Geological Mapping & Surveying

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Measurements

Linear measurements:

Meaning of distance in surveying, Chain and tapes and their types, Taping and chaining

Ranging direct and indirect, corrections to distance measured.

No.	Plain Surveying	Geodetic Surveying
1	The earth surface is considered as plain Surface.	The earth surface is considered as Curved Surface.
2.	The Curvature of the earth is ignored	The curvature of earth is taken into account.
3	Line joining any two stations is considered to be straight	The line joining any two stations is considered as spherical.
4.	The triangle formed by any three points is considered as plain	The Triangle formed by any three points is considered as spherical.
5.	The angles of triangle are considered as plain angles.	The angles of the triangle are considered as spherical angles.
6.	Carried out for a small area < 250 km^2	Carried out for a small area > 250 km^2

Measurement

Measurement is the process of determining or finding a target's size, length, weight, capacity, quantity or other aspect.

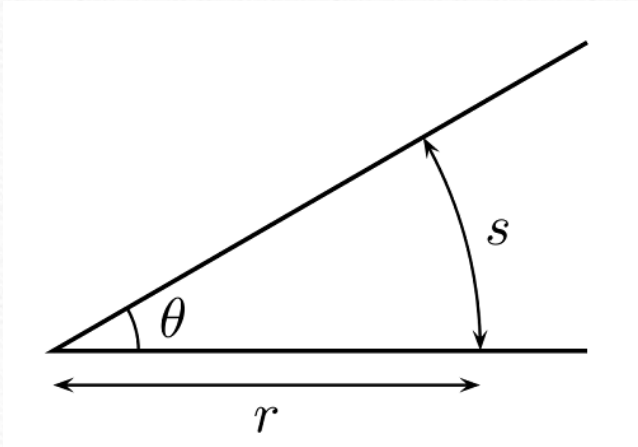
The principle dimensional measurement is length; secondary measurement is angle and curvature. You can describe shape without describing size, but not the reverse.

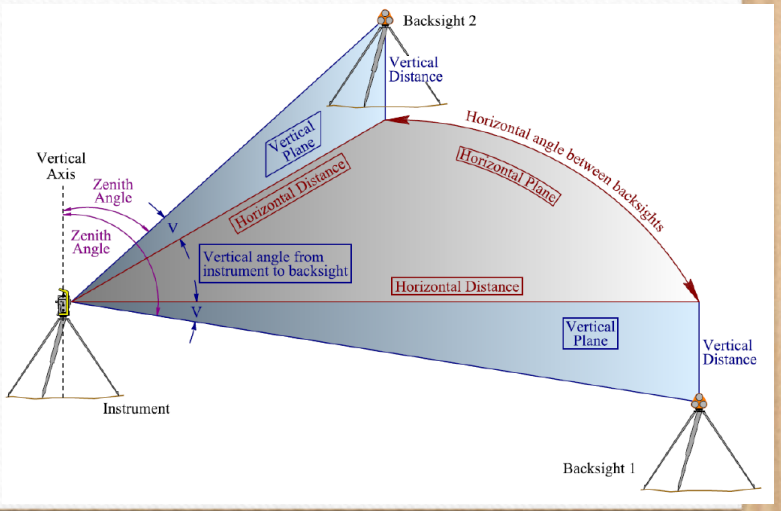
Measurement is the assignment of a number to a characteristic of an object or event, which can be compared with other objects or events.

Types of Measurements in surveying

Surveying is the art of making suitable measurements in horizontal or vertical planes. Two kinds of measurements are:-

1. Linear Measurements
   - Horizontal Distance
   - Vertical Distance
2. Angular Measurements





Methods of Linear Measurement

There are various methods of making linear measurements and their relative merit depends upon the degree of precision required.

They can be mainly divided into three heads:

Direct Measurements: Distances are actually measured on the ground with help of a chain or a tape or any other instrument.

Measurements by Optical Means: Observations are taken through a telescope and calculations are done for the distances, such as in tacheometry or triangulation.

Electronic Methods: Distances are measured with instruments that rely on propagation, reflection and subsequent reception of either radio or light waves.

Direct Measurements

The various methods of measuring the distances directly are as follows:

A. Pacing or Stepping
B. Measurement with Passometer
C. Measurement with Pedometer
D. Measurement by Odometer and Speedometer
E. Chaining or Taping

Pacing or Stepping: For rough and speed work, distances are measured by pacing, i.e. by counting the number of walking steps of a man. The walking step of a man is considered as 2.5 ft or 80 cm.

Measurement with Passometer: Passometer is an instrument shaped like a stop watch and is carried in pocket or attached to one leg. The number of paces registered by the passometer can then be multiplied by the average length of the pace to get the distance.

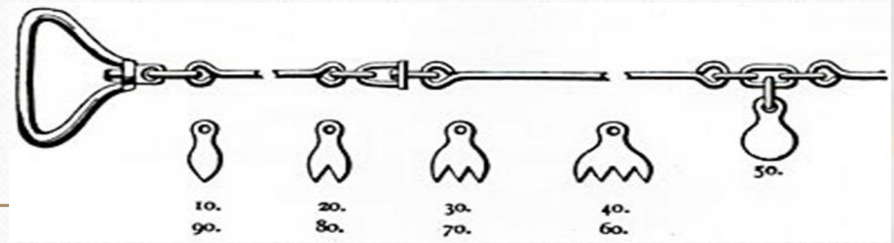
Measurement with Pedometer: Pedometer is a device similar to the Passometer except that, adjusted to the length of the pace of the person carrying it, it registers the total distance covered by any number of paces.

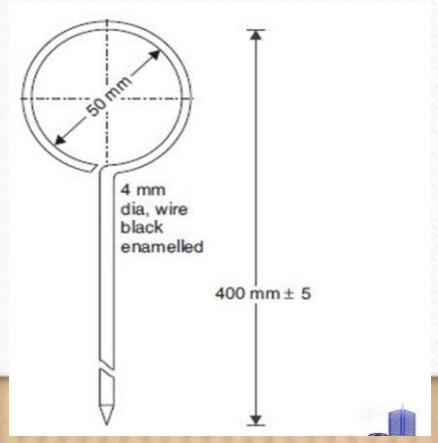
Measurement by Odometer and Speedometer: Odometer is a wheel fitted with a fork and handle. The wheel is graduated and shows a distance per revolution.

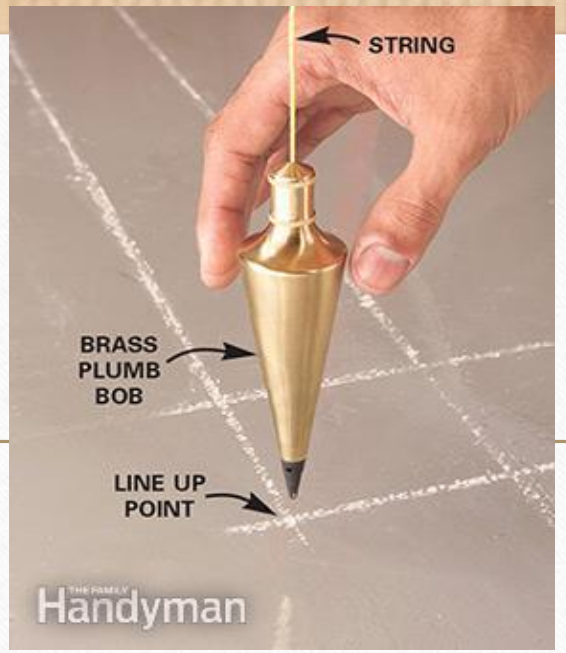
Chaining: Chaining is a term which is used to denote measuring distance either with the help of a chain or a tape and is the most accurate method of making direct measurements.

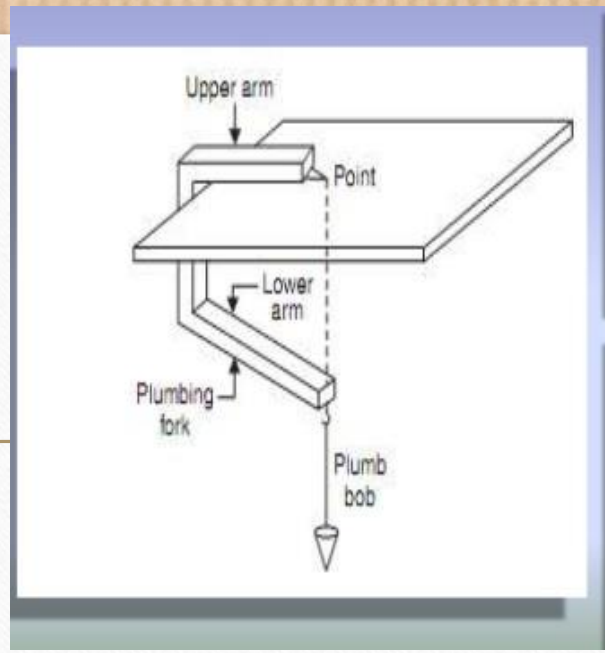
The various instruments used for the determination of the length of line by chaining are as follows

