Northern Technical University (NTU)
Technical college of Kirkuk (TCK)
Surveying Engineering Department

1st class

SURVEYING I

Lecture One:
Introduction to Surveying

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Outline

1.1 Definitions

1.2 Divisions of surveying

1.3 Classification of surveying

1.4 Units of measurements

1.1 Definitions

1-Surveying. is the art determining the relative position of distinctive features on the surface of the earth or beneath the surface of the earth by means of measurements of distances, directions and elevations.

Or

The measurement of dimensional relationships, as of horizontal distances, elevations, directions, and angles, on the earth's surface especially for use in locating property boundaries, construction layout, and mapmaking.

2-leveling. It is the type of surveying which deals with the measurements of relative heights of different points on the surface of the earth.

1.2 Divisions of surveying

Plane surveying	Geodetic surveying
Effect of the curvature of the earth surface is ignored.	Effect of the curvature of the earth surface is included.
The earth surface is assumed to be plane, i.e. two dimensional.	The earth surface is assumed to be spherical, i.e. three dimensional.
Involves smaller areas less than about 260 km2.	Involves larger areas more than about 260 km2.
Lower degree of accuracy.	Higher degree of accuracy.
Done locally by the individual organization	Done by the concerned state or government department.

1.3 Classification of surveying

1- Classification based up on the nature of the field:

- **Land surveys**

a. Topographical surveys.

b. Cadastral surveys.

c. City surveys.

- Hydrographic surveys.
- Astronomical surveys.

2- Classification based on the purpose of the surveys:

a) Engineering surveys.

b) Mine surveys.

c) Geological surveys.

d) Industrial surveys.

3. Classification based on instrument used:

a) Chain surveying.

b) Theodolite surveying.

c) Compass surveying.

d) Plane table surveying.

e) Tachometric surveying.

f) Triangulation surveying.

g) Photogrammetric surveying.

1.4 Units of measurements

There are two kinds of measurements used in plane surveying:-

1) Linear measure [Horizontal or vertical distance].

2) Angular measure [Horizontal or vertical angles].

➢ Linear measure

a- Basic units of length in metric system:

10 millimeters = 1 centimeter

10 centimeters = 1 decimeter

10 decimeter = 1 meter

1000 m = 1 km

10 hectometers =1 km

b- Basic units of area in metric system:

100 .sq meters = 1 acre.

100 acre =1 hectors.

100 hectometer = 1 sq. km.

10 ULK = 100 sq. m

1 donam = 2500 sq. m.

1 km = 400 don am.

c- Basic units of volume in metric system: -

1000 cub millimeters = 1 cub Centimeters.

1000 cub Centimeters = 1 cub Decimeter.

1000 cub Decimeters = 1 cub Meter.

The measurement of length according the British units:

Basic units of earth.

12 inches = 1 foot.

3 feet = 1 yard.

5.5 yards = 1 radian, pole or perch

4 poles = 1chain (66 feet)

144 sq .inches = 1 sq. feet

9 sq. feet = 1sq yard.

640 acres = 1sq. chain

484 sq. Yards = 1 acre

Angular measure

There are three popular systems of angular measurements:

A- Sixagesmial system of angular measurements:

In this system, the circumference of a circle is divided in to 360 equal parts each part is known as one degree.

1 circumference = 360 of arc

1 degree = 60 minutes of arc

1 mint = 60 seconds of arc.

B- Centesimal system of angular measurements:

In this system the circumference of a circle is divided in to 400 equal. Each part is known as one grad.

1 circumference = 400 grads

1 grads = 100 centigrade

1 centigrade = 100 cencentigrads

C- Radian system:

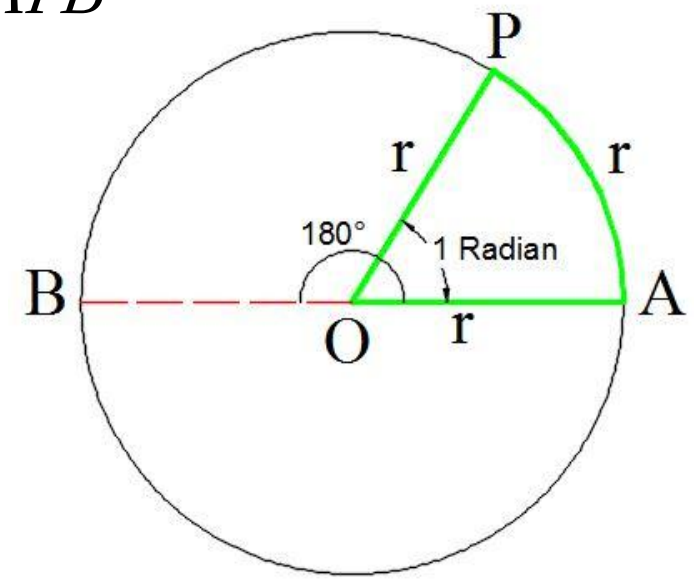
The difference in direction of two intersecting lines, or it is the inclination of two straight lines. The radian is defined as the measure of the angle between two radian of circle which contains an arc equal to the radius on the circumference of the circle.

Angle AOP/ Angle AOB= Arc AP /Arc APB

1 Radian /180˚= r/π r

1 Radian = 180˚/π , π=3.14259

1 Radian = 57.29577951 ˚



1 Degree = π/180˚ Radian

1 Degree = 0.017453292

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SURVEYING I

Lecture two:

-Scales

-Measurement of horizontal distance

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Scales:

Considering the actual surface dimension of the earth, it is never possible to make its drawing to full size. This operation is generally known as drawing to scale. The scale of a map or plan is defined as the ratio of the ground distance between the locations of points on the map.

The scale may represent as:

1- Words: such as thus if (10) m on the ground is represented by (1) cm on the map.

2-Representation fraction (R.F):

This is the ratio of the plotted distance to the ground distance in the fraction:

a-The numerator is usually kept unity.

b- The numerator and denominator must be expressed in the same units, for example (1) cm = (10) m is written in the R.F. as: -

$$\frac{1}{10 \times 100} = \frac{1}{1000}$$

Or 1 / 1000

Or 1: 1000

The distance (250 m) on the ground: -

$$250 \times \frac{1}{1000} = 0.25 \text{ m} = 25 \text{ cm on the map}.$$

Area $250 \times \frac{1}{1000} \times \frac{1}{1000} = 0.0025 \text{ m}^2 = 2.5 \text{ m}^2 \text{ on the map}.$

Volume (250m^2) on the ground: -

$$250 \times \frac{1}{1000} \times \frac{1}{1000} \times \frac{1}{1000} = 0.00000025\text{m}^3$$

$$= 0.25 \text{ cm}^3 \text{ on the map}.$$

The selection of a proper scale depends on the following factors.

Extent of survey.

- Purpose of the survey.
- Accuracy required
- The size of the sheet to contain that surveying. The following are the same of the scales recommend for survey map

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Type or purpose of survey	*Scale*	*R.F.*
(a) Topographic Survey		
1. Building sites	1 cm = 10 m or less	$\frac{1}{1000}$ or less
2. Town planning schemes, reservoirs etc.	1 cm = 50 m to 100 m	$\frac{1}{5000}$ to $\frac{1}{10000}$
3. Location surveys	1 cm = 50 m to 200 m	$\frac{1}{5000}$ to $\frac{1}{20000}$
4. Small scale topographic maps	1 cm = 0.25 km to 2.5 km	$\frac{1}{25000}$ to $\frac{1}{250000}$
(b) Cadastral maps	1 cm = 5 m to 0.5 km	$\frac{1}{500}$ to $\frac{1}{5000}$
(c) Geographical maps	1 cm = 5 km to 160 km	$\frac{1}{500000}$ to $\frac{1}{16000000}$
(d) Longitudinal sections		
1. Horizontal scale	1 cm = 10 m to 200 m	$\frac{1}{1000}$ to $\frac{1}{20000}$
2. Vertical scale	1 cm = 1 m to 2 m	$\frac{1}{100}$ to $\frac{1}{200}$
(e) Cross-sections (Both horizontal and vertical scales equal)	1 cm = 1 m to 2 m	$\frac{1}{100}$ to $\frac{1}{200}$

Types of scales:

There are two types of scales:

1) Numerical scales.

