① Father of Survey → Survey of India - HQ - Dehradun - Uttar Khand
Peter Jefferson.
① East India Co. ⟶ F/O Survey In India.

① UNIT: 01 (a) FUNDAMENTAL SURVEYING

INTRODUCTION —

① Surveying is the art of determining the relative positions of the pts. on, above or below earth surface by means of elevation, dirn., etc.

or.

Surveying also includes establishing the pts. wrt. refrence pts. by predetermined linear (Hori, Verti) and angular (Hori and vertical angles) measurements. dirn.

NOTE ① Reconnaissance (investigation) is a type of preliminary survey which is performed to find out Method of a survey to be adopted and its rough cost.

Earth —

① earth - oblate Spheroid

$D|_{cal} = 12740\,Km.$

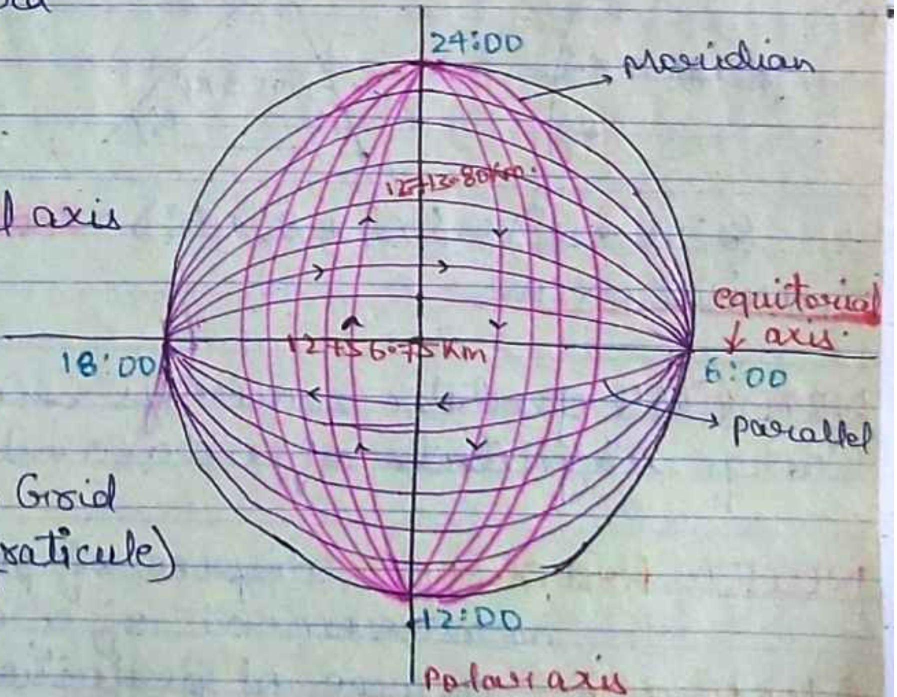
$R|_{cal} = 6370\,Km$

② polar axis < equitorial axis

42.95 Km

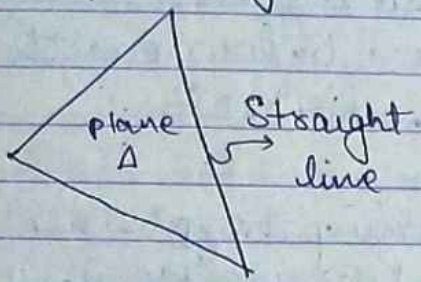
≈ 0.34% loss

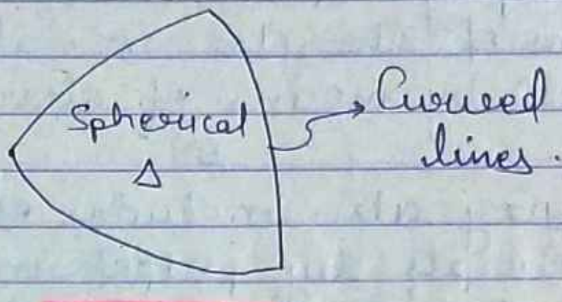
③ Meridian + parallel → Grid (graticule)



NOTE : ① Survey.

plane	Geodetic.
Curvature negligible	Curvature Considered.