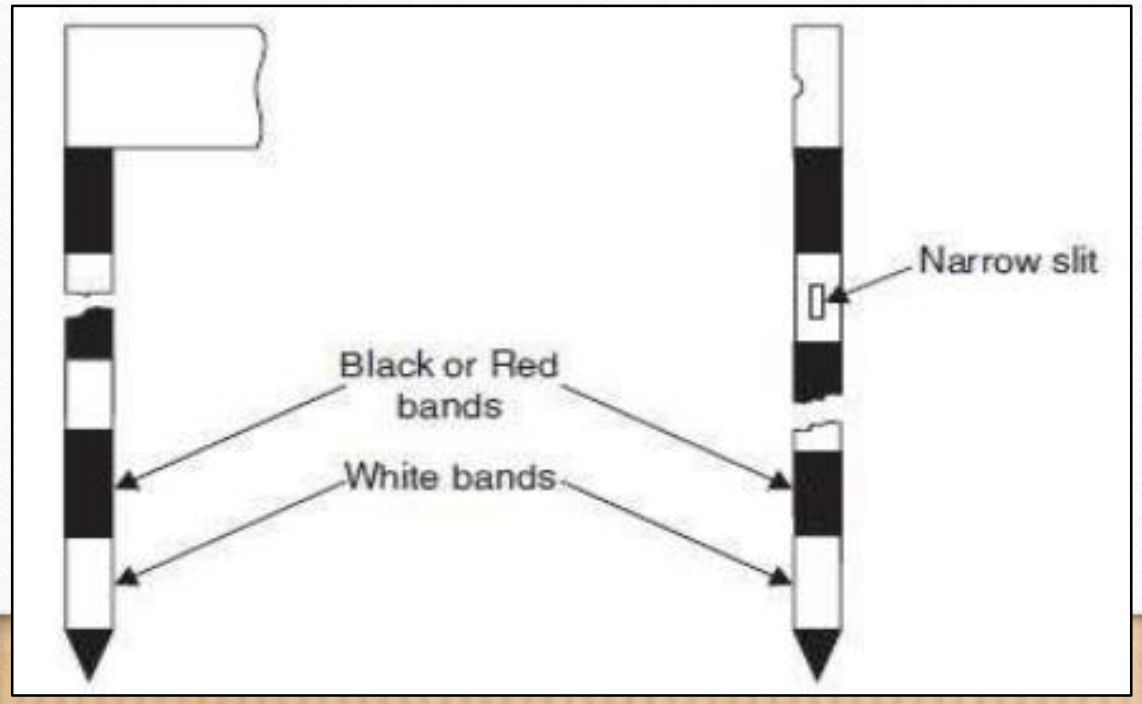
- **Chain or tape**
- **Arrows**
- **Pegs**
- **Ranging rods**
- **Offset rods**
- **Plumb bob**





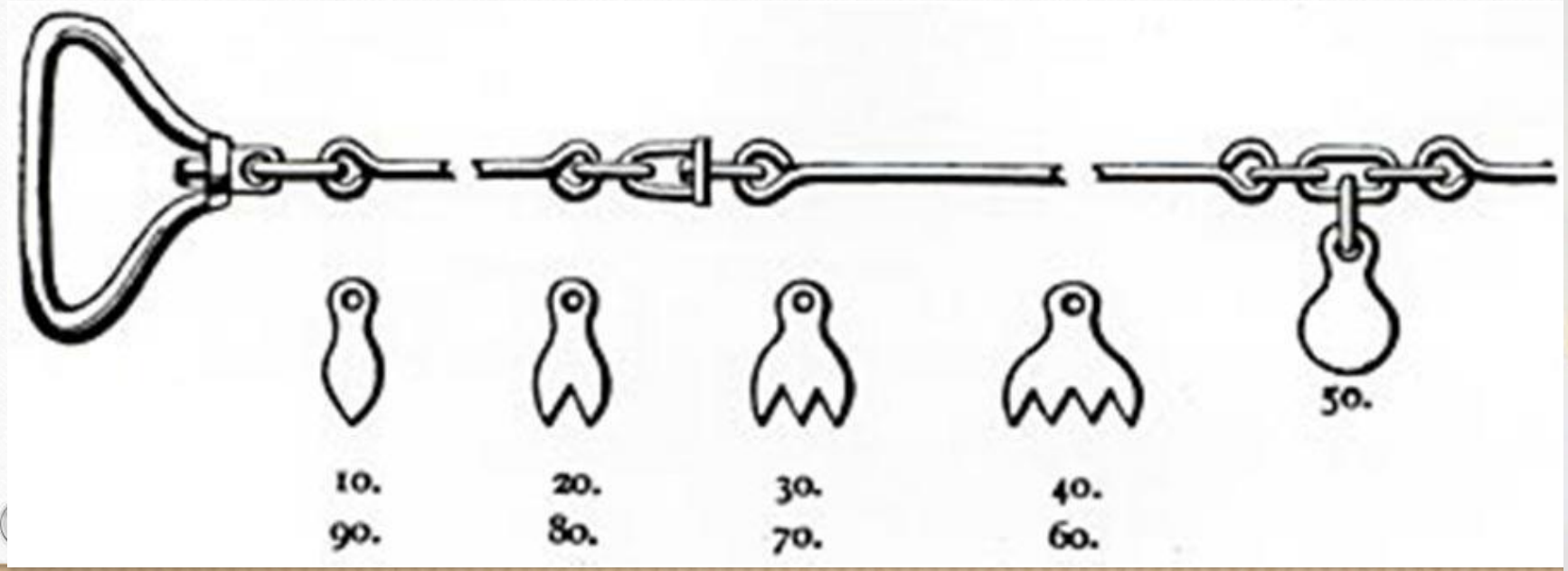

STRING
BRASS PLUMB BOB
LINE UP POINT
Handyman


Upper arm
Point
Lower arm
Plumbing fork
Plumb bob


Narrow slit
Black or Red bands
White bands

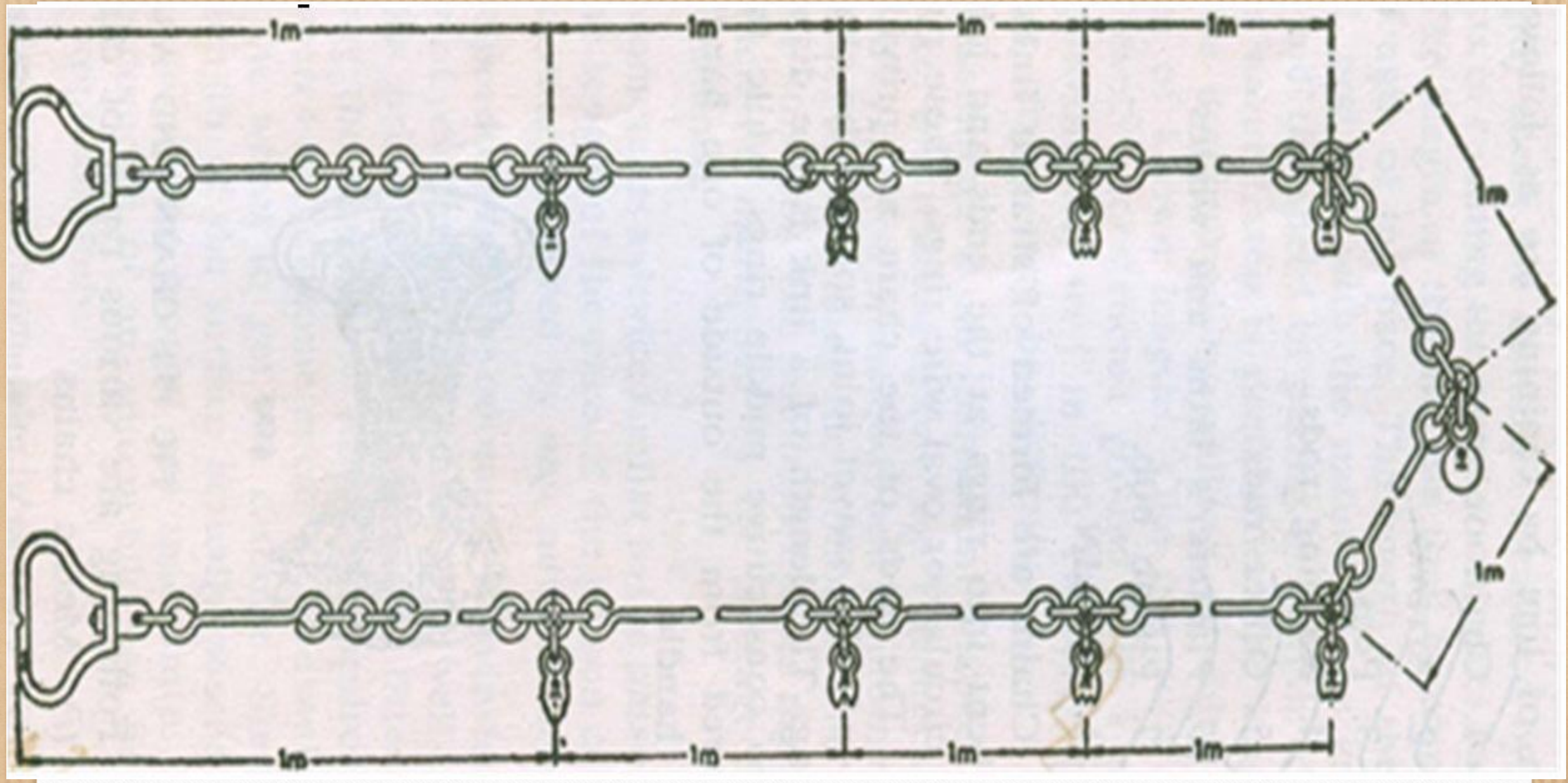
Chain: Chains are formed of straight links of galvanized mild steel wire bent into rings at the ends and joined each other by three small circular or oval wire rings. These rings offer flexibility to the chain. The ends of the chain are provided with brass handle at each end with revolve joint, so that the chain can be turned without twisting. Tallies are provided at every 10 or 25 links for facility of counting.

The length of a link is the distance between the centers of two consecutive middle rings, while the length of the chain is measured from the outside of one handle to the outside of the other handle.