1.1 A word scales (Engineers scales).

(1 cm = 5 m)

1.2 Fraction scales

One unites of length on the plan represents same number of same units of length on the ground for example 1: 500, 1: 1000.

To convert an engineer's scale in to fraction scale multiply the whole number of meters by 100 similarly a fraction scale may be converted in to engineer's scale by dividing the denominator on by 100

2) Graphical scale:

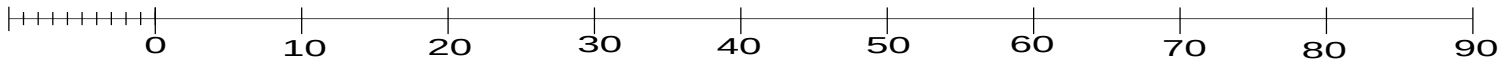
A graphical scale is a line sub-divided in to plan distance corresponding to same units of length on the surface of the earth.

The classifications of scales:

The scales drawn on maps or plans may be classified as follows:-

1-Plain scale.
2-Diagonal scale.
3-Scale of chords.
4-Vernier scale.

2.1 A plain scale is one on which it is parallel to measure only two dimensions, such as meters and decimeters



2.2. Diagonal scales:

On a diagonal scales, it is possible, to measure these dimensions such as meters, decimeters and centimeters. The following points should be considered in construction these types of scales.

A-It should be convenient to use.
B-It should read the smallest unit for survey use.
So, the drawing should be sufficiently large.

Accurately drawn and properly numbered.

C-The zero of the scale should be placed between the unit and its sub –division.
D-It should be easily read and no computations should be required for measuring distance.
1 cm = 5 m

$$R.F = \frac{1}{500}$$

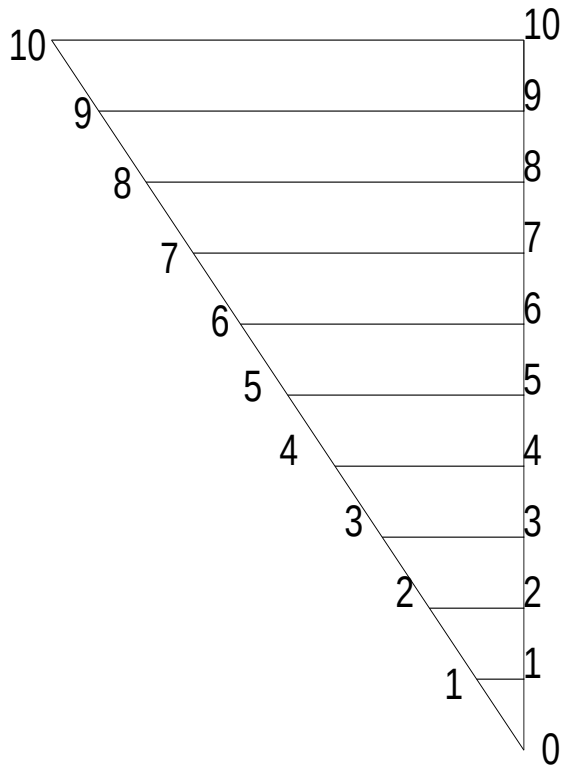
2.2.1 Principle of diagonal scale:

The construction of a diagonal scale is based on the principle of similar triangles in which like sides are proportional

1-1' = $\frac{1}{10}$ of AB

2-2' = $\frac{2}{10}$ of AB

9 -9' = $\frac{1}{10}$ of AB



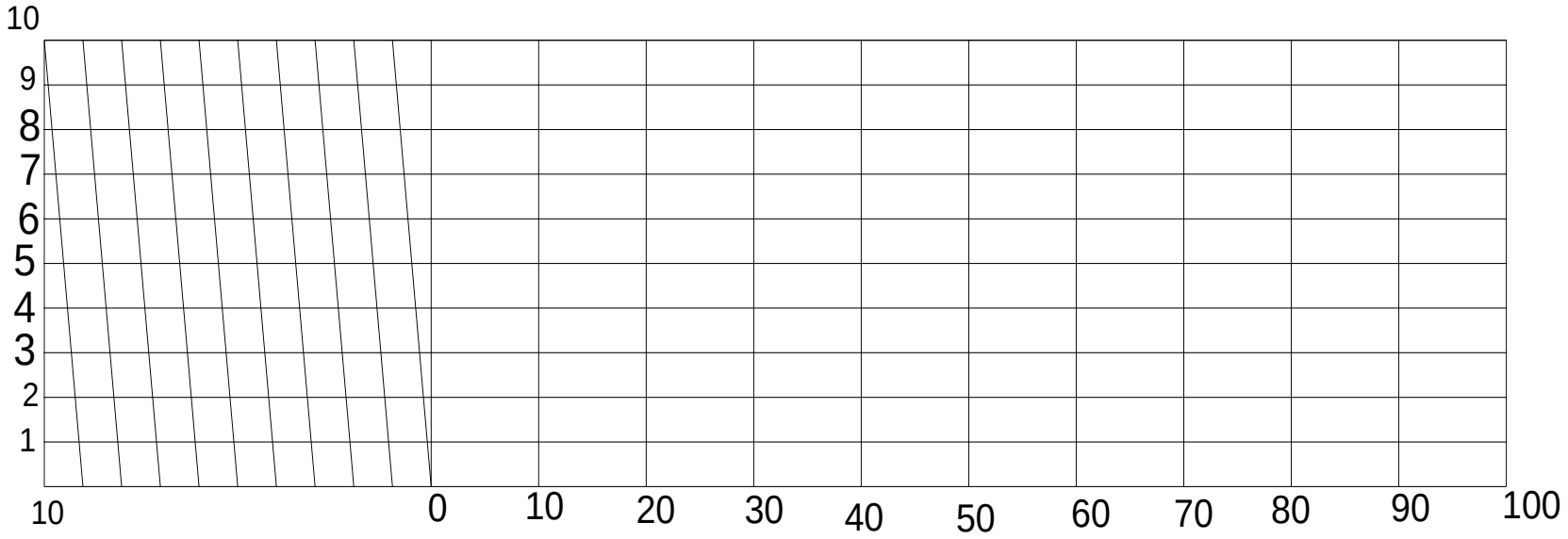
Example:

Construct a diagonal scale 1 cm = 5 m

$22 \text{ cm} = 5 \times 22 = 110 \text{ m}.$

*Take 22 cm and divided it in to legal parts, each part representing 10 m.

Divided the left hand division in to 10 parts and draw the scale.



Measurement of horizontal distance

Measurement of horizontal distance

There are two main methods of determining the distance between two points on the surface of the earth

1) Direct Measurement.

In this method distances are actually measured on the surface on ground by means of chain, tape, etc.

2) Indirect Measurement.

In this method distances are determined by calculation as in tachometric triangulation, or telemeter.

