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Engineering Surveying
Theory 2:
Units of Measurements & Principles of Surveying

Basic Units of Measurements In Surveying

In surveying; the most commonly employed units are for: **length, area, volume, and angle**

Two different units are in use for specifying units:

1. **Metric system (international system SI)**
2. **English system.**

- **Metric system (international system SI)**

  For length; km, m , cm , mm
  For area ; Km^2, m^2, cm^2, mm^2
  For volumes; km^3, m^3, cm^3, mm^3

- **English system**

  For length; mile , yard(y) , foot (ft) , inch(in)
  For area; $mile^2$, y^2, ft^2, in^2
  For volumes; $mile^3$, y^3, ft^3, in^3

Basic Units of Measurements In Surveying

Measurements Table

Linear measurements	Metric (SI) units
1 kilometer (km)	1000 meter (m)
l meter (m)	100 centimeter (cm)
1 centimeter (cm)	10 millimeter (mm)
1 hectare (ha)	10 000 m2
1 square kilometer	1 000 000 m2
1 square kilometer	100 hectares

Basic Units of Measurements In Surveying

Linear Measurements		Foot units	
1 miles =	5280 feet	1 foot	12 inches
	1760 yards	1 yard	3 feet
	320 rods	1 rod	16.5 feet
	80 chains	1 chain	66 feet
		1 chain	100 links
1 acre = 43560 ft square = 10 square chains			

Foot units	
1 foot (ft)	12 inches (in)
1 yard (yd)	3 feet (ft)
1 chain	66 feet (ft)

1 mile =	5280 feet
	1760 yards
	80 chains

Basic Units of Measurements In Surveying

Foot –to – metric conversion	
1 ft	0.3048 m (exactly)
1 inch	2.54 cm (exactly)
1 km	0.62137 miles
1 meter = 39.37 inches = 3.28 feet	

Conversions	
1 inche =	25.4mm
1 ft =	0.3048 m
1 km	0.62137 miles
1 hectare (ha)	2.471 acres
1 sq. kilometer	247.1 acres

Basic Units of Measurements In Surveying

Angles:

Angular Measurement (degree system)	
1 revolution	360 degree
1 degree	60`
1 minute	60`` (seconds)

Angular Measurement (radian system)	
total angle	2 π
$\theta_{(rad)}$ =	$\theta_{(degree)}$ x (π/180)
$\theta_{(degree)}$=	$\theta_{(rad)}$ x (180/π)

- ✓ Example: Convert 2.053rad to degree:
  - Solution: $\theta_{degree} = \theta_{rad} * \frac{180}{\pi} = 2.053 * \frac{180}{\pi} = 117.580^{o} = 117^{0}\ 34`\ 48``$
- ✓ Example: Convert 11.111^{o} to θ_{rad}:
  - Solution: $\theta_{ra} = \theta_{degre} * \frac{\pi}{180} = 11.111^{o} * \frac{\pi}{180} = 0.194\ _{ra}$

Basic Units of Measurements In Surveying

Example 1: convert 1.7 mile to meter.

1 mile = 5280 feet > 1 ft = 12 in > 1 in = 2.54 cm = 0.0254 m

= 1.7 * 5280 * 12 * 0.0254 = 2735.885 m

Example 2: convert 500 m sq. to in sq.

1 in = 2.54 cm = 0.0254m

= 500/(0.0254)^2 = 775001.55 in sq.

Example 3: convert 20 yard^3 to cm^3

1 yard = 3 ft > 1 ft = 12 in > 1 in = 2.54 cm

= 20 * (3 * 12 * 2.54)^3 = 20 * 764554.857984 = 15291097.16 cm^3

Q1/B: Convert 3 of the following measured data.

(1) Convert 1.99 rad to degree, (2) convert 0.99 mile to meters, (3) convert 13 yard^3 to cm^3, (4) Convert 2.3 km^2 to Hectare

1. $\theta_{degree} = \theta_{ra} * \frac{180}{\pi} = 1.99 * \frac{180}{\pi} = 114.0764^{o} = 114^{0}\ 4`\ 35``$
2. 1 mile = 5280 feet > 1 ft = 12 in > 1 in = 2.54 cm = 0.0254 m

   = 0.99 * 5280 * 12 * 0.0254 = 1593.25056 m
3. 1 yard = 3 ft > 1 ft = 12 in > 1 in = 2.54 cm

   = 13 * (3 * 12 * 2.54)^3 = 9939213.154 cm^3
4. = 2.3*1000000/10000= 2.3*100 = 230 hec.