Metric Chains: Metric chains are generally available in lengths of 5, 10, 20 and 30 metres. To enable the reading of fractions of a chain without much difficulty, tallies are fixed at every metre length for chains of 5 m and 10 m lengths and at every five-metre length for chains of 20 m and 30 m lengths.

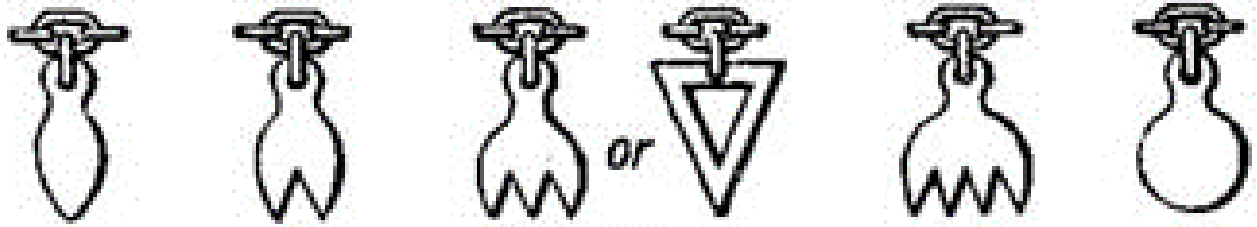
In the case of 20 m and 30 m chains, small brass rings are provided at every metre length, except where tallies are attached.


1m
1m
1m
1m
1m
1m
1m
1m
1m
1m

Gunter's Chain or Surveyor Chain: Gunter's Chain or 66 ft. Chain: Divided into 100 links, each link is of 0.66 ft. or 7.92 inches.

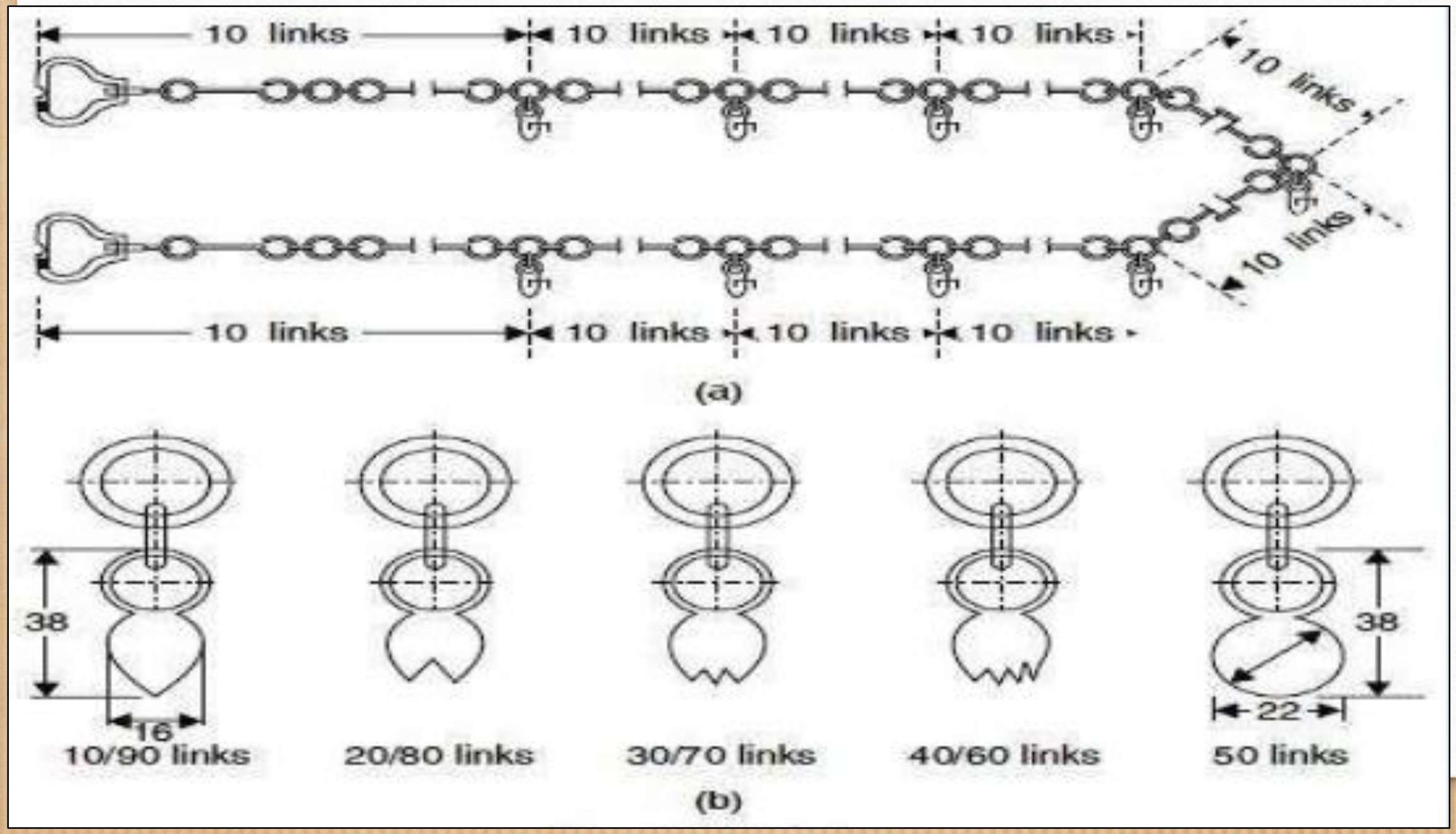
Also called Surveyor's chain. Engineer's chain and Gunter's chain are commonly used in our country.

It was previously used for measuring distance in miles and furlongs (10 Gunter's chain = 1 furlong 80 Gunter's chain = 1 mile)



Tallies on a Gunter's Chain

Engineer's Chain: The engineer's chain is 100 ft. long and consists of 100 links, each link being 1 ft. long. Tallies are provided at every 10 links, then central tally being round.


10 links
10 links
10 links
10 links
10 links
10 links
10 links
10 links
10 links
10 links
(a)
38
16
10/90 links
20/80 links
30/70 links
40/60 links
38
22
50 links
(b)

Revenue Chain: The revenue chain is 33 ft long and consists of 16 links each link being 2 1/16 ft long. It is mainly used in cadastral survey.

Steel Band or Band Chain: The steel band consists of a long narrow strip of blue steel, of uniform width of 12 to 16 mm and thickness of 0.3 to 0.6 mm. Metric steel band are available in lengths of 20 or 30 metres. It is graduated in meters, decimeters and centimeters on one side and has 0.2 m links on the other. It is used in projects where more accuracy is required.

Revenue Chain

- Length 33’

Tapes: Tapes are available in a variety of materials, lengths and weights. The different types of tape in general use are discussed below:

Cloth or Linen Tape: These are closely woven linen or synthetic material and are varnished to resist the moisture. These are available in 10 to 30 m in length and 12 to 15 mm in width.

It is affected by moisture and gets shrunk; length gets altered by stretching; and it is likely to twist and does not remain straight in strong winds.

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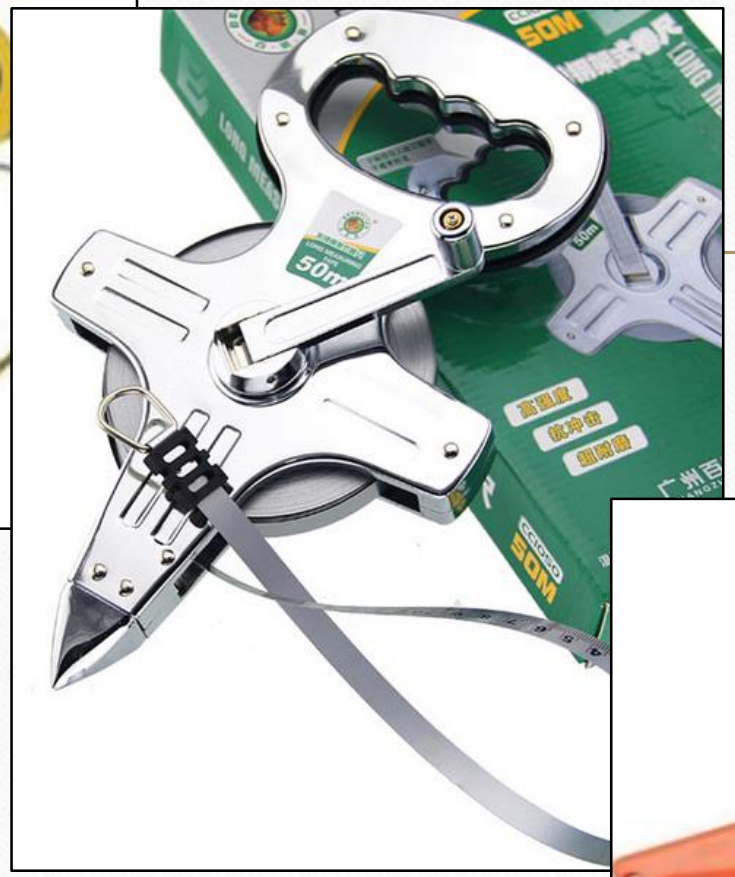
Metallic Tape: It is a linen tape with brass or copper wires woven into it longitudinally to reduce stretching. As it is varnished, the wires are not visible. These are available in 20-30 m length. As it is reinforced with wires, all the defects of linen tapes are overcome.