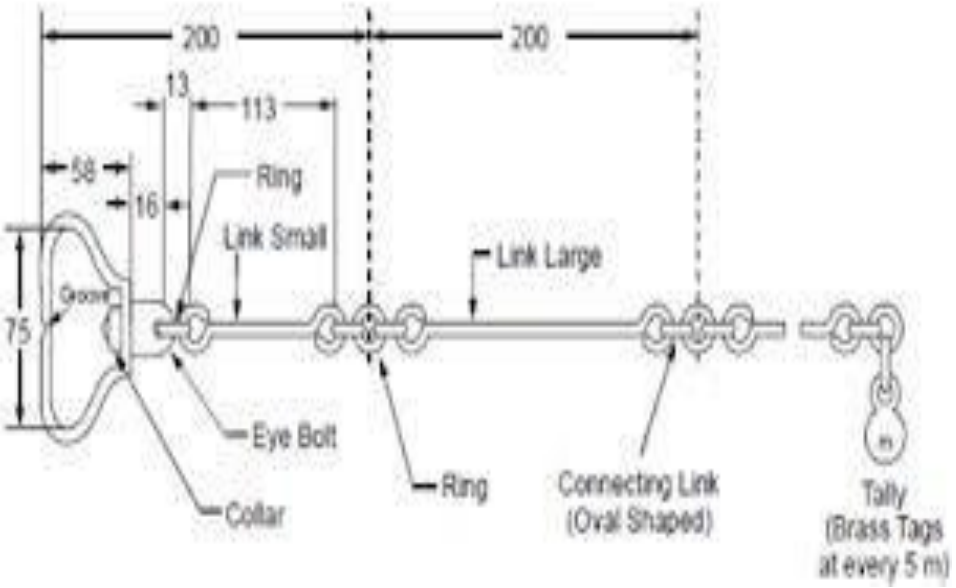
Instrument s of measuring distance:

1- Chain: There are many types of chains depending on their length:

1.1 Metric surveying chain:

1.2 Engineers chain:

1.3 Canters chain:



2- Tape:

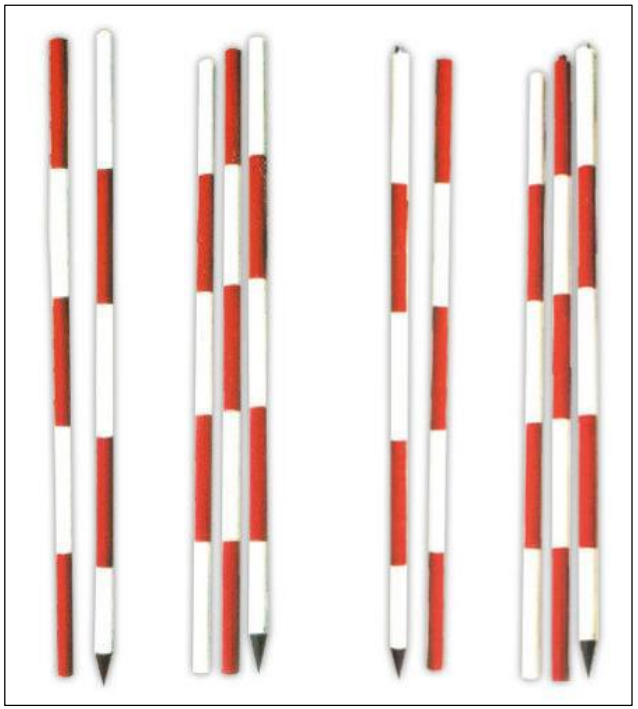
Tapes are classified according to material of which they are made such as follows:

a) Metallic tape. b) Steel tape: c) Invar tape:

3) Tools of making station:

a) Pegs: b) Ranging rods: c) Arrow:

Pegs and Arrows



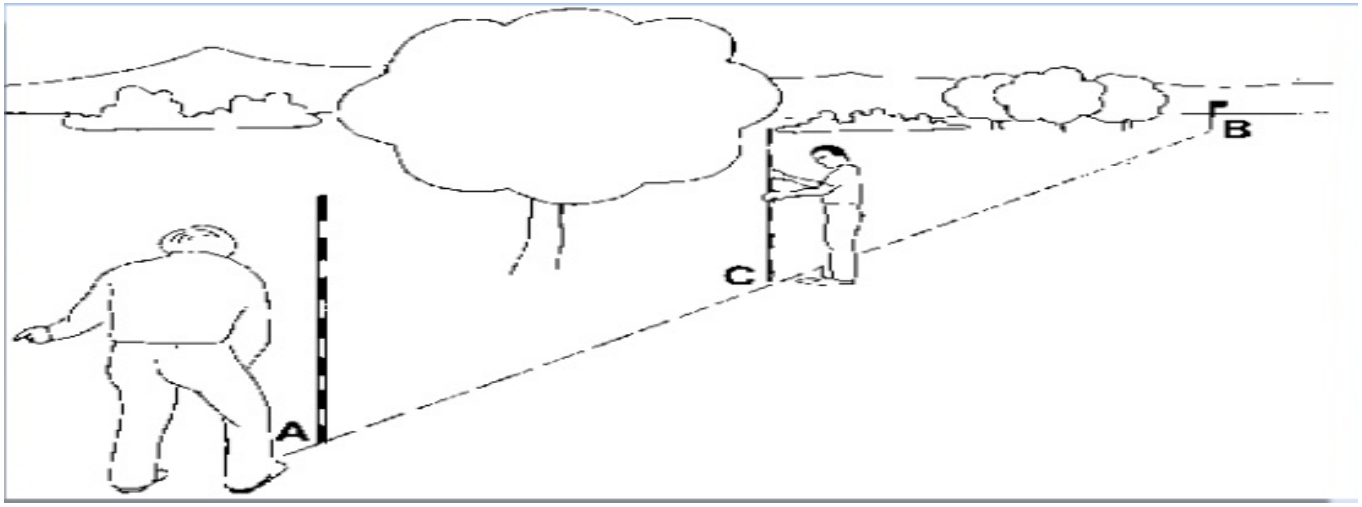
Ranging Rods

Ranging a line: Ranging in of two types:

1) Direct ranging:

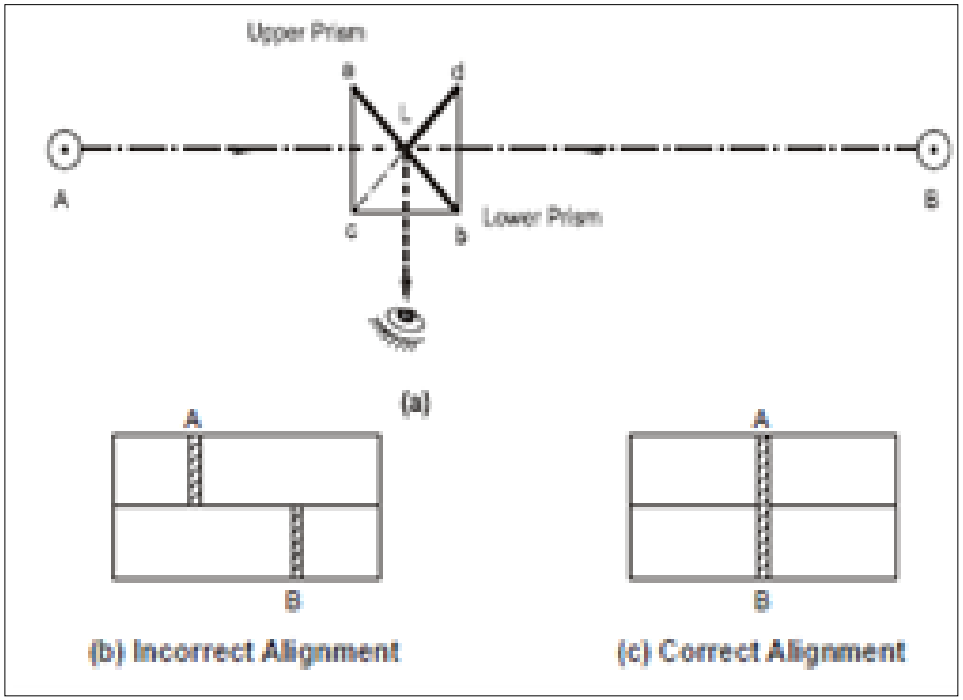
It is used hence the end point of line is inviolable; then ranging is done by:

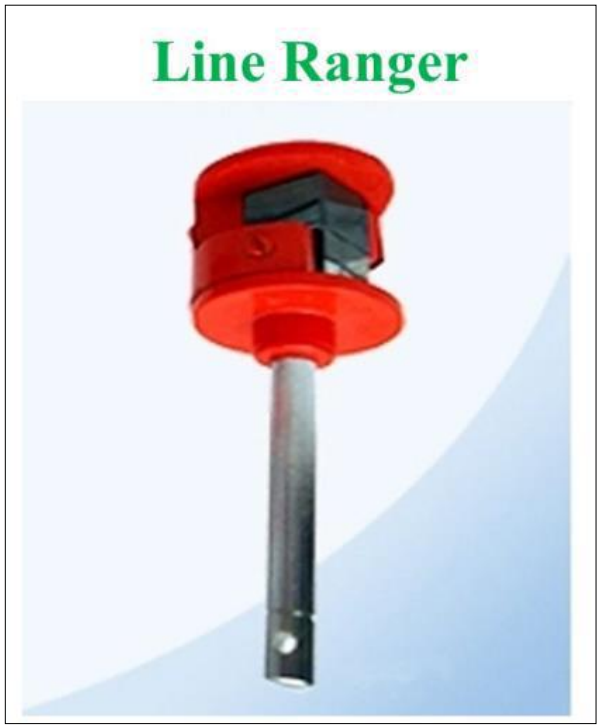
a) Eye : Two ranging rods are fixed at the end points the surveyor tends about (0.5)m behind the rod at the starting point , looking at the first and end rod simulate tenuously , then he directs the assistant to insert rods at intermediate points .



b) Ranging by line ranger:

The line ranger consists of two right angled is ocular prism, placed one above the other, with the help of this instrument, a single person can do ranging without help, as the surveyor with his instrument stands at the intermediates points of the line looking to the image of two end point rods, that appears as one line in the device, so he inserts other rods between them and the rods should be imaged as one line.





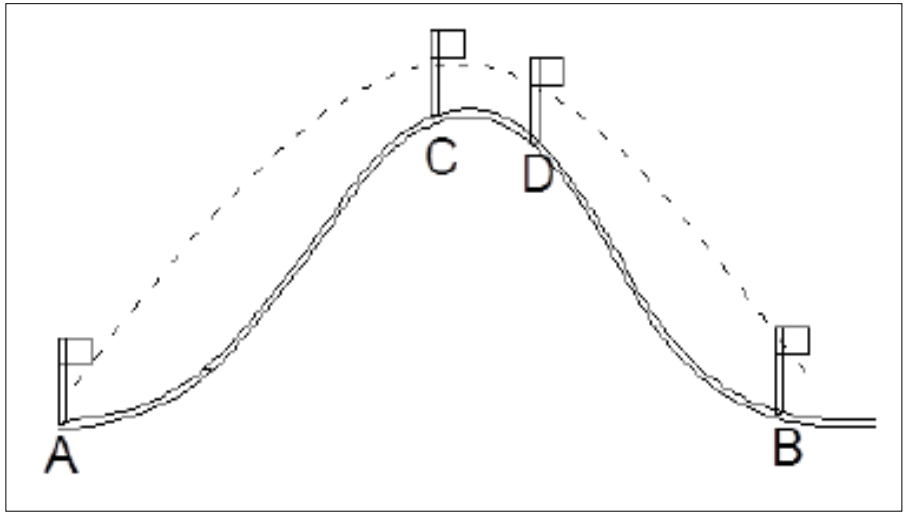
2) Indirect ranging:

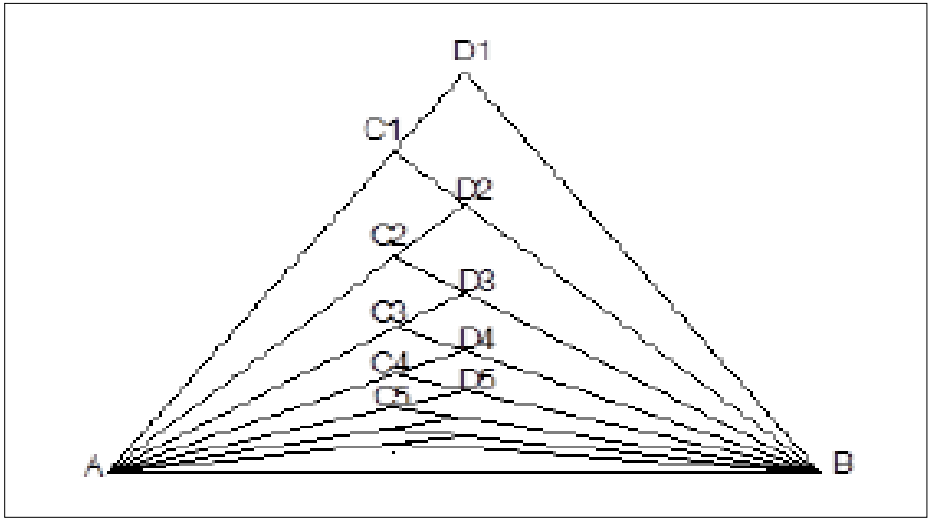
Indirect ranging is represented to:

a) When the end stations of a line are invisible from one another due to large distance.

b) When the stations of a line are invisible from one another due to range distance.

The ranging between this points is done by reciprocal ranging ; let us take **A** , **B** as two end points and hill is between them , select two points as **C** , **D** on the hill , such points one inter visible to each other and the points **A**,**B** then the surveyor at (**D**) look to rod (**A**) ,and of (**C**) looks at (**B**)both marks position as (**C1**) , (**D1**) then at points (**C1**), (**D1**) they do the same operation to marks points (**C2**) , (**C3**) .... Till the four rods **A**, **C**, **D**, and **B** are inter visible and they become at straight line then we measured its length.





Chaining a line:

For chaining operations, required two men are called chain men. The chain man at the furrowed end of the chain is called leader and other known as the follows.

Error in measurements due to incorrect chain length

Let L = true length of chain on tape.

L' = faulty length of the chain or tape

Then the true length of the line. $= \frac{L'}{L} * \textbf{measured length of the line}$

The true area of a plot $= (\frac{L'}{L})^2 \times \textbf{measured area of the plot}$

The true volume of solid$= (\frac{L'}{L})^3 \times \textbf{measured volum ofsolid.}$

.a

Chaining one loping grounds:

There are two methods for getting the horizontal distance between two points on the sloping ground.

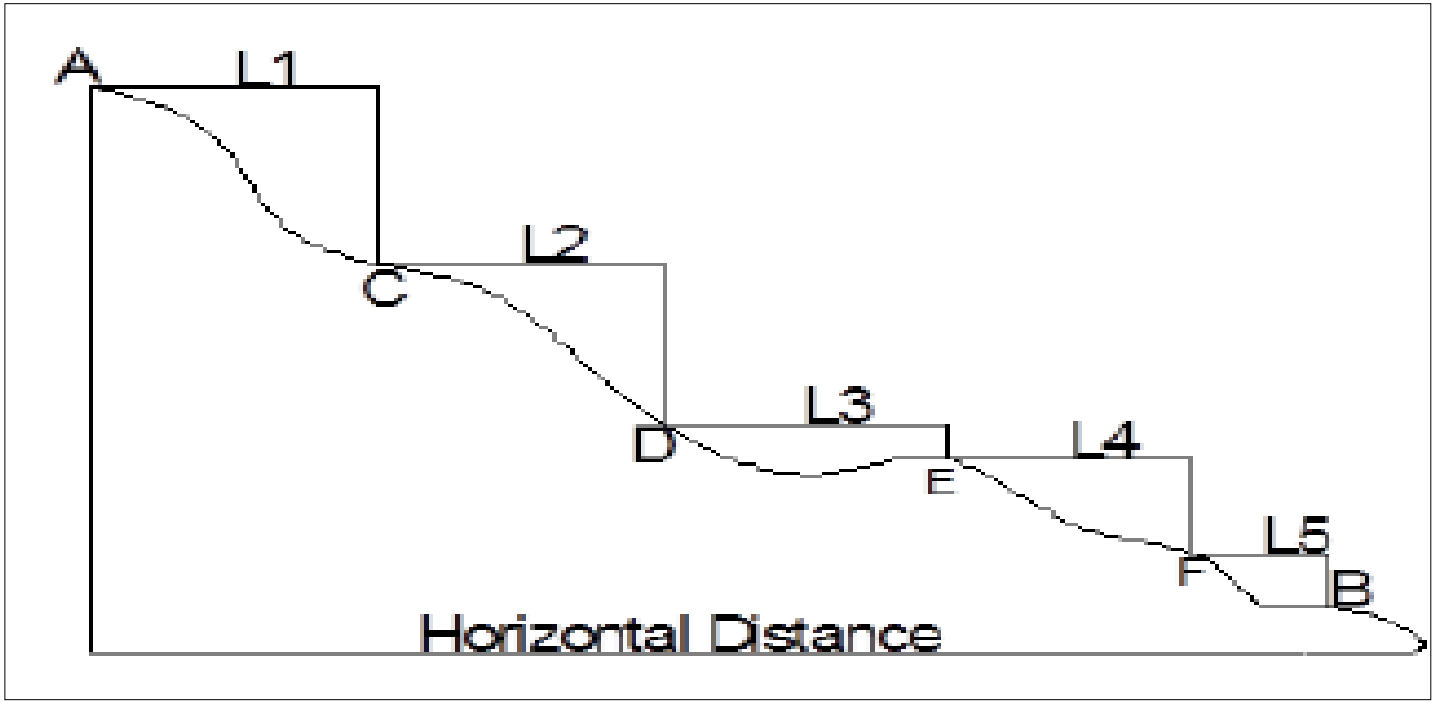
1) Direct method. 2) Indirect method.