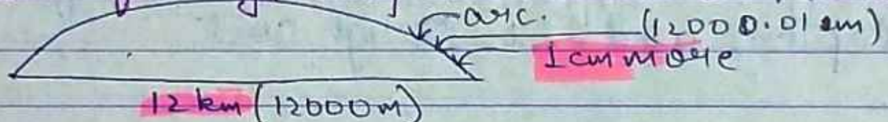




$A \geq 260 Km^2$.

Reason for neglecting curvature in Plane Survey :

①



②

Residual error = Most Probable Value − Measured Value

$(\theta_1+\theta_2+\theta_3)-(\theta_1'+\theta_2'+\theta_3') = 0°0'1''$ of an arc.

Spherical Excess

NOTE ② All geodatic surveys includes the work of large magnitude of area and ↑ degree of precision

NOTE ③ Precision — degree of perfection used for the measurement of a quantity.

Accuracy — degree of perfection obtained using a precise instrument. $\left(LC/_{RF}\right)$

More precise is the instr., more accurate result will be there

TRUE ERROR – True value – measured value.
DISCREPENCY – diffⁿ b/w 2 measurement of a quantity taken under identical conditions.

PRINCIPLES OF SURVEYING –

① Establishing a pt. wrt. reference pt. ~~by~~ with the help of
- → Chain
- → tape.
- → theodo.

② Working from whole to part : Errors will not be accumulated i.e., +ve & -ve errors compensates each other

CLASSIFICATION OF SURVEY (Acc. to purpose of Resulting Maps)

A. Based on nature of field Survey :

① Land.
- → topographical : To know abt details of earth's surface, elevations, etc, features, manmade obj.
- → Cadastral : To locate field boundaries (using cross staff Survey)
- City Maping

② Astronomical
eg. lattitude, longitude, GMT, IMT, etc.

③ Hydrographical / Marine.
- Weddeli Sounding m/c and fathometer are used for meaurement of depth of rivers or sea.
- Pricemeter is used for measurement of velocity of waterbodie

B. Based on Objective of the survey :
① Military S: – eg – Missile development centre.
② Engg S. – eg – Building, Hway.
③ Geological S – for diffⁿ layers of earth Surface.
④ Mine S – eg. – coal mines in Jharkhand.
⑤ Archeological S – To know abt. old. structures.

C- Based on instrument used & type of Survey :

	HD	VD	HA	VA
① Chain	✓	×	×	×
② Tape	✓	✓	×	×
③ Compass	×	×	✓ bearing	×
④ theodolite	×	×	✓	✓
⑤ TS	✓	✓	✓	✓

⑥ Traversing.

↓

Plane table traversing

⑦ Tacheometric Survey.

⑧ Photogrammetry.

- for details of areas which are not reachable.
- In aerial photography, photos are taken @ proper interval to maintain @ least 60% longitudinal and 30% side overlap.

UNITS OF MEASUREMENT.

- Acc. to standards of wt. and measures act, 1956, the basic unit of linear measurements are metre and cm.
- before intro. of metric units in India (SI, MKS, FPS, CGS) (1 pound = 453 gm) units of linear measurements were foot, 1/10th foot, furlong, mile.

1 furlong = 10 gunters chain = 10 × 66' = 660'

1 mile = 80 gunters chain = 1.609 km = 80 × 66' = 5280' = 1609 m = 1.609 km

1m = 3.28'

- An angle is the diff^n b/w dir^n of 2 intersecting lines
- Basic unit of an angle → radian = $\left(\frac{180^\circ}{\pi}\right)$

