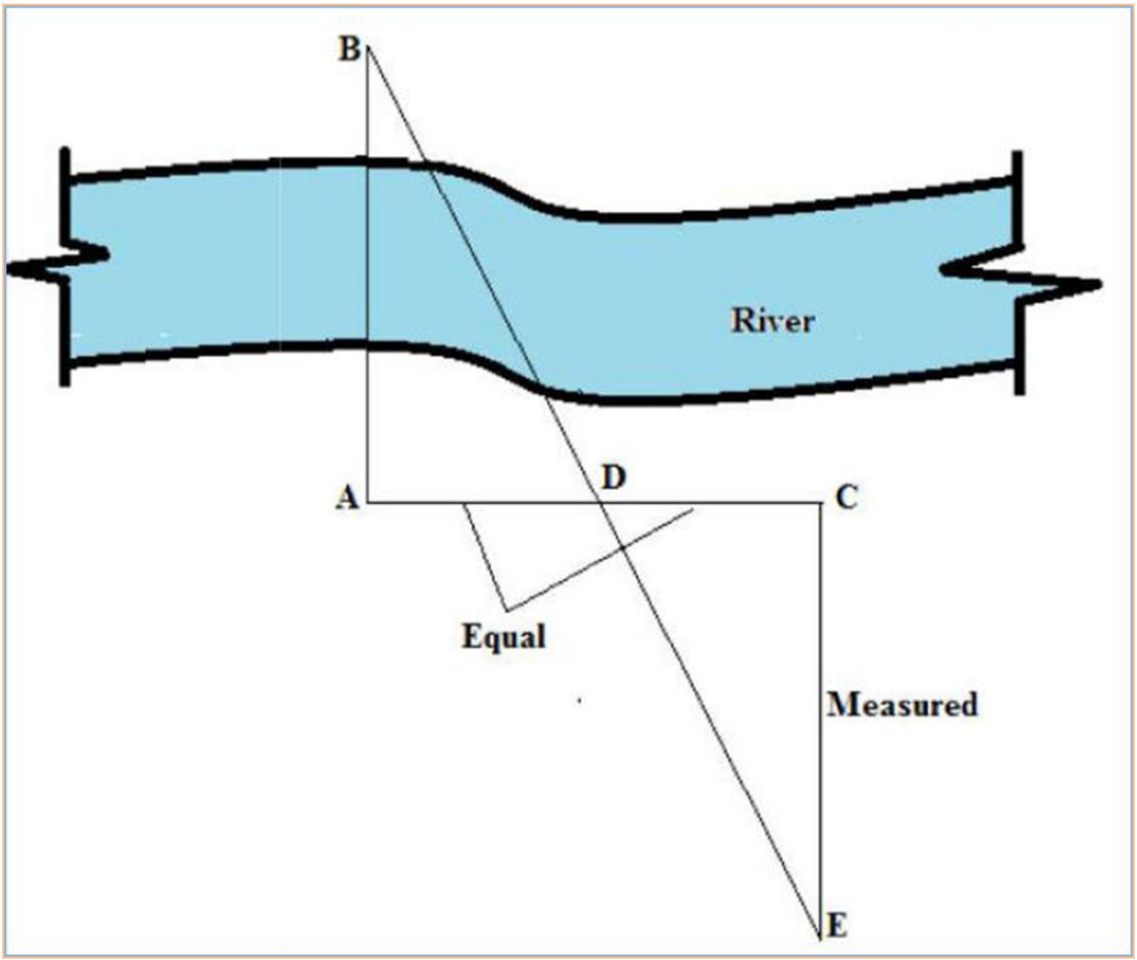
a. $$\frac{AB}{DF} = \frac{AD}{FE}$$

$$\therefore AB = DF * \frac{AD}{FE}$$



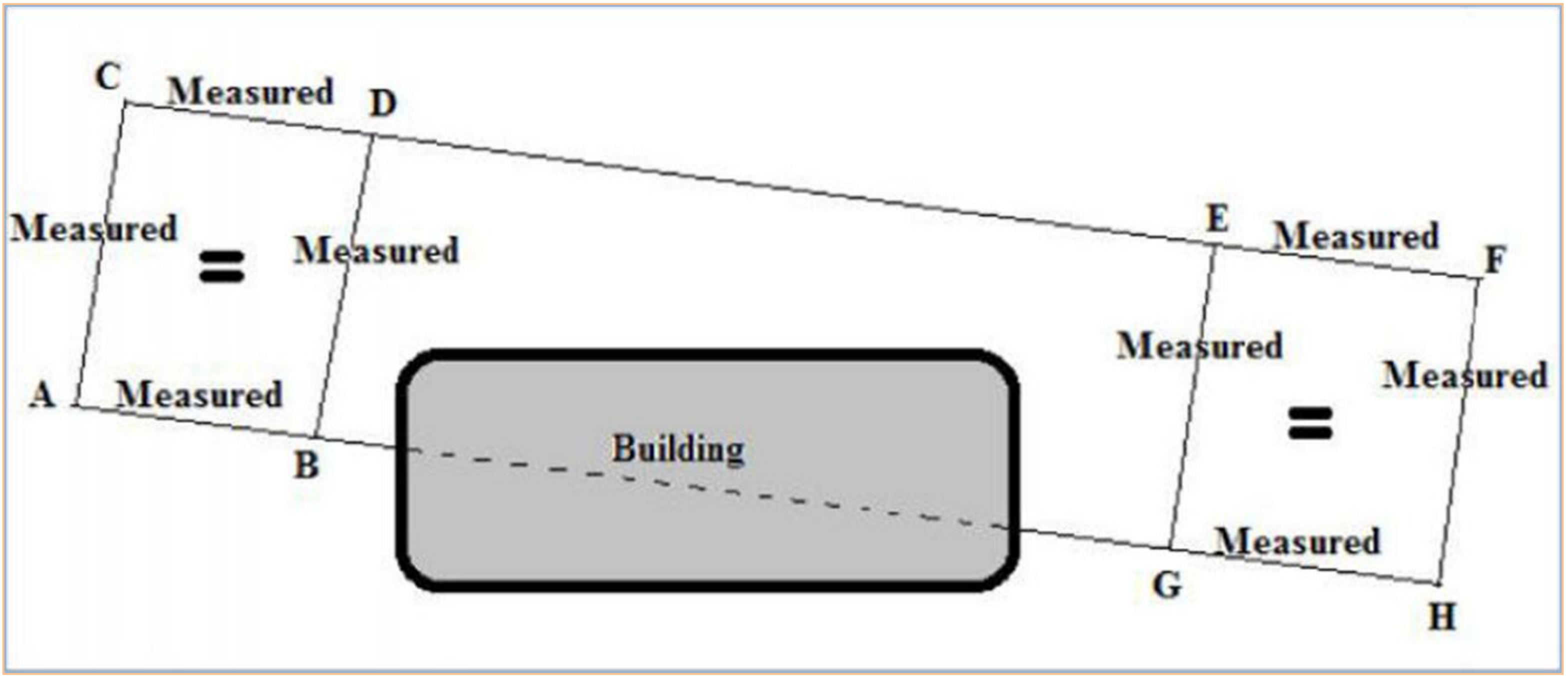
b.

$$AB = CE$$



3. Obstacles to both chaining and ranging: A building is typical example on this type of obstacles. At first, marking point B and G but necessary AB is equal to HG, after that perpendicularly at the same length drawing lines AC, BD, GE, and HF, finally measuring CD, DE, and EF.