1) Direct method.

The total length equal to the sum of the length of the steps:

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

D = the horizontal distance



Precautions to be taken in using the method of stepping:

1) The tape should be stretch horizontal.

2) As the error due to sag in proportional to $\left(\frac{\text{weight}}{\text{tension}}\right)^2$

3) It is not necessary to keep the length of steps uniform.

4) It is always convenient to chain the slopes downhill than to chain up the hill.

2) In direct method:

a) By measuring along the slope also the slope of the ground.

b) By applying the hypotenuse allowance to each chain length laid along the slope.

- When the ground slopes uniformly for a long distance, the distance may be measured more quickly and accurately along the surface of the ground as compared to by the method of stepping.
- Angle of slope may be measured by clinometers or its value may be computed from the difference in elevations obtained by differential or trigonometrically leveling.

Method of measuring along slope:

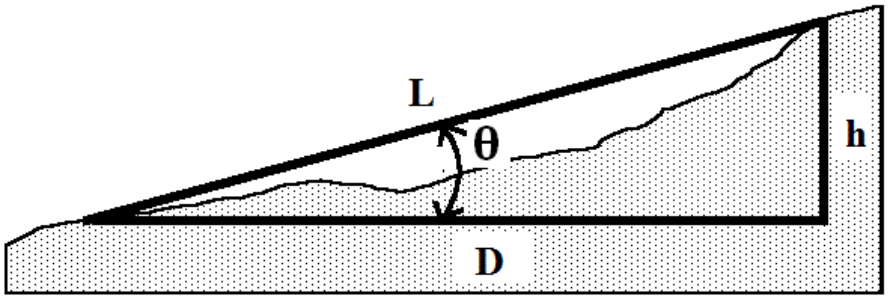
1) First method:

The spot levels of the two points are obtained by differential leveling. Let the difference in level be (h) knowing the angle of slope the horizontal distance calculated from the formula:

$$D = L \cos \theta$$

If (L) incline distance measured on the slope than the angle of slope is given by the formula:

$$\theta = sin^{-1} hL$$

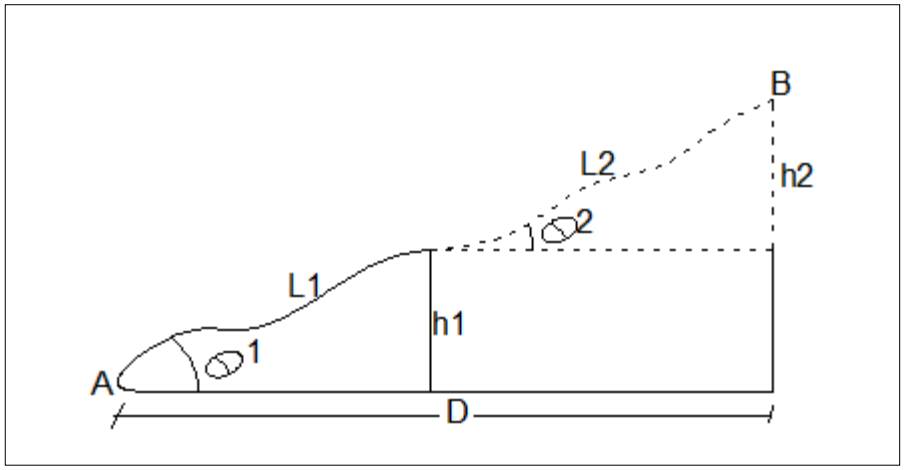


When the slope of the ground is not regular and consists of varying inclinations, the line should be divided in two sections of number of uniform slopes and are measured the length and slope of each section spiritual.

If **L1, L2 and L3** = measured lengths

θ1 , θ2 ,θ3 : angle of slope of section respectively .

D= L1cos θ1+ L2cos θ2+ L3cos θ3



2) Second Method :

D = $\sqrt{\mathbf{L^2 + h^2}}$

L: The distance measured angle the slope.

h: the difference in elevation, the vertical distance between the end points of the slope.

D: - horizontal distance.

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Lecture three :

Error on chaining

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Error on chaining:

1) Cumulative errors.

2) Compensative errors.

Cumulative errors: The Cumulative errors are those errors which occur in the some direction and tend to accumulate, or to odd up such errors mark the apparent measurements always either too long or too short.

(a) Positive cumulative error:

Those errors which make the measured lengths more than the actual are known as positive cumulative errors, these are caused by the following:

- The length of the chain or tape is longer than the standard length.
- The slope correction ignored when measuring along the slopping ground.
- The sag correction, if not applied when the chain or tape is suspended at the ends in the air.
- In correct alignment.
- Working in windy weather.

(b) Negative cumulative errors:

Those errors which make the measured lengths less than the actual are known as negative cumulative errors, these are caused by the following:-

- The length of the chain or tape is shorter than the standard length.
- Opening of ring joints.
- The temperature of the atmosphere being bigger than that at which it was calibrated.

Cumulative errors are proportional to (L), the length of the line.

Compensative errors: The Compensative errors are those errors which occur in either direction or hence tend to compeer sate and are caused by the following:

- In correct holding of the chain.
- If the chain is not uniformly calibrated through – out its length, fractional parts of the chain or tape will not be correct.

Common Mistakes in chaining: An in – experienced chain man generally makes the following mistakes, while chaining a line

1- Displacement of arrows.

2- Failure to observe the zero point of the tape.

3- Adding or omitting a full chain length.

4- Reading from the wrong end of the chain.

5- Reading number wrongly.

6- Calling numbers wrongly.

7- Reading wrong meter marks.

8- Wrong recording in the field.

Correction for liner measurements:

The following corrections are necessary to be made:

1- Correction for standard length.

2- Correction for standard alignment.

3- Correction for standard slope.

4- Correction for standard tension.

5- Correction for standard temperature.

6- Correction for standard sag.

7- Reduction to M .S.L.

1- Correction for length.

L = the measured length of the line.

Ca = the correction for absolute length.

$\boldsymbol{l}$ = the nominal designated length of a tape.

C = the correction to be applied to a tape.

$$C_a = [\frac{l-C}{c}]*L$$

The sign of the correction (Ca) will be the same as that of C before applying the above formula, L and l should be expressed in the same units and the units of Ca and C should be the same.

$$\bar{D}=D-Ca$$

$\bar{D}$=correction length

D= length of the line

Ca = the correction for absolute length.

2- Correction for alignment:

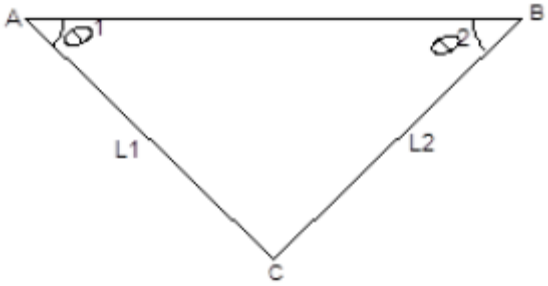
Generally a survey line is set out in one continuous straight line, but some times. It be becomes .necessary due to obstruction to a bent line.