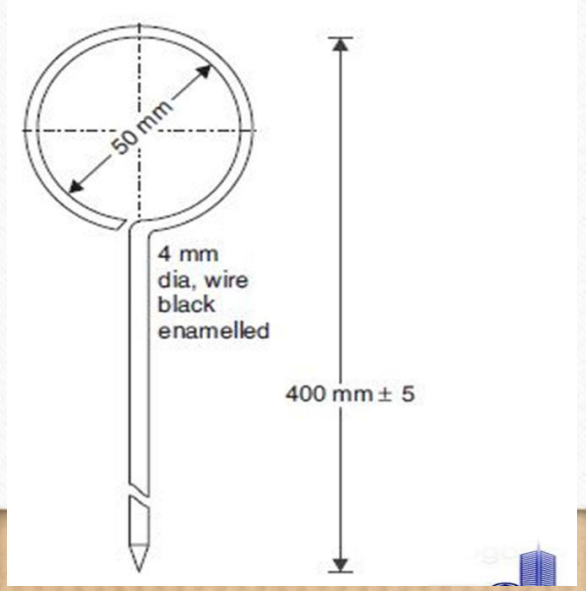
Steel Tapes: These are 1 to 50 m in length and are 6-10 mm wide. At the end of the tape a brass ring is attached, the outer end of which is zero point of the tape.

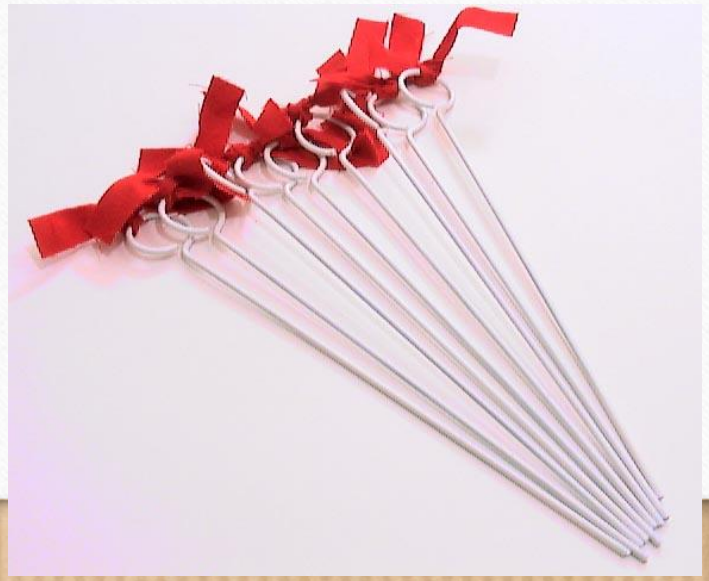
Invar Tape: This is made of an alloy of nickel (36%) and steel, having very low coefficient of thermal expansion (0.122x10-6/0C). These are available in lengths of 30, 50 and 100 m and in a width of 6 mm.


50M
50m
50M

Pegs: Wooden pegs are used to mark the positions of the stations or terminal points of a survey line. They are made of stout timber, generally 2.5cm or 3cm square and 15 to 60cm long, tapered at the end. They are driven in the ground with the help of a wooden hammer and kept about 4cm projecting above the surface.

Arrows (Chain pin): Arrows are made of stout steel wire. An arrow is inserted into the ground after every chain length measured on the ground. Arrows are made of good quality hardened and tempered steel wire 4 mm in diameter and are black enameled. The length of arrow may vary from 25 cm to 50 cm (generally 40 cm). One end of the arrow is made sharp and other end is bent into a loop or circle for facility of carrying.

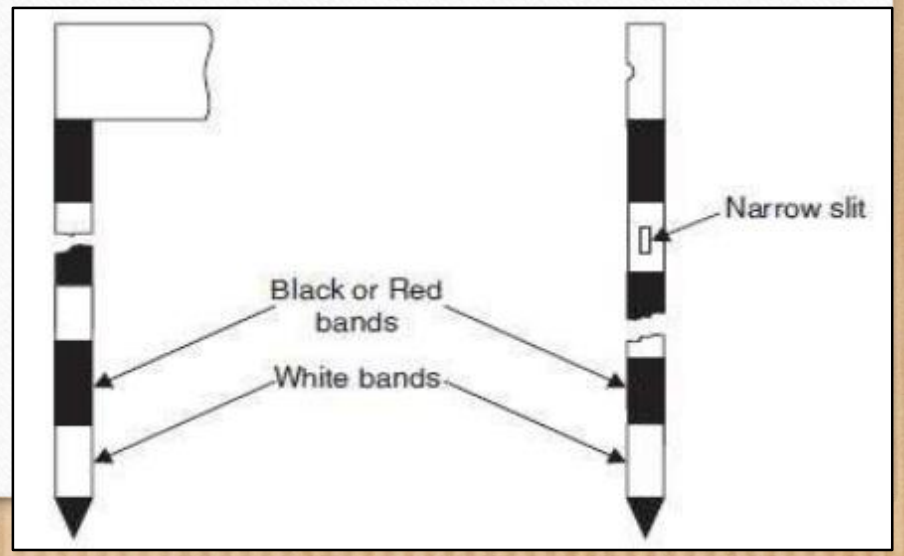




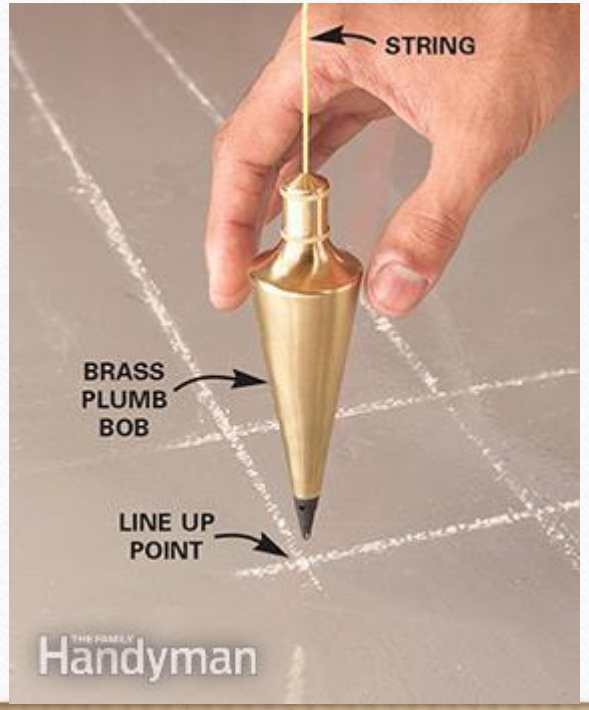
Ranging Rods: Ranging rods have a length of either 2/3m, the 2 metre length being more common. They are combined at the bottom with a heavy iron point, and are painted in alternative bands in succession.

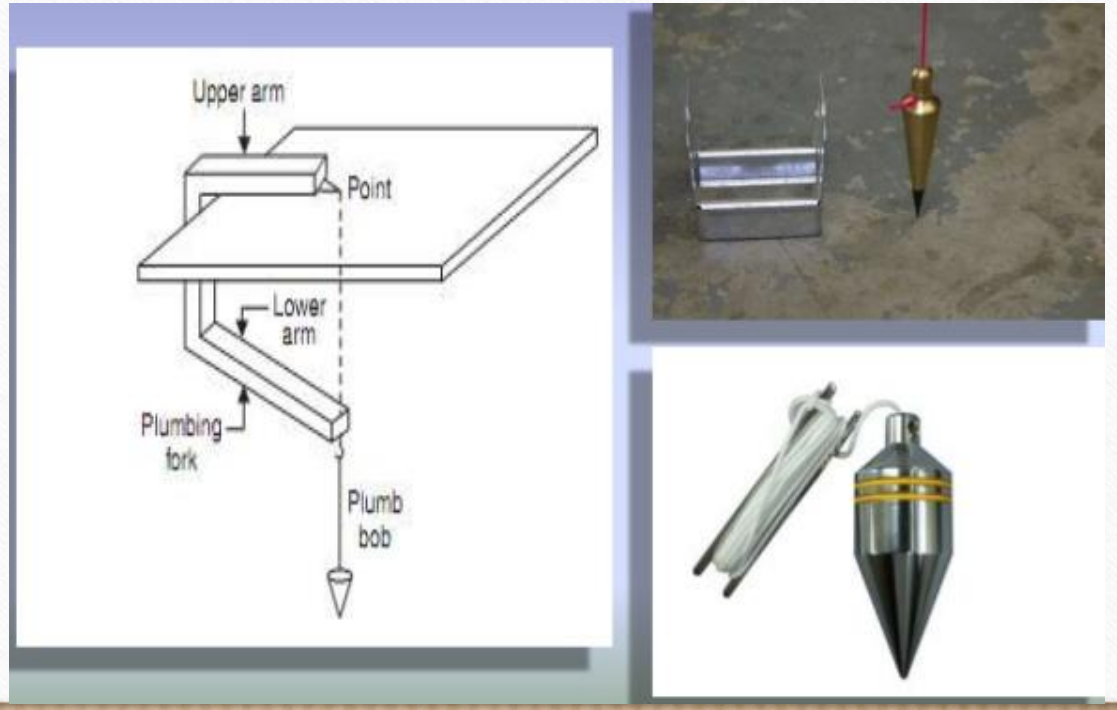
The rods are almost invisible at a distance of about 200 metres; hence when used on long lines each rod should have a red, white or yellow flag, about 30 to 50 cm square, tied on near its top.

Offset Rod: An offset rod is similar to a ranging rod and has a length of 3m. They are round wooden rods, shod with pointed iron shoe at one end, and provided with a notch or a hook at the other. The hook facilitates pulling and pushing the chain through hedges and other obstructions. The rod is mainly used for measuring rough offsets nearby. It has also two narrow slots passing through the centre of the section, and set at right angles to one another, at the eye level, for aligning the offset line.



Plumbing Bob: While chaining along sloping ground, a plumb-bob 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 theodolites, compass, plane table and a variety of other surveying instruments.