Scales

The scale of a map or a plan is the ratio of a distance measured on the plan or map to its corresponding distance on the ground. Example 1:100, 1:10,000. Scale primarily depends on the type of the work done (the accuracy with which a distance is to be transferred from the map or the plan). In general, scales may be categorized as follows:

For maps

a) Large scales < 1:200

b) Intermediate scales 1:2000 to 1:10,000

c) Small scales 1:10,000 to 1:100,000,000

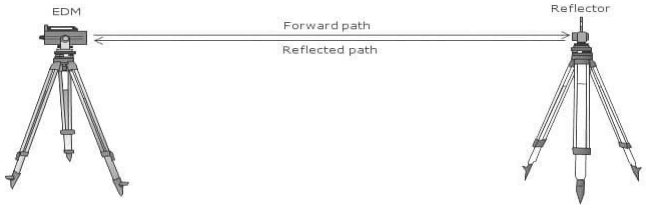
For plans

d) Site plans 1:50 to 1:500

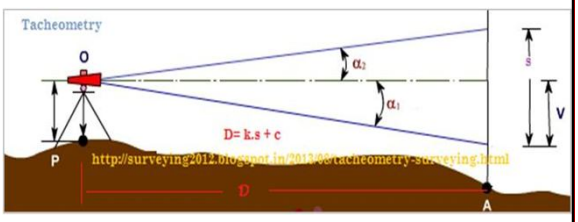
e) Detail plans 1:1 to 1:20

Types of Linear Distance Measurement

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



2. Optical Method: by Theodolite instrument.



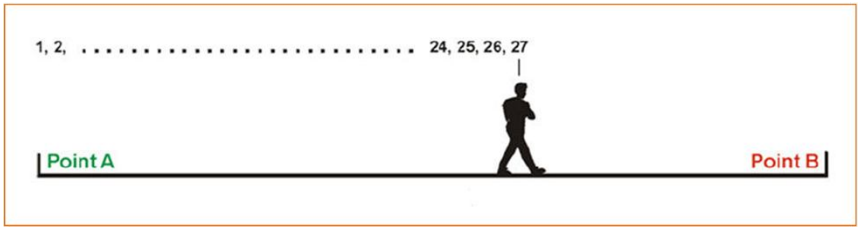
3. Direct Method: Is very important and use in general:

Direct Method

Approximate 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.

Chaining and taping

Chain and Tape: Chaining is a term which is used to denote measuring distance either with the help of a chain or a tape and is the most accurate method of making direct measurements.
The surveying chain or Gunter chain is 66 feet long and divided into 100 links each link equal to 0.66 foot.

Chaining and taping

Nowadays, tape has been using instead of Chain because it is metric system and more accurate. This metric Tape is available in length of 5, 10, 15, 20, 30, 50, and 100 m.

Apparatus used in chaining:

1. Chain or Tape:

Tape has four types

a. Cloth tape
b. Metallic tape
c. Steel tape
d. Invar tape.

Chaining and taping

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

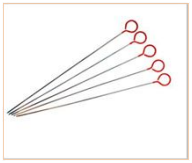
1. It's affected by moisture dampness and thus shrinks.
2. It's likely to twist.
3. It's not strong.

-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

Chaining and taping

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



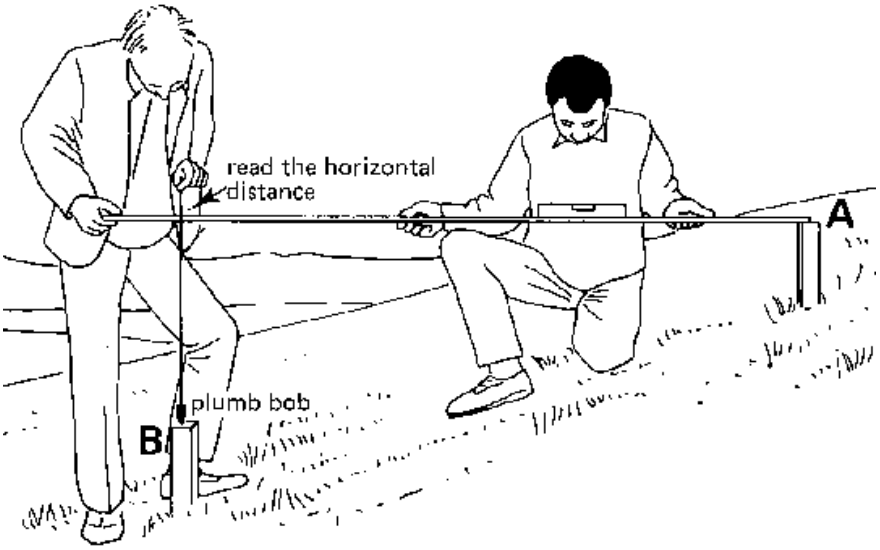
3. Pegs: Steel or wooden pegs are used to mark the positions of the stations. The height is (15 cm).

4. Ranging rods: For temporary marking. They have a length of either 2m or 3m, the 2m length being more common. They are painted in alternative bands of either black and white or red and white.