Let: AC = **L1** and BC = **L2**

$< \mathbf{BAC} = \theta\,\mathbf{1}$ and $< \mathbf{ABC} = \theta\,\mathbf{2}$

$< \mathbf{BAC} = \theta\,\mathbf{1}$(**Measured with theodolite**)

$< \mathbf{ABC} = \theta\,\mathbf{2}$(**Measured with theodolite**)



Then

AB = $\mathbf{L1}\cos\theta 1 + \mathbf{L2}\cos\theta 2$

The required correction

= $(\mathbf{L1} + l2)$-$(\mathbf{L1}\cos\theta 1 + \mathbf{L2}\cos\theta 2)$

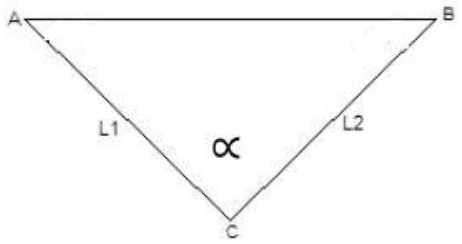
= $\mathbf{L1}(1 - \cos\theta 1) + \mathbf{L2}(1 - \cos\theta 2)$

In case, A and B are not inter visible, the angle (ACB) ($\propto$) may be measured accurately with theodolite and the length at AB may be computed with the following formula : -

AB = $\mathbf{AC2} + \mathbf{BC2} - 2\mathbf{AC}\,\mathbf{BC}^{*}\cos\propto$

Note: -

The correction for alignment is always **subtracted** from the measured length of the line.



3- Correction for slope : •

The distance measured along the slope between two points is always greater than the horizontal distance between them- :

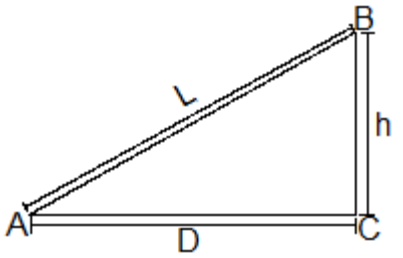
(-ve)=The slope correction

L:-the inclined distance.

D: - the horizontal distance

H: - the difference in elevation of A and B

$$Cs = L\,(1 - \cos\theta)$$



4- The correction for Tension:

If the pull applied during measurements is more than the pull at which the tape was standardized, the length of the tape increases and hence the measured distance becomes less than actual, the correction is therefore ،positive. On the other hand if the pull is less the length of the tape decrease and consequently the measured distance becomes more which makes the correction negative.

Let:

Let: P = pull or tension applied during the measurement in the kg.

A = Area of the tape: - cross –sectional

L: - The length of the tape

Po: The standardized pull = 5 kg

E: The Young's modulus for the tape materials

$\frac{\text{kg}}{\text{cm}^2}$ **E for steel =** 21×10^6 , $\frac{\text{kg}}{\text{cm}^2}$ **E for invar =** 15.4×10^5

$$C_P = \frac{(P - P_O)}{A\,E} \,.\, L$$

5- The correction for Temperature:

The length of the tape increases as its Temperature is raised and decreases as its temperature is lowered , if the Temperature of a tape is above the normal , the correction is positive if it is below the normal ,the correction is negative (-ve)

Let: -

L: - The measured length.

Tm = the mean temperature in the field during measurements.

To = the normal temperature of the tape at the time of standard is station (20℃)

$\propto$= Coefficient of normal expansion .

For invar $\propto = 0.0000010$

And for steel $\propto = 0.000012$

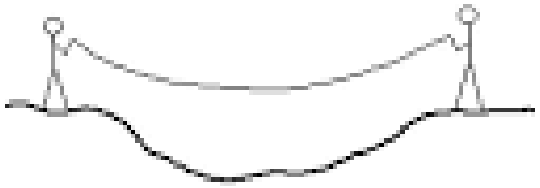
Then the temperature correction **$Ct = \propto (To - Tm).L$**

6- Sag correction :

When a tape is suspended from two supports in air it assumes the shape of catenaries'. The difference the curved length of the tape and the horizontal distance between one supports to the next is known as sag correction. The apparent length of the tape is too large and as such sag correction. Is always negative (- ve)

The Sag correction:

$$\mathbf{Csag} = \frac{\mathbf{L}W^2}{24P^2} \ \mathbf{approximately}\ (-\mathbf{ve}\ )$$



L: - The measured distance.

P = Field pull.

W = Weight of tape / unit length.

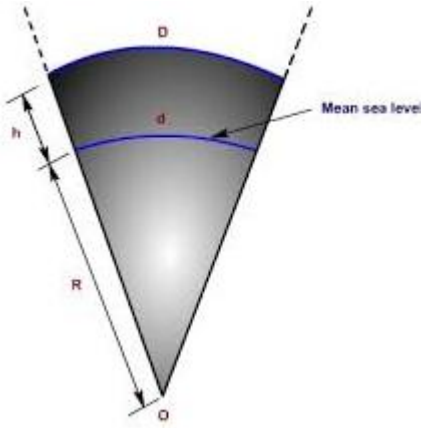
7- Reduction to Mean Sea Level

The measured horizontal distance should be reduced to the distance at the mean sea level, called the geodetic distance. If the length of the base is reduced to mean sea level, the calculated length of all other triangulation lines will also be corresponding to that at mean sea level.

Let

AB = L = measured horizontal distance

A'B' = D = equivalent length at M.S.L. = Geodetic M .S. L.



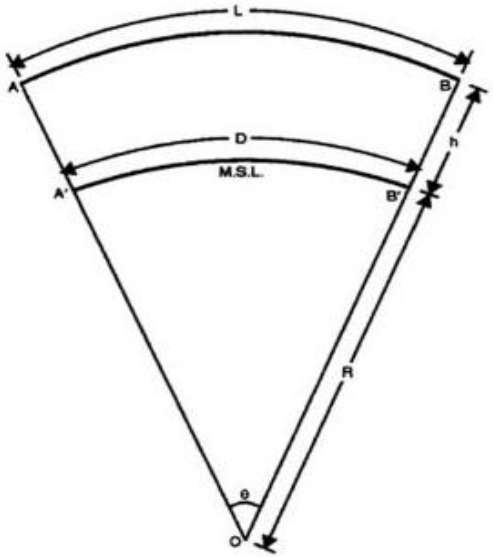
h = mean equivalent of the base line above M.S.L.

R = Radius of earth 0 = angle subtended at the center of the earth, by AB.

Then

$$\theta = \frac{D}{R} = \frac{L}{R+h}$$

$$D = L.\frac{R}{R+h} = L\,(1+\frac{h}{R})^{-1} = C\left(1-\frac{h}{R}\right) = L - \frac{Lh}{R}$$



$$Correction\ (C_{m.s.l}) = L - D = \frac{L\,h}{R}$$ **(Subtractive)**

Examples of corrections

Q1/A measurement of 171.278 m was recorded with a 30-m tape that was only 29.996 m long under standard conditions. What is the corrected measurement?

ANS.:

$$C_a = [\frac{l-C}{C}]*L$$

$$C_a = [\frac{29.996-30}{30}]*171.278$$

$$C_a = -0.022837$$

$$\bar{D} = D + Ca$$

$$= 171.278 - 0.022837 = 171.255m$$

Q2/A 30-m tape is used with a 100N force instead of the standard tension of 50N. If the x-section area of the tape is 1.8 mm2, what is the tension error per tape length?

Note: The Young's modulus for the tape materials= $200 * 10^9\ N/m^2$

$$C_P = \frac{(P - P_O) * L}{A\,E}$$

ANS: $C_P = \dfrac{(100\text{-}50\ \text{N})\ 30.000\ \text{m}}{(1.8\text{x}10^{-6}\ \text{m}^2)\ 200\text{x}10^9\ \text{N/m}^2}$

$= +0.0042\ \text{m}$

The corrected tape length would be 30.004m.