Method of Chaining on Sloping Ground

In surveying, for the purpose of plotting, only horizontal distances are required. If the ground is sloping, the horizontal distances are obtained either

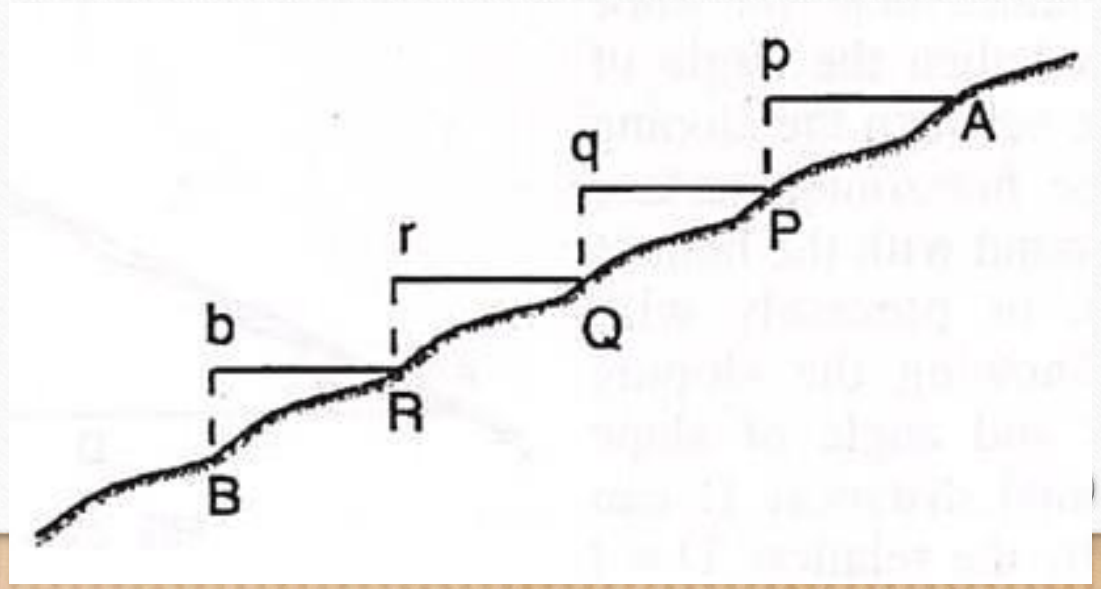
- Directly or
- Indirectly.

Direct Method: This method is applied when slope of the ground is very steep.

In this method, sloping ground is divided into a number of horizontal and vertical strips, like steps. So the method is also known as stepping method.

The length of horizontal portions are measured and added to get the total horizontal distance between th points.

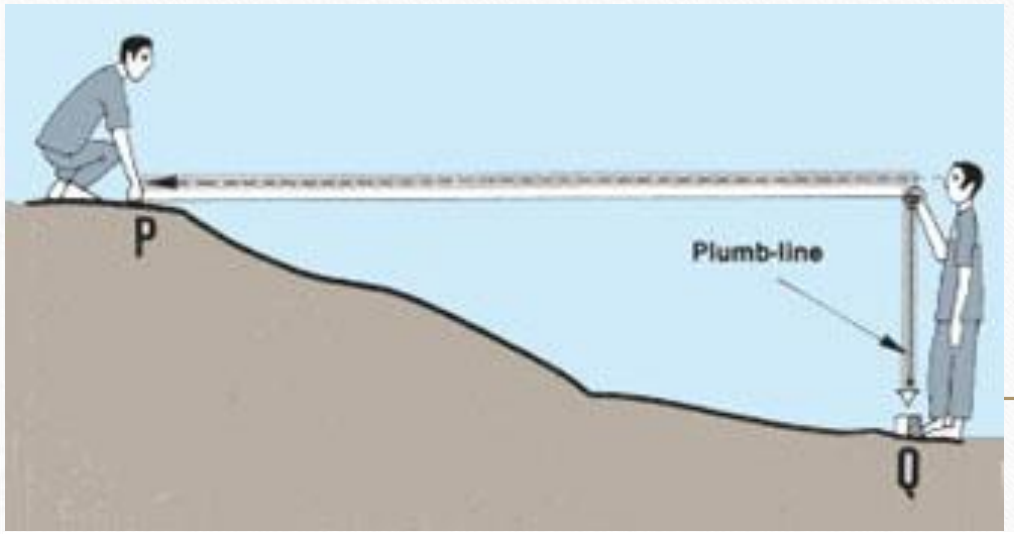
AB = Ap + Pq + Qr + Rb

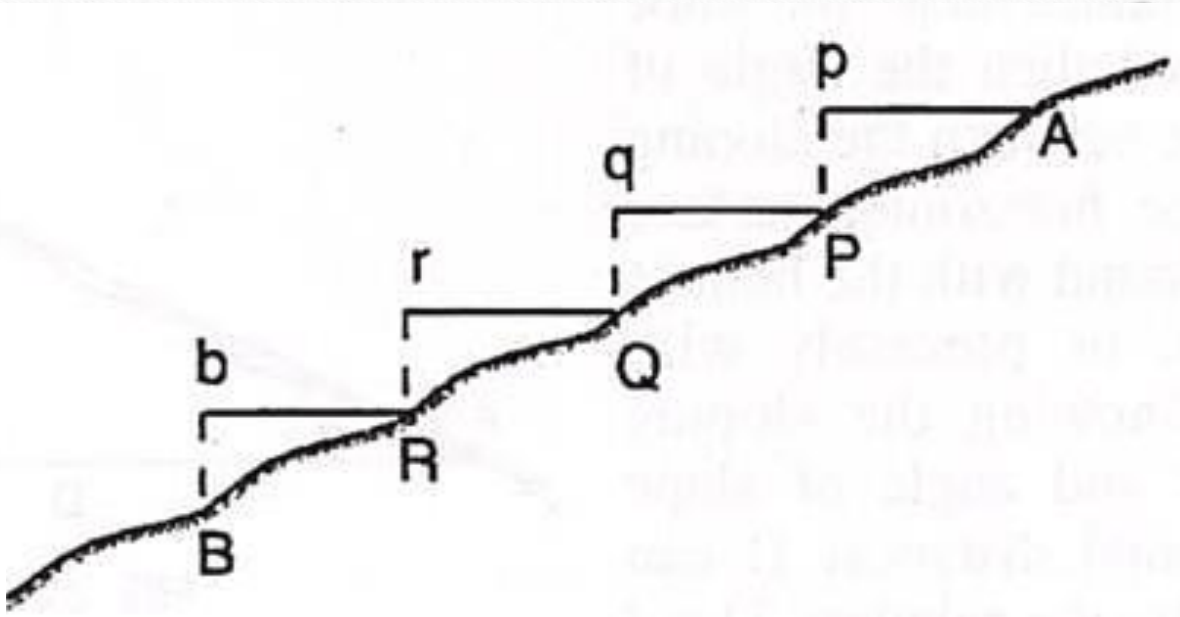


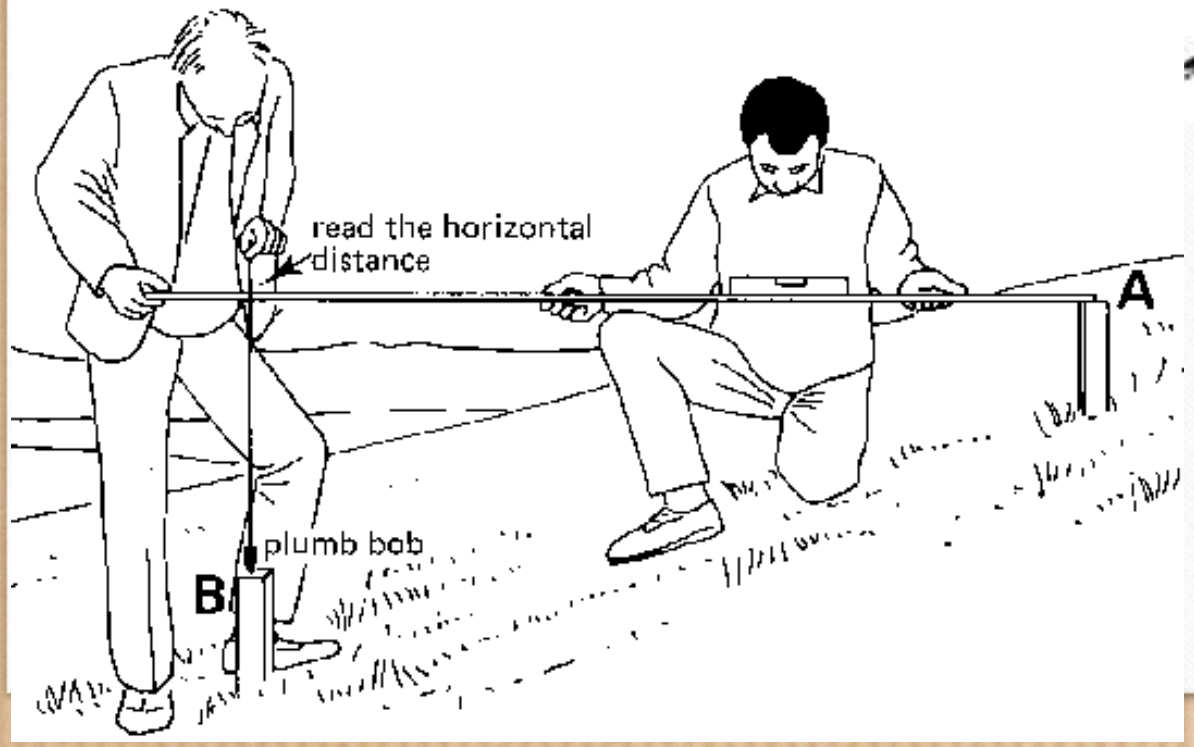
The follower holds the zero end of the chain at ‘P’ and directs the leader at ‘Ap’ to be in the line of AB and stretch the chain or tape above the ground in horizontal line. The leader then transfers the point ‘p’ to P on the ground by means of plumb bob or dropping a pebble or an arrow.