5. Plumb bob:

while chaining along sloping ground is required to transfer the points to the ground. It is also used to make ranging poles vertical and to transfer points from a line ranger to the ground. In addition, it is used as centering aid in Theodolite.

Chaining and taping



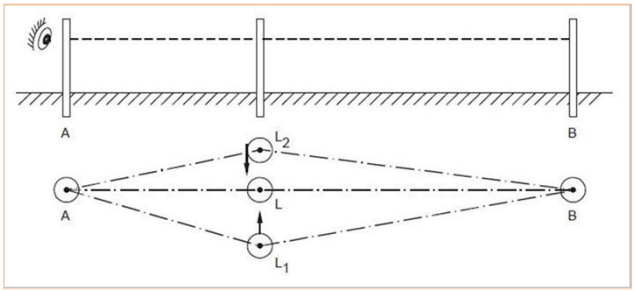
Chaining and taping

-There are two cases for measurement distance by Tape

First: If the length is less than tape or chain length for horizontal ground length is easy.
Second: If the length is more than tape or chain length. In this case the ranging rod process is necessary.

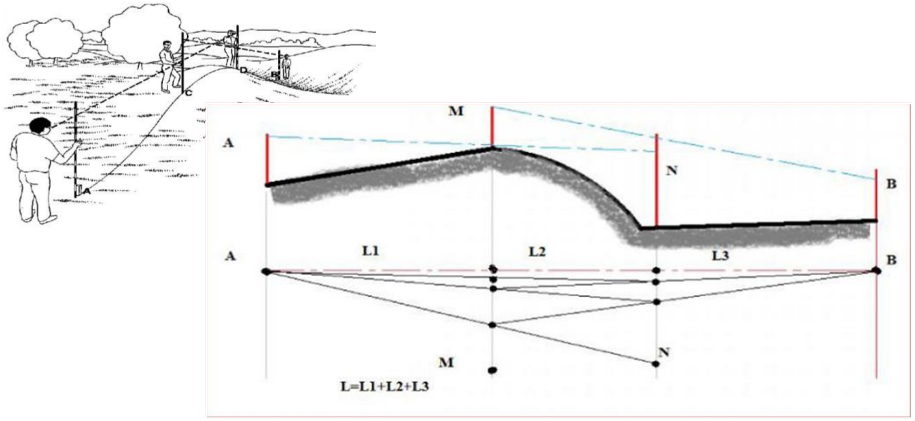
-Ranging rod process:

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.



Chaining and taping

2. Indirect or reciprocal ranging: 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 M and N where from N we can see M and A, also from M we can see N and B.



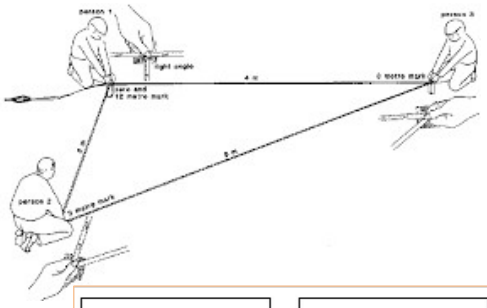
Chaining and taping

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.

Chaining and taping

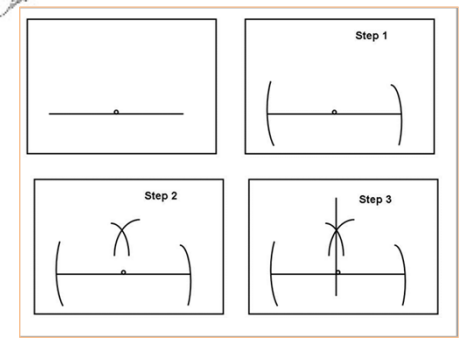
How to draw a perpendicular?



A. Where the point is on the line:

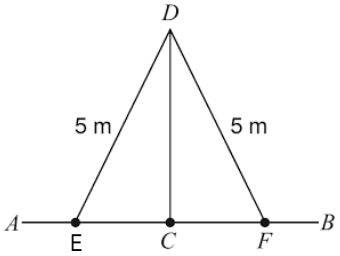
1. By 3-4-5 Method:

2. By arc method:



3. Equal distances:

Again AB as shown below is the chain line. It is required to erect perpendicular at C on the chain line. Select two points E and F on the chain line equidistant from C. Zero end of the chain is held at E, and 10 m end at F. Pick up the 5 m mark, stretch the tape tight and establish the point D. Join DC and this DC at C is the perpendicular to the chain line. Here, $DE = 5$ m, $DF = 5$ m, $CE = CF$.

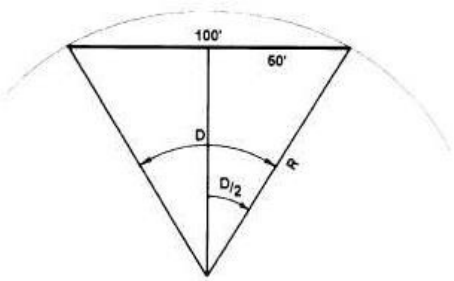


Equidistant method.