Q3/*A steel tape in (100 ft) long at a temperature of 60 °F when being horizontally on the ground. It's cross sectional area in 0.01259 .in, its weight in 2 lb the coefficient for expansion 65 * 10−7 pe ,°F the tape is strict ahead over three support which are of the same level and at equal intervals. Calculate the actual length between the end graduations under the following conditions T = 80°F, pull = 30 lb E (for steel) = 3∗106 per sq.m.*

ANS.:

1) $Ct = \propto * (To - Tm)$ $L = 0.0000065 * (60 - 80) * 100$ ft $= -0.0130$ ft (+ ve)

2) Sag correction:

$$Cs = \frac{L.W^2}{24\,P^2} = \frac{100.(2)^2}{24\,(30)^2}$$

Cs = 0.018518 (-ve)

True length = 100 - 0.013 – 0.018518

The length of steel tape = 99.994 ft.

Northern Technical University (NTU)
Technical college of Kirkuk (TCK)
Surveying Engineering Department

1st class

SURVEYING I

Lecture four:

Obstacles in chaining

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Obstacles in chaining:

Various obstacles by any one of these methods:

1) Those which obstruct ranging but not chaining.

2) Those which obstruct chaining but not ranging.

3) Those which both ranging and chaining.

1) Obstacles which obstruct ranging but not chaining:

Two cases may occur:

a) Both ends are visible from intermediate points on the line.

b) Both ends may not be visible from intermediate point on the line.

Difficulties faced in both cases may be overcome by reciprocal ranging and random line methods.

2) Those which obstruct chaining but not ranging

The typical types of obstruction under this category are such as water bodies i.e. , lakes , ponds , rivers , hills , etc. , where the distance between two convenient points on the survey line on either side of the obstacle is required to be determined : - There may be two cases : -

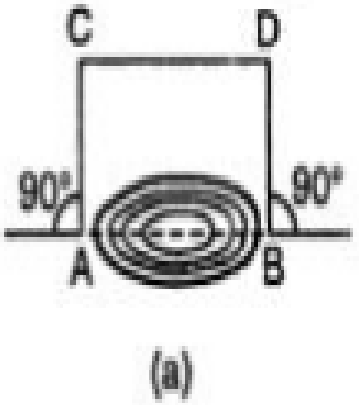
Case (I) in which it is possible to chain round the obstacle, **tank, pond, river etc**.

Case (II) in which it is not possible to chain round the **obstacle river, long lake etc**.

Case (I) Following are the chief methods

Method (a):

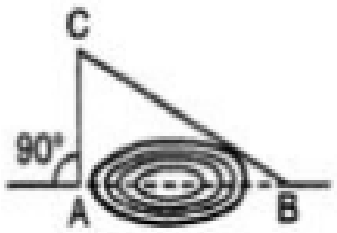
- Select two points **A** and **B** on either side.
- Set out equal perpendiculars AC and BD.
- Measure CD;
- then **CD = AB**



(a)

Method (b):

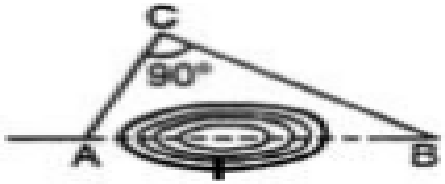
- Set out **AC** perpendicular to the chain line.
- Measure **AC** and **BC**.
- The length **AB** is calculated from the relation **AB=** $\sqrt{BC^2 - AC^2}$



(b)

Method (c):

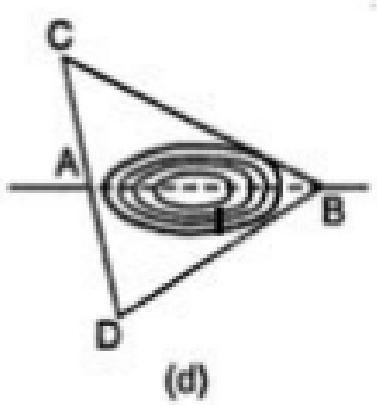
- By optical square or cross staff, find a point **C** which subtends **90°** with **A** and **B**.
- Measure **AC** and **BC**
- The length **AB** is calculated from the relation: **AB=** $\sqrt{BC^2 + AC^2}$



(c)

Method (d):

- Select two points **C** and **D** to both sides of **A** and in the same line.
- Measure **AC**, **AD**, **BC** and **BD**.
- Let angle **BCD** be equal to $\boldsymbol{\theta}$.
- From **ΔBCD**, $\mathbf{BD^2 = BC^2 + CD^2 - 2BC \times CD \cos \theta}$



(d)

$$\boldsymbol{\cos\theta = \frac{BC^2 + CD^2 - BD^2}{2 \times BC \times CD}} \quad \boldsymbol{\ldots\ldots\ldots\ldots (i)}$$

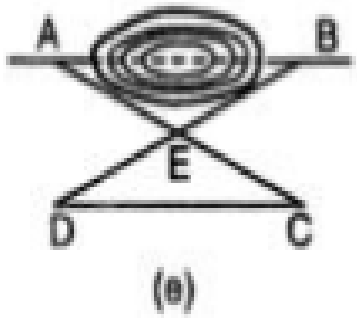
- Similarly from **Δ** BCA $\quad \boldsymbol{\cos\theta = \frac{BC^2 + AC^2 - AB^2}{2 \times BC \times AC}}$ **…… (ii)**

- Equating (i) and (ii) and solving for **AB** we get

$$\boldsymbol{AB = \sqrt{\frac{(BC^2 \times AD) + (BD^2 \times AC)}{CD} - (AC \times AD)}}$$

Method (e):

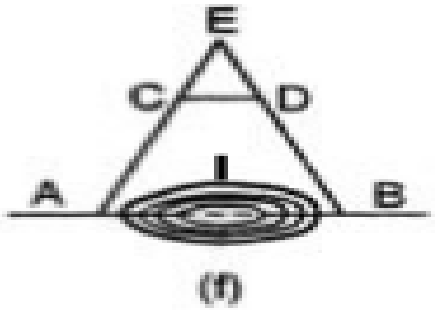
- Select any point **E** and range **C** in line with **AE,**
- Making **AE = EC.**
- Range **D** in line with **BE** and make **BE = ED.**
- Measure **CD** ; then **AB = CD**



(e)

Method (f):

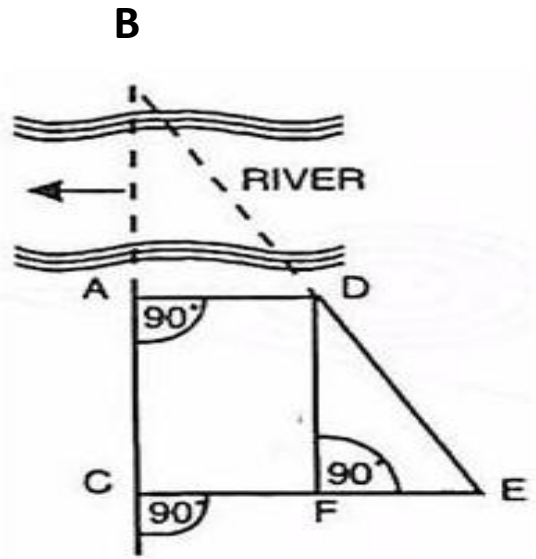
- Select any suitable point **E** and measure **AE** and **BE.**
- Mark **C** and **D** on **AE** and **BE** such that **CE** = $\frac{AE}{n}$ and **DE** = $\frac{BE}{n}$
- Measure **CD**; then **AB = n. CD**



(f)

Case (II):

Method (a):



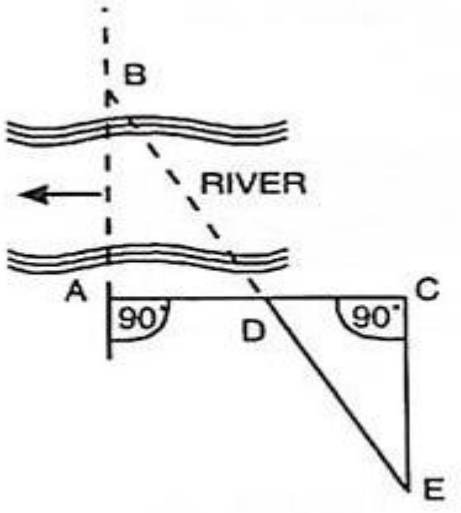
- Select point **B** on one side and **A** and **C** on the other side.
- locate **AD** and **CE** as perpendiculars to **AB** and range **B**, **D** and **E** in one line.
- Measure **AC**, **AD** and **CE**. If a line **DF** is drawn parallel to **AB**, cutting **CE** in **F** perpendicularly, then triangles **ABD** and **FDE** will be similar.