Now the followers take the new position ‘P’ and directs the leader to move forward and stretch the tape or chain in a line of Pq and transfer the point q to Q.

This process is repeated till the point B is reached.


P
Plumb-line
Q


p
A
q
P
r
Q
b
R
B


read the horizontal distance
A
plumb bob
B

Indirect Method: When the slope of the ground surface is long and gentle, the stepping method is not suitable, in such a case, the horizontal distance may be measured by the following process:

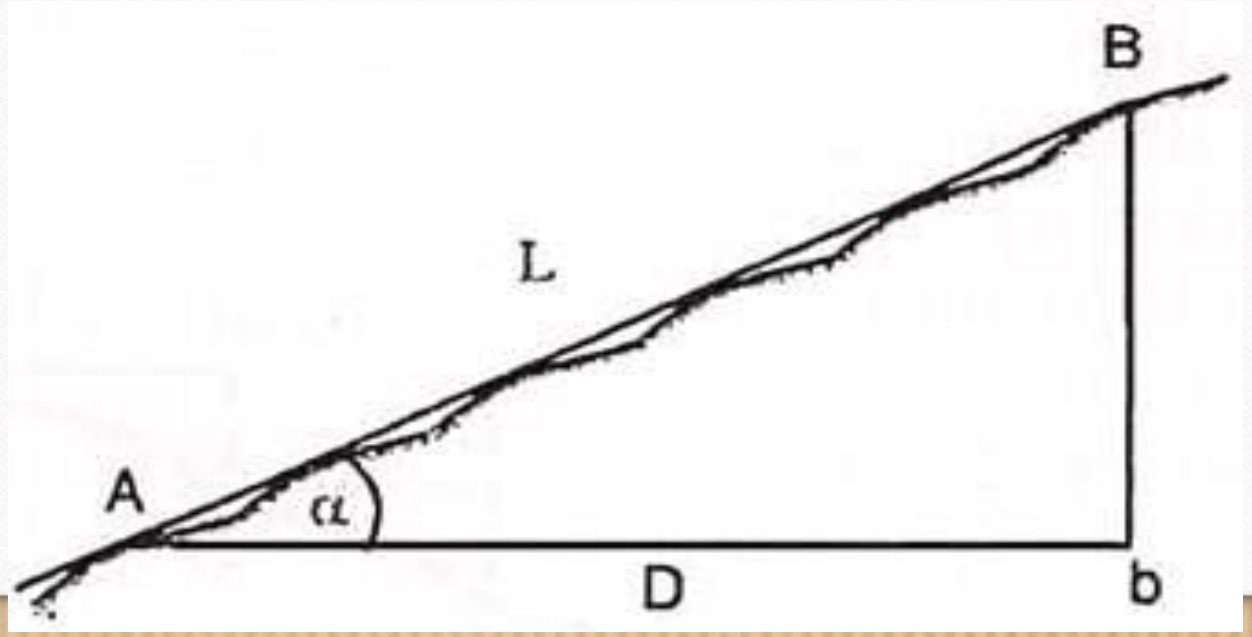
a) By measuring the slope angle with clinometer
b) By Applying Hypotenusal Allowance
c) By knowing the defference of level

By measuring the slope angle with clinometer: The distance along the slope is measured and then angle i.e. angle between the sloping ground and the horizontal surface.

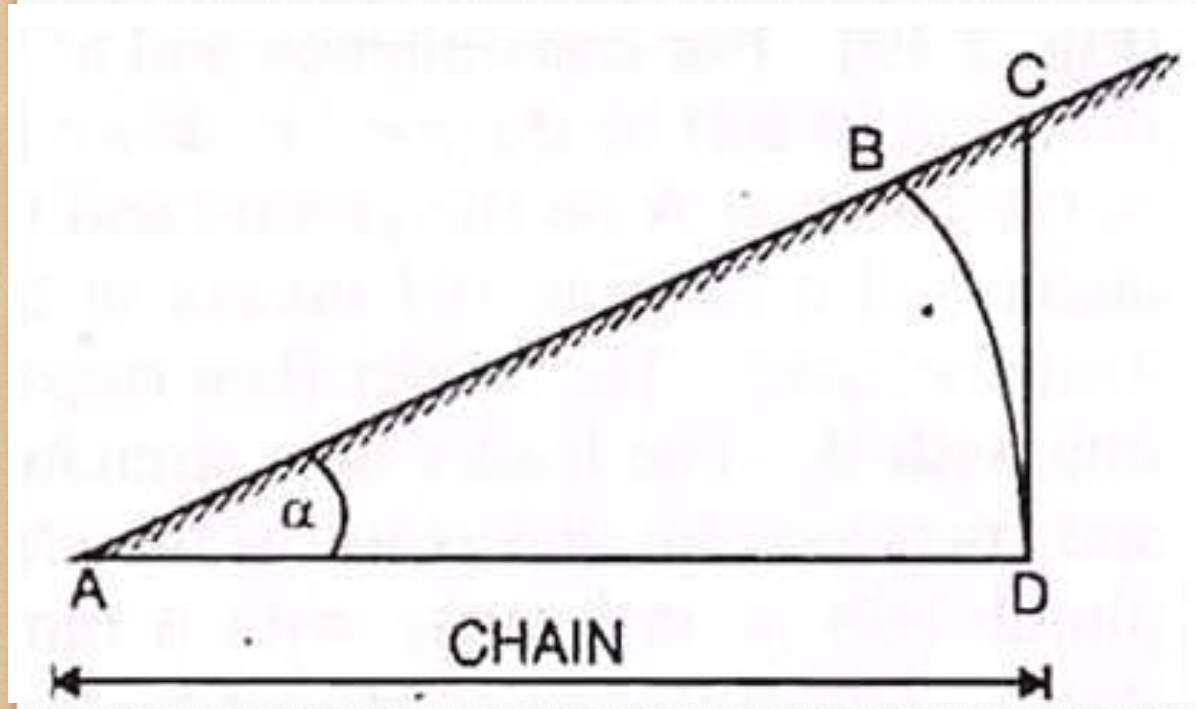
The distance along the slope is measured and then the angle of slope i.e. angle between the sloping ground and the horizontal surface is found with the help of Abney's level or precisely with theodolite.

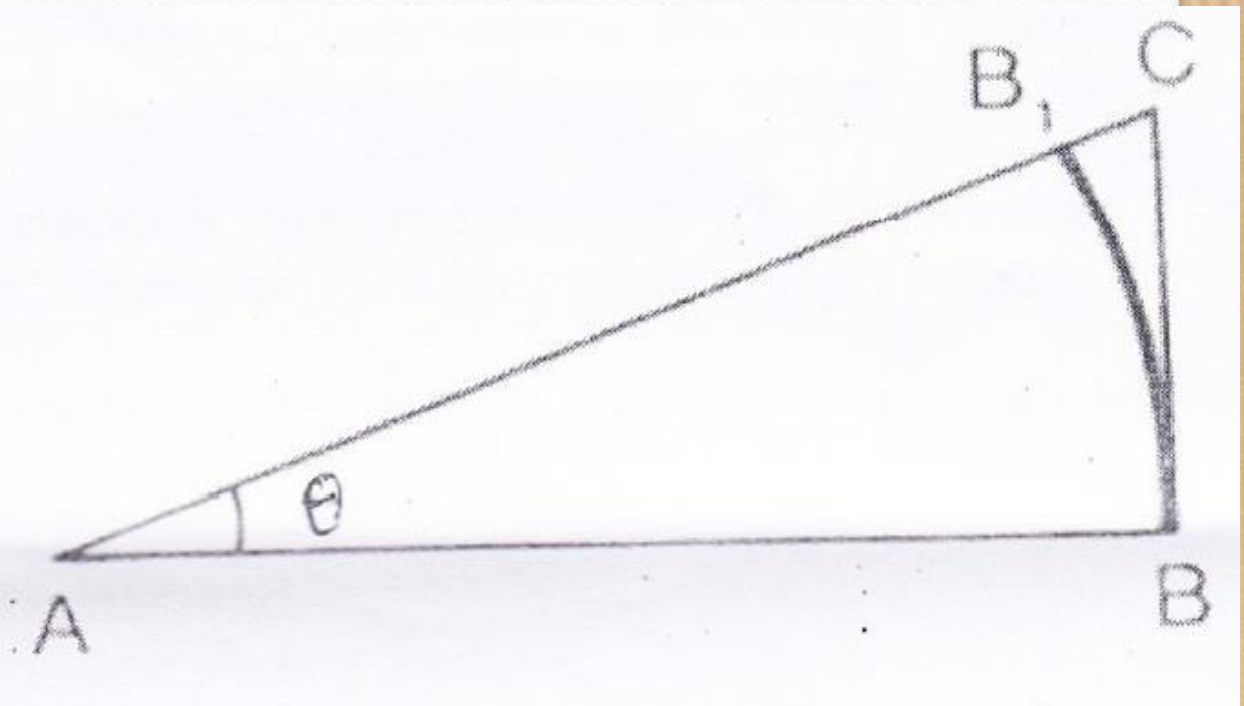
Knowing the sloping distance say 'L' and angle of slope say 'α' horizontal distance, 'D' can be calculated by the relation,

$D = L \cos \alpha$



By Applying Hypotenusal Allowance: In this method, the slope of the ground is first found by clinometer. Hypotenusal allowance is then made for each tape length.