Chaining and taping

B.Where the point is outside the line:

1. by cord bisection method.
2. by optical square.
3. by prism.

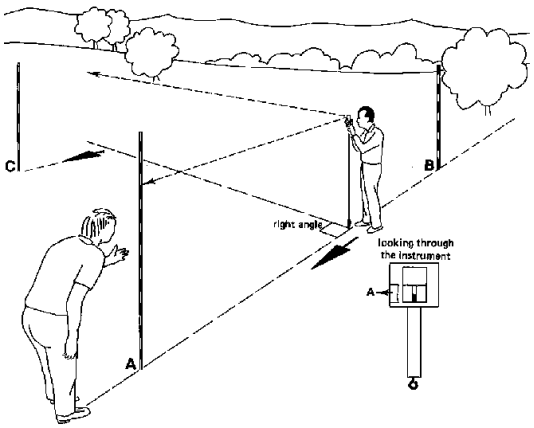


Cord bisection method

Chaining and taping

B.Where the point is outside the line:

1. by cord bisection method.
2. by optical square.
3. by prism.



Using optical square

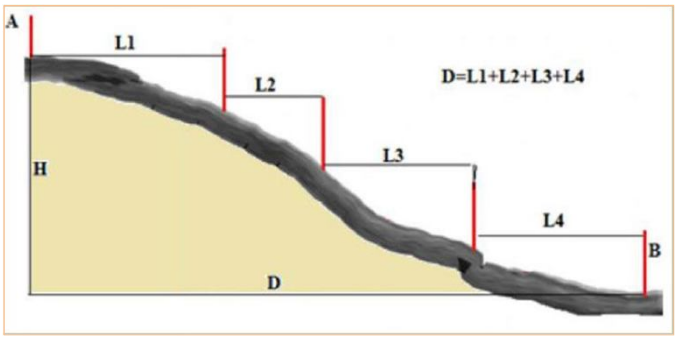
Distance Measurement

Measurement distances on sloping ground:

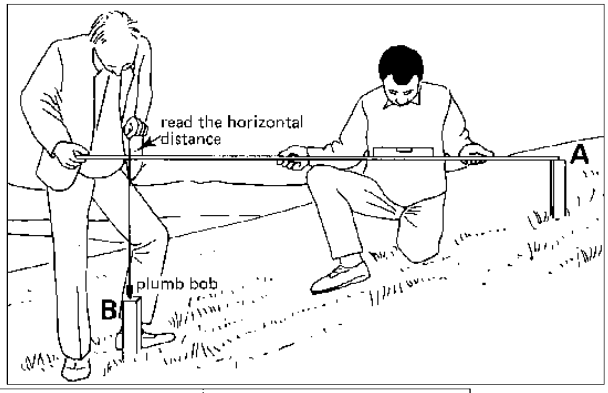
1. Direct method:

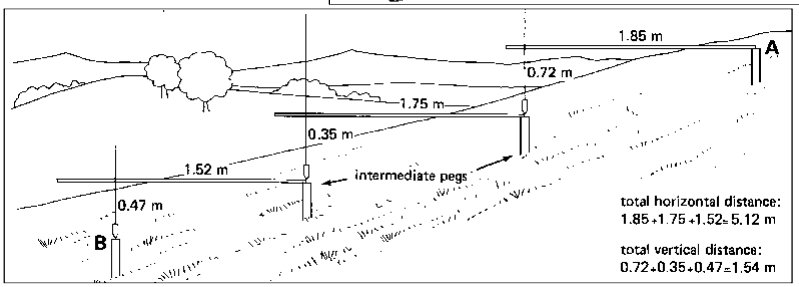
For all plotting works horizontal distances between the points are required. It is therefore necessary either to directly measure the horizontal distance between the points or to measure the sloping distance and reduce it to horizontal as explained in the figure below.

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



Again slide 14





Distance Measurement

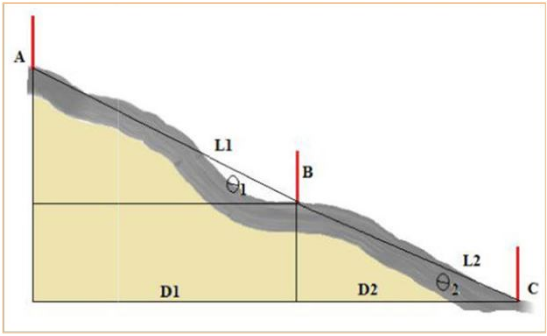
2. Indirect method:

a. Angle measured:

$$total\ distance = D_1 + D_2$$

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

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



Distance Measurement

- 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.