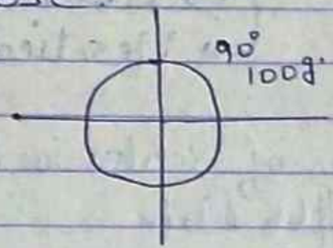
Systems of angular measurements :⟶

	1 Circumference.		
① Sexagesimal (most used)	360° (degree of arc)	1° = 60' (min. of arc)	1' = 60" (sec of arc)

2) Centesimal 400^g (grades of arc) $1^g = 100^{cg}$ (cg of an arc) $1^{cg} = 100^{ccg}$ (centi-centi grade of an arc)

3) Hours ↓ 24 hrs. $1^h = 60\,min$ $1^{min} = 60^{sec}$

Acc to rotation of earth abt its axis used for astronomical and navigational purpose.



- $360° = 24^{hr}$

$$1\,hr = \frac{360}{24} = 15°$$

$$60^{min} = 15°$$

$$4^m = 1°$$

- Earth completes revolution of 1° in 4 min.

SCALES USED IN SURVEY

- Ar. which is surveyed is vast and hence maps & plans are made to some scale.
- If scale is small, representation is cld as a Map.
- Representation is cld as plan, if scale is large.
- Scale is the fixed ratio that every plan on drawing bears with corresponding distⁿ on the ground.
- Ratio of Map distⁿ to corresponding ground distⁿ is independent of units and is cld as Representative fraction (RF)

eg: If 1cm = 10m

$$RF = \frac{1\,cm}{1000\,cm} \qquad RF = \frac{\text{Map dist}^n}{\text{Corresp}^g\text{ ground dist}^n}$$

Types of Scales as per purpose of surveys are given:

1) Topographical map.
   - ↳ building sites → $\leq \frac{1}{1000}$
   - ↳ town planning schemes, Reservoirs, etc. → $\frac{1}{5000}$ to $\frac{1}{250000}$.

② Cadastral Survey. → $\frac{1}{500}$ to $\frac{1}{5000}$

③ Geographical maps. → $\frac{1}{50000}$ to $\frac{1}{16000000}$

④ Cross-Sections → $\frac{1}{100}$ to $\frac{1}{200}$

⑤ longitudinal Sxns.
- ↳ Hori. Scale → $\frac{1}{1000}$ to $\frac{1}{20000}$
- ↳ Vertical Scale → $\frac{1}{100}$ to $\frac{1}{200}$

⑥ forest Map → $\frac{1 \text{ cm}}{25000 \text{ cm}}$

Types of Scales in Survey.

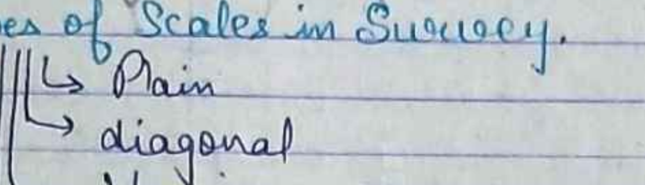
⑦ location Map → $\frac{1}{500}$ to $\frac{1}{2500}$

1° [
- ↳ Plain
- ↳ diagonal

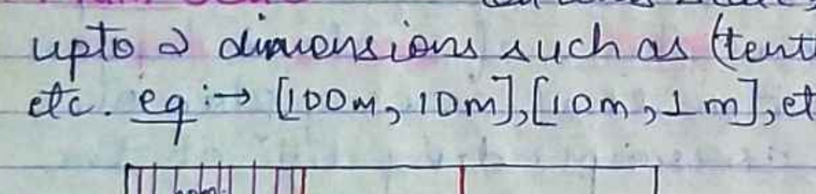
⑧ Rough/Hilly ground → $\frac{1}{250}$.

2° [
- ↳ Vernier → Direct Vernier
  - ↳ Indirect / Retrograde V
  - ↳ Extended type V
  - ↳ double folded V.
  - ↳ double direct V.
- ↳ Micrometer Microscope
- ↳ Shrunk Scale.
- ↳ Scale of Chord.

1. Plain Scale —— On this scale, it is possible to read upto 2 dimensions such as (tenths, units); (Hundreds, tenths) etc. eg → [100m, 10m], [10m, 1m], etc.