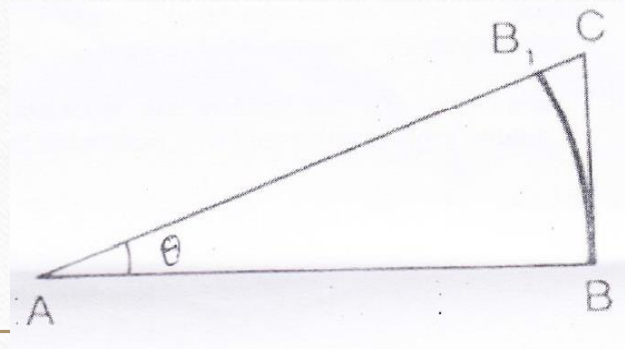




Let

θ =Angle of slope

AB= AB_1= 20m = 100 links



AC= AB Secθ = 100 Secθ

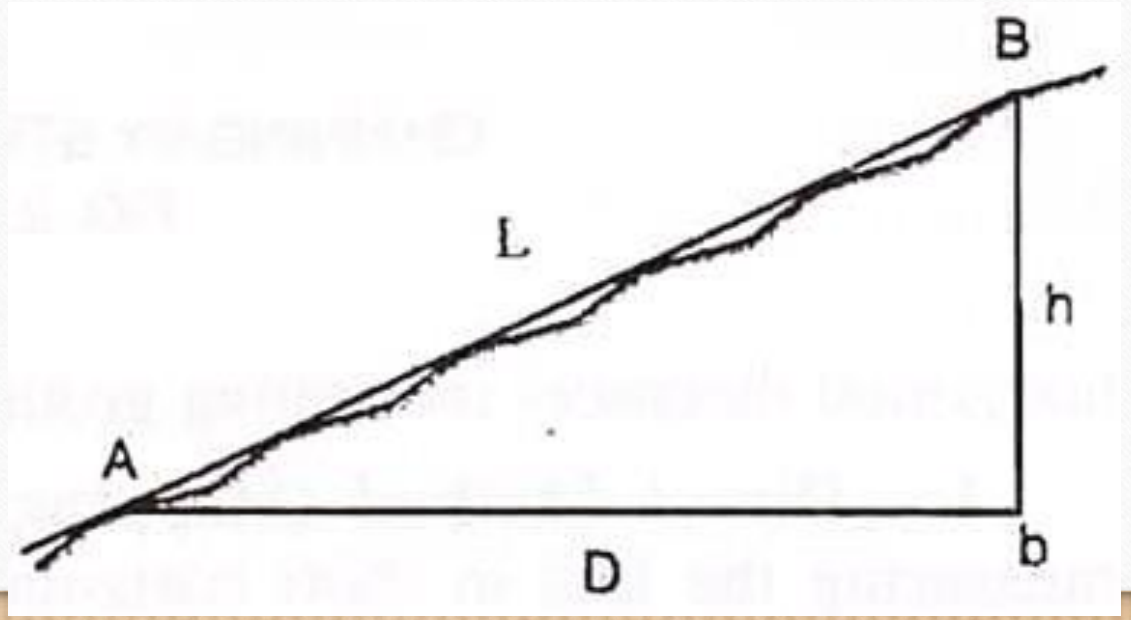
B_1C = AC – AB_1 = 100 Secθ – 100 = 100(Secθ - 1)

The amount 100(Secθ - 1) is said to be the ‘hypotenusal allowance’. While chaining along the slope, one chain would be actually located at B_1. But the arrow should be placed at C after making hypotenusal allowance. The next chain length will be start from C. The same principle is followed until the end of the line is reached.

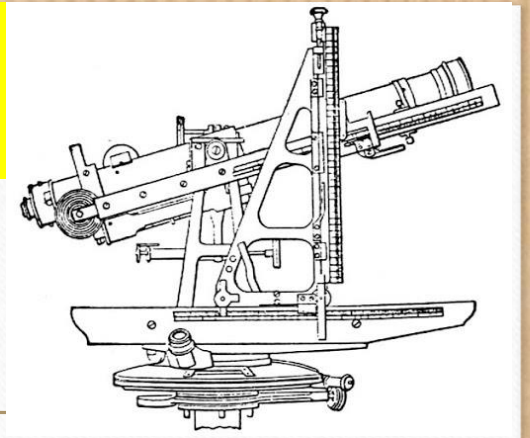
By knowing the difference of level: The distance along the slope is measured with chain and the difference in elevation between the first and the end stations is found with the help of any levelling instrument.

Knowing the sloping distance L and the difference in elevation h, the horizontal distance, can be found out by the relation:

$$D = \sqrt{L^2 - h^2}$$



Measurements by Optical Means

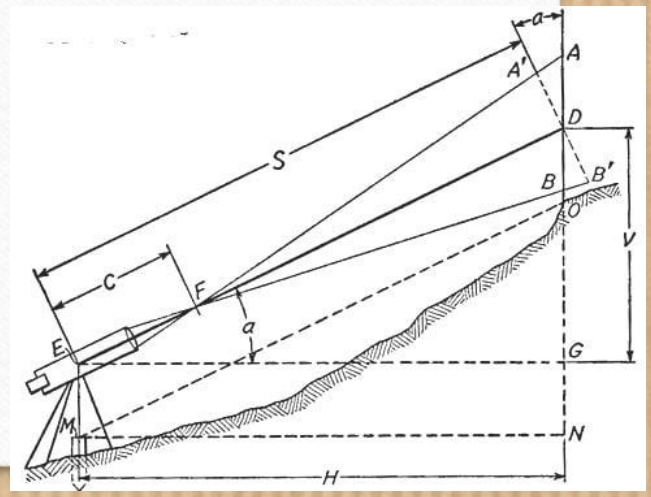


Optical measurement method is also known as tacheometry method or stadia method.

Optical measurement is inspection of measurement with the help of telescope and then calculations are solved using triangulation method to find out the distance.

-Tacheometer is considered ass important.

-Reading a level staff (graduated wooden or aluminium rod) needed optical measurement.



-Before electronic method, it was more famous and accurate for particular distance measurement.

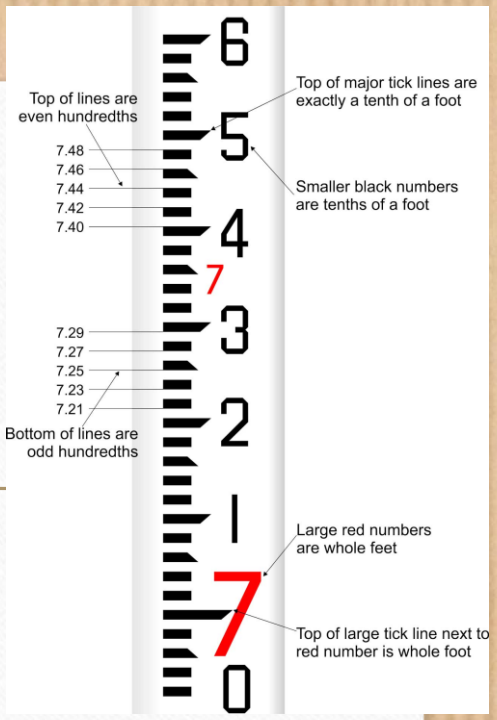
-It is suitable to survey a hill country and counter lines.

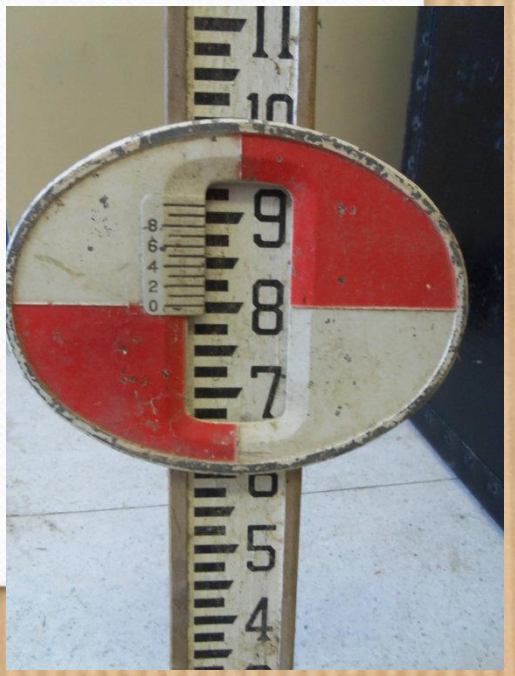
Manual, semi-automatic and automatic measurement

Level Staff

It is a helpful instrument to determine height of points.

For a good view we need telescope, that lead us to use optical means in surveying.





Tacheometer

It is an instrument used to measure vertical as well as horizontal distance between two points.

Tacheometer is more similar to theodolite.

Tacheometry is the procedure by which horizontal distances and difference in elevations are determined indirectly using subtended intervals and angles, observed with a transit or theodolite on a graduated rod or scale.

(Plane land): Distance, $D = KS + C$

(Incline land): Horizontal distance, $H = KS\cos^2\alpha$

Elevation(V.distance), $V = (1/2)KS \sin 2\alpha$

(Plane land): Distance, D= KS+C

Where, D is the distance from telescope to rod

K is the

S the stadia intercept

C stadia constant

(Incline land): Horizontal distance, $H= KS\cos^2\alpha$

Elevation(V.distance), $V= (1/2)KS \sin 2\alpha$

Where, H is the horizontal distance

V is the vertical distance or elevation

α is the angle of inclination

Electronic Methods

Electronic Distance Measurement (EDM) is an instrument that transmits a carrier signal of electromagnetic energy from its position to receiver located at another position.