- $\frac{AB}{AD} = \frac{DF}{FE}$ But FE = CE - CF = CE - AD, and DF = AC.

$\frac{AB}{AD} = \frac{AC}{CE-AD}$ From which **AB** = $\frac{\boldsymbol{AC \times AD}}{\boldsymbol{CE-AD}}$

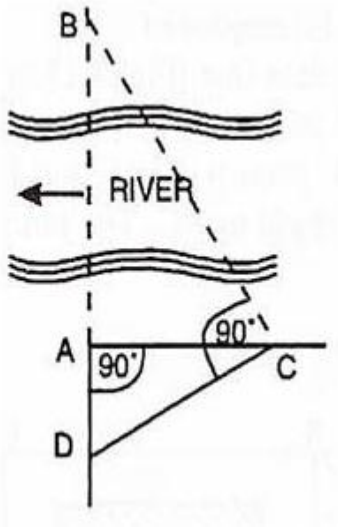
Method (b):

- locate a perpendicular **AC** and bisect it at **D**.
- locate perpendicular **CE** at C and range **E** in line with **BD**
- Measure **CE**
- Then **AB = CE**

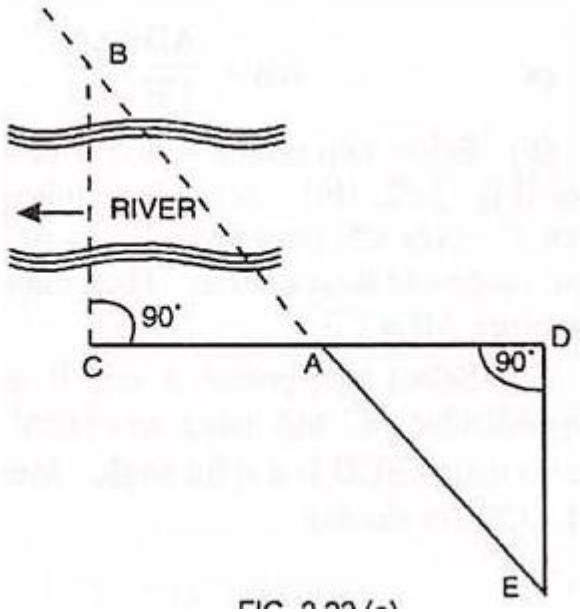


Method (c):

- locate a perpendicular **AC** at **A** and choose any suitable point **C**.
- With the help of an optical square fix a point **D** on the chain line in such a way that **BCD** is a right angle
- Measure **AC** and **AD**. Triangles **ABC** and **DAC** are similar.



- Hence $\frac{AB}{AC} = \frac{AC}{AD}$ Therefore **AB =** $\frac{AC^2}{AD}$



Method (d):

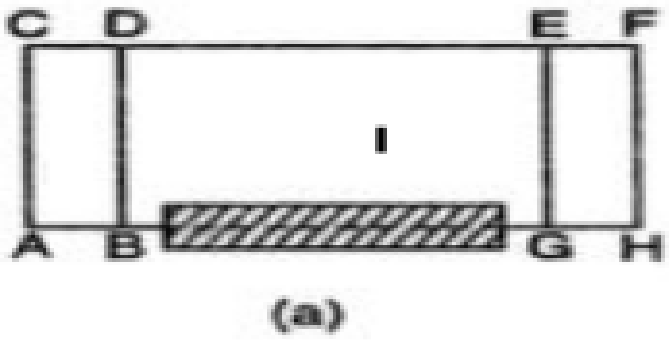
- Fix point **C** in such a way that it subtends **90°** with **AB**.
- Range in line with **AC** and make **AD = AC**.
- At **D**. is perpendicular **DE** to cut the line **E**
- Then **AB = AE**

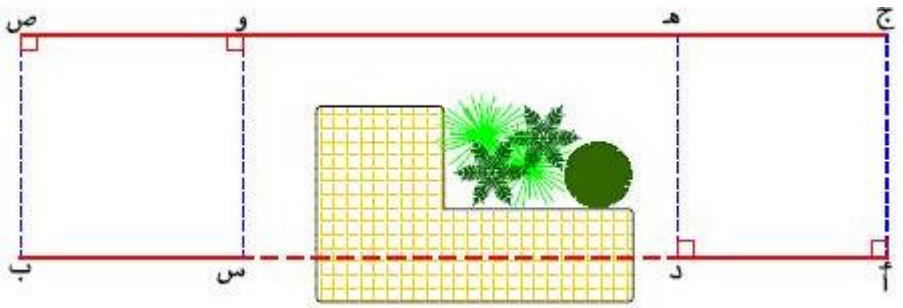
3) OBSTACLES TO BOTH CHAINING AND RANGING

A building is the typical example of this type of obstacle. The problem lies in prolonging the line beyond the obstacle and determining the distance across it. The following are some of the methods

Method (a):

Choose two points **A** and **B** to one side and
Locate perpendiculars **AC** and **BD** of equal length.
Join **CD** and prolong it past the obstacle.
Choose two points **E** and **F** on **CD** and
locate perpendiculars **EG** and **FH** equal to that of **AC** (or **BD**).
Join **GH** and prolong it.
Measure **DE**. Evidently, **BG = DE**





Method (b):

Select a point **A** and locate a perpendicular **AC** of any convenient length

Select another point **B** on the chain line such that **AB = AC**.

Join **B** and **C** and prolong it to any convenient point **D**.

At **D**. set a right angle **DE** such that **DE = DB**.

Choose another point **F** on **DE** such that **DE = DC**.

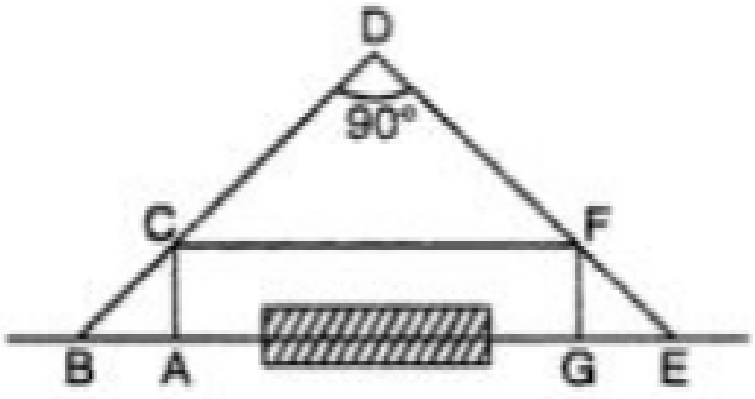
With **F** as center and **AB** as radius, draw an arc.

With **E** as center, draw another arc of the same radius to cut the previous arc in **G**.

Join **GE** which will be in range with the chain line.

Measure CF

Then **AG = CF**



(b)

Method (c):

Select two points **A** and **B** on the chain line and construct an equilateral triangle **ABE** by swinging arcs.

Join **AE** and produce it to any **V** point **F**.

On **AF**, choose any point **H** and construct an equilateral triangle **FHK**.

Join **F** and **K** and produce it to **D** such that **FD = FA**.

Choose a point **G** on **FD** and construct an equilateral triangle **CDG**.

The direction the chain line

The length **BC** is given by **BC = AD – AB - CD = AF – AB - CD**

(c)