2. Diagonal ~~Vernier~~ — On diagonal scale, it is possible to read 3 dimensions [units, 10th & 100th], → eg [100, 10, 1]m.
- This scale uses the properties of similar Δ.



3. Vernier Scale —— Given by Pierre Vernier in 1631.

On this Scale 3 dimensions can be read (cm, mm, $\frac{1}{10}$th mm)

least count is the mini dimension that can be read by any instrument.

· Least Count / Fineness of reading is diff^n b/w smallest division of main Scale and smallest division VS and vise versa.

a – direct vernier:

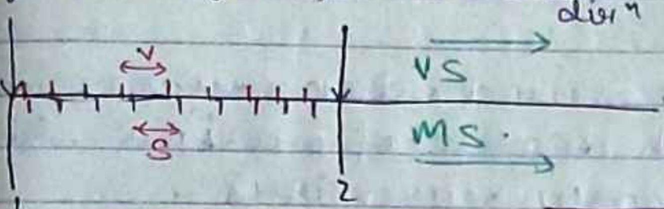
→ Main Scale and VS moves in same dir^n.

→ (n−1) divisions of MS are divided into n division of VS; ie. $\boxed{S > V}$

→ divi of VS & MS in same dir^n

S = Smallest divi of MS.

V = ——— V.S.



$(n-1)S = n \cdot V$

$$\boxed{LC = S - V}$$

$= S - \frac{(n-1)S}{n}$

Least Count $= \left(\frac{x-y}{x}\right)$ least measured value of MS

x = Max Value
y = Smallest Value

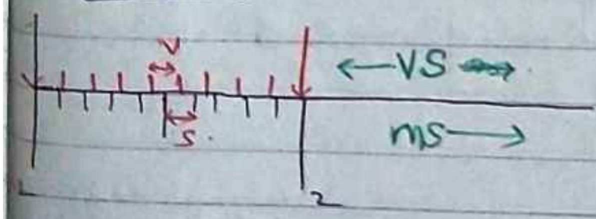
of VS & MS.

$$\boxed{LC = \frac{S}{n}}$$

b – Indirect or retrograde vernier:

→ vernier & MS moves in opp dir^n wrt eachother and (n+1) division of MS are divided into n divi of VS.

→ $\boxed{S < V}$



$(n+1)S = n \times V$.

$V = \frac{(n+1)S}{n}$.

$LC = V - S$

$$\boxed{LC = S/n}$$

c. Extended type Vernier: In case of astronomical sextant, vs provided is of extended type having 60 divisions equals to 119 divi. of MS. (each of 10°)/(10/60 min), least count be 10"

$60v = 119s$.

$nv = (2n-1)s$. • This vernier is used in Abney level.

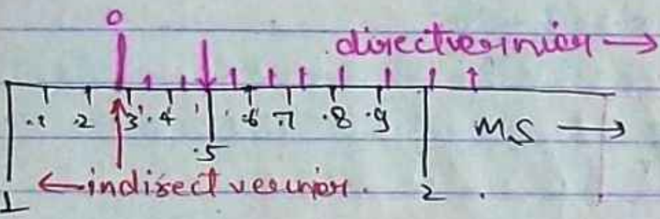
$v = \frac{(2n-1)s}{n}$.

$LC = 2s - v$.

$= \frac{2ns - 2ns - s}{n}$

$\boxed{LC = \frac{s}{n}}$

d. Double folded Vernier: DFV is used when a measurement needs to be taken to high degree of precision which is not possible by ordinary verniers.



$19v = 20s$.

$9\frac{1}{2}v = 10s$.

$LC = 3'$

[Reading = 1.232]

e. Double direct Vernier: provided in instruments having circular scales eg → theodolite, Clinometer, Sextant, etc.

	LC
Graduated to 30° →	1'
Graduated to 20' →	30"

NOTE: Scale of Chords: is used for setting out the ∠s of a long chord.