-Quick and precise measurements

-Save time and money

-Automatically display direct readout measurements

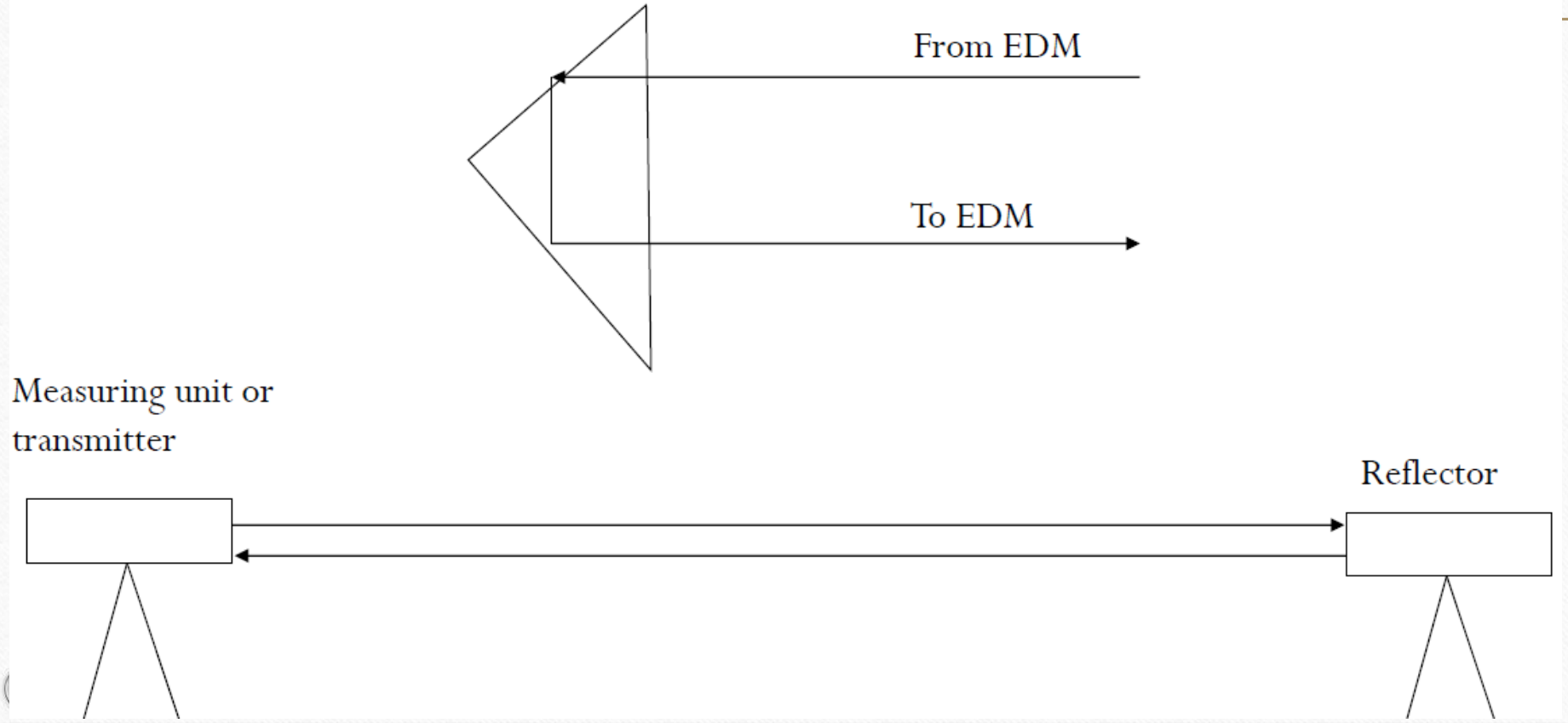
-Mistakes are reduced

-EDM instruments are combined with digital theodolites and microprocessors to produce total station.

Basic Instruments

-An electronic distance-measuring devise

-A reflector consist of several prisms mounted on a tripod



Based on the wavelengths of the electromagnetic energy which the transmit, there are two types of EDMs.

1. Electro-optical instruments:
   - Transmit light in short wavelengths of about 0.4 to 1.2 µm. (laser and infrared)
   - Light is visible or just above the visible limit
   - Almost al short-range EDMs for measuring up to a few miles are the infrared type
   - Laser types are visible
2. Microwave instruments:
   - Transmit long wavelengths of about 10 to 100 µm.
   - Waves penetrate through fog or rain
   - More affected by humidity than are the light-wave instruments.

Distance Measurement:

- Distance are observed electronically by determine the number of full and partial waves.
- Knowing the precise length of the wave, the distance can be determined.

$$L = \frac{n\lambda + p}{2}$$

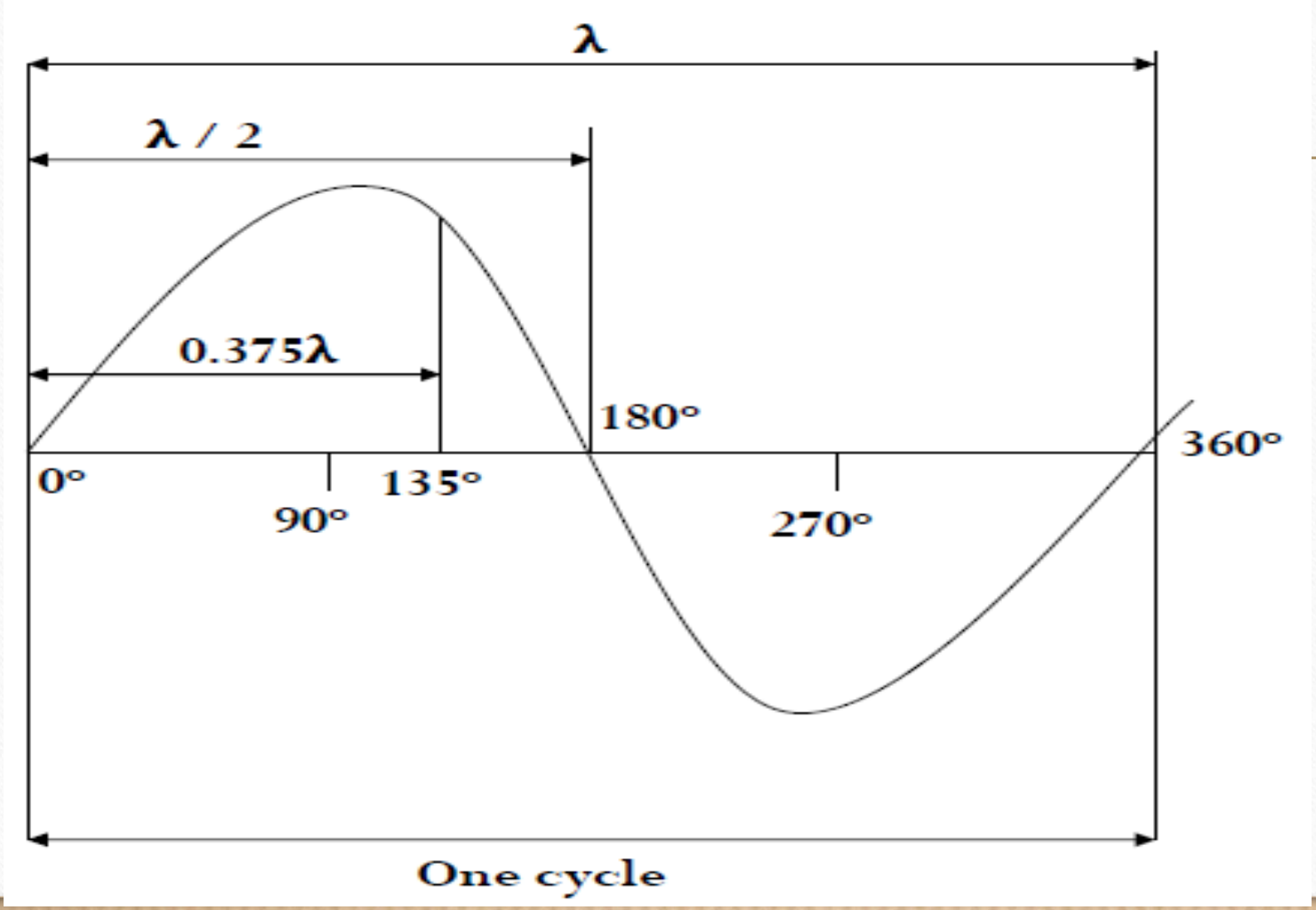
Where, L distance between EDM and the reflector

λ is the wave length

n is the number of full wavelength

p the length of the fractional part

The fractional length is determine by the EDM instrument from measurement of phase angle of the returned signal



Methods of Angular Measurement

A critical component to the surveying process is the measurement of angles. Initially compass assisted surveyors to define their direction, putting the survey on a magnetic meridian.

Theodolites were developed to allow more accurate measurement of angles both in horizontal and vertical plane.

A survey line can only be plotted if its length and direction both are known.

So, it is necessary to measure linear (length) as well as angular (direction or horizontal angle) measurement of survey line.

Bearing:

- ✓When the bearing of a line is measured with respect to magnetic north in clockwise direction, is called magnetic bearing or **whole circle bearing**. Values 0º to 360º
- ✓**Quadrant Bearing,** the bearing of a survey line is measured with respect to north or south, in clockwise or anticlockwise direction towards east or west. Values 0º to 90º
- ✓**True Bearing,** bearing of a line is the horizontal angle between the true meridian and the survey line. The true bearing is measured from the true north in clockwise direction.
- ✓**Magnetic Bearing,** the bearing of a line is the horizontal angle which the line makes with the magnetic north.