$$AH = CD + DE + EF \qquad or \qquad AH = AB + DE + GH$$

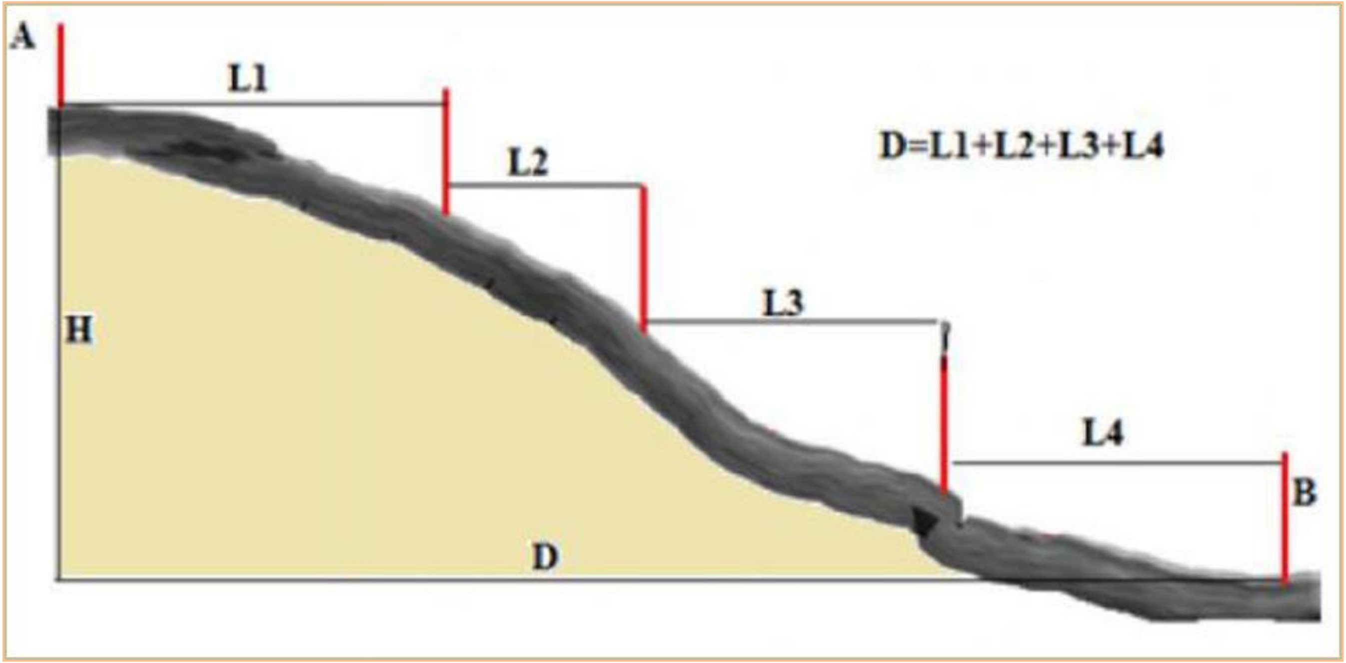


Measurement distances on sloping ground:

1. Direct method:

For all plotting works horizontal distances between the points are required. It is therefore necessary either to directly measure the horizontal distance between the points or to measure the sloping distance and reduce it to horizontal as explained in the figure below.

$$D = L_1 + L_2 + L_3 + L_4$$



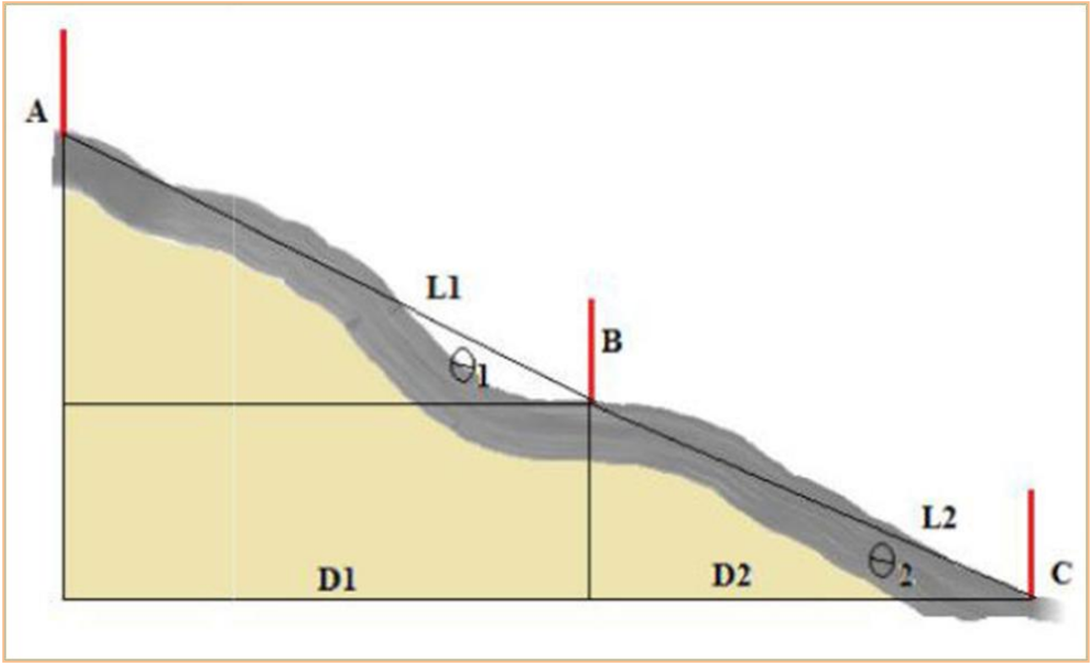
2. Indirect method:

a. Angle measured:

$$total\ distance = D_1 + D_2$$

$$D_1 = L_1 * \cos\theta_1 \ , \qquad and \qquad D_2 = L_2 * \cos\theta_2$$

-The slope of the lines can be measured with the help of Clinometers.



Clinometer

- Clinometers are simple shape consist of:

1. A line of sight.
2. A graduated arc.
3. A light plumb bob with along thread suspended at the centre.