4. Micrometer Microscope — It is a device which enables a measurement to be taken to very fine degree of accuracy.

- Provided in Geodatic theodo.
- $\boxed{LC = 1''}$

NAME	LC
Micrometer Microscope	1''
Extended Vernier	10''
Theodolites	20''
DDV – Graduated to 20'	30''
DDV – ——— 30°	1'
DDFV	3'
Prismatic Compass.	30'
Surveyor Compass.	~~60'~~ 15'

Note ① Mini dim^n that can be drawn on a sheet = ·25mm
= ·025 cm

Note ② $\text{Scale} = \dfrac{\text{Map dis}^n}{\text{Ground dis}^n} = \sqrt{\dfrac{\text{Map area}}{\text{Corrected ground area}}}$

5. Shrunk Scale. —

If Scale is 1cm = 100m

Original $RF = \dfrac{1}{10000}$

If it is found that $10\text{cm} \xrightarrow{\text{Shrunk}} 8\text{ cm}$.

10 cm = 1000m.

$\Downarrow$

$\dfrac{1\cancel{0}}{10000\cancel{0}}$

8 cm = 1000 m.

$\dfrac{8}{100000} = \dfrac{1}{12500}$ Shrunk RF.

$\boxed{1\text{cm} = 125\text{ m}}$ Shrunk Scale

Shrinkage factor = $\frac{\text{Shrunk length}}{\text{Original length}}$

Shrunk RF = Original RF × S Factor

eg:→ $SF = \frac{8.0}{10.0} = 0.8$ $\qquad \frac{SRF}{ORF} = \frac{SL}{OL}$

Shrunk RF $= \frac{1}{10000} \times .8 = \frac{1}{12500}$ Ans.

$\boxed{1\,cm = 125\,m}$

Q. A measurement of a field from drawing was found to be $275\,cm^2$. Original scale 1 cm = 50 m. If it is found that 15 cm line has shrunk to 12.5 cm Calculate area of field acc. to current scale.

Sol^n: $275\,cm^2$

1 cm → 50 m

15 cm → 12.5 cm

• ar. of drawing $= 275\,cm^2$

Field ar $= 275 \times 50^2\,cm^2$

$= 687500\,cm^2$

~~Original RF = $\frac{1}{5000} = \frac{15}{15 \times 5000}$~~

• Shrinkage factor $= \frac{12.5}{15}$

• Shrunk RF $= \frac{1}{5000} \times \frac{12.5}{15} = \frac{1}{6000}$ Shrunk Scale.

$\boxed{1\,cm = 60\,m}$

• Actual ar. of field $= 275 \times 60^2 = 990000\,m^2$ Ans

UNIT : 01 (b) LINEAR MEASUREMNTS

INTRODUCTION

- There are various methods of making linear measurements and their relative merit depends upon the degree of accuracy req.
- Diffⁿ methods are.

① Measurement ~~of~~ by direct Mthd. — chain, tape, etc

② Measurement by Optical Means — Tacheometry, Trigno levelling, (D = KS + C), etc

③ Electro-magnetic Mthd.

distances (Hoz) are measured with the help of propagation, reflection and subsequent reception of either light wave, Radio wave, microwave or infra red wave.

→ Geodimeter — light wave

RADAR [Radio active detector & Ranging] — Radio wave

Tellurometer — microwave

↳ all other — Electronic distⁿ Measure instruments

- Diffⁿ instruments used for Hori. distⁿ measurements are:

① Padometer — directly Measure distⁿ

② Passometer → total distⁿ = no. of paces × pace length

③ Parambulator ⟷ Only disⁿ is included.

④ Odometer / Speedometer — Total disⁿ = No. of revolⁿ × Circumference of wheel.

⑤ Pacing —

- used for rough surface / explorations when a surveyor is cld to make survey as quickly as possible.
- Avrg length of pace = 60 cm – 80 cm

⑥ Chaining System —

- very accurate Mthd. of direct LM.
- for ordinary work, chain is used
- for accurate work, tape is used.

NOTE : Steps for Chain Survey are :⟶
① Reconnaissance (fly levelling/ diff^n tial levelling)
② Fixing and marking terminal points or survey stations Preliminary
③ Running the Survey lines. location

NOTE : Diff^n instruments used in chaining ⟶
① Chain and tape
② arrows or marking pins.
③ wooden pegs.
④ Ranging rod and offset rod.
⑤ Ranging pole and butt Rod.
⑥ Plasterer's lath and whites
⑦ Plumb bob.

1) CHAIN (IS:1492:1970)

• Chains are formed of straight links of galvanised mild steel wire bent into rings @ ends and joined together by 3 small circular/oval rings.
• Ends of chain are provided with brass handle @ both ends with swivel Joints so that chain can be turned without twisting.
• If the length of chain is found to be short can be adjusted by straightening the links.
• Diff types of chains are :
① Metric Chain —
2m , 5m , 20m , 30m
20m ↓ 100 links } 30m ↓ 150 links.
→ (@ every 2 m) brass tags are fastened } (@ 5m)
→ 1m = 5 links.
→ tolerance = ± 5mm

• permissible error in chaining on rough or hilly ground = $\frac{1}{250}$
• Mud → +ve error.

② Gunter's Chain / Surveyor's Chain :—
• initially used for land measurements and length meas. in furlongs and miles.

- 66' long = 100 links (.66' each = 7.92'' long)
- 1 Acre = 10 (Grunters Chain)^2
  = 198' × 220' = 43560 sq.ft = 4840 Sq. yard = 40 Gunthas

- 1 sq yard = 9 ~~gunthas~~ sq.ft.
  1 Guntha = (33')^2
- 1 Furlong = 10 gunters Chain
- 1 Mile = 1609 M = 80 gunter chain

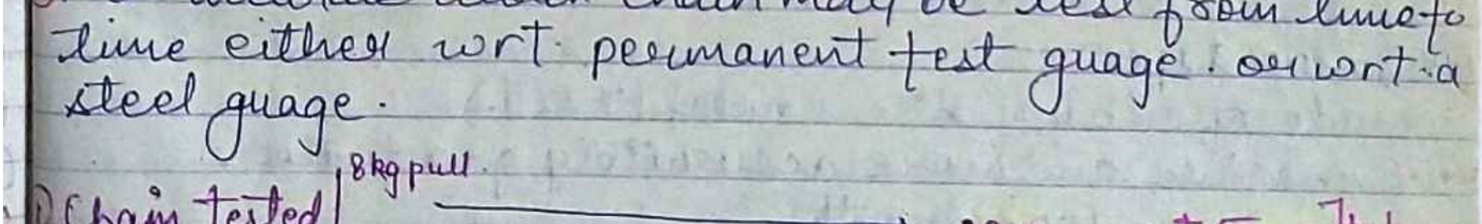
③ Engineer's Chain —
100' long = 100 links (@ every 10', brass tags fastened)

④ Revenue Chain —
33' long = 16 links ($2\frac{1}{16}$' each)
It is used for measurement of field boundaries in a cadastral survey. →

⑤ Steel band / band chain (On Reels) —
- It Consists of a narrow strip of 12mm to 16mm width (steel) and 3mm to 6mm ~~wide~~ thick
- Available in the length of 20m and 30m.

NOTE :
① For accurate work chain may be test from time to time either wrt permanent test guage or wrt a steel guage.

① Chain tested | 8kg pull wrt steel tape Std @ 20°C → 20 m → ± 5mm, 30m → ± 8mm (tolerance limit)



2) TAPE

① Cloth tape —
- Available in 25 m, 20 m, 50 m, 33', 66', 50', 100' length.
- provided with a metal ring whose length is also included in total length of tape.

② Metallic tape —
- Made up of cloth + wire
- 2m, 5m, 10m, 20m, 30m, 50m length available.
- @ outer ends, a metal strip is fastened which is having same width ~~Ø~~ as that of width of the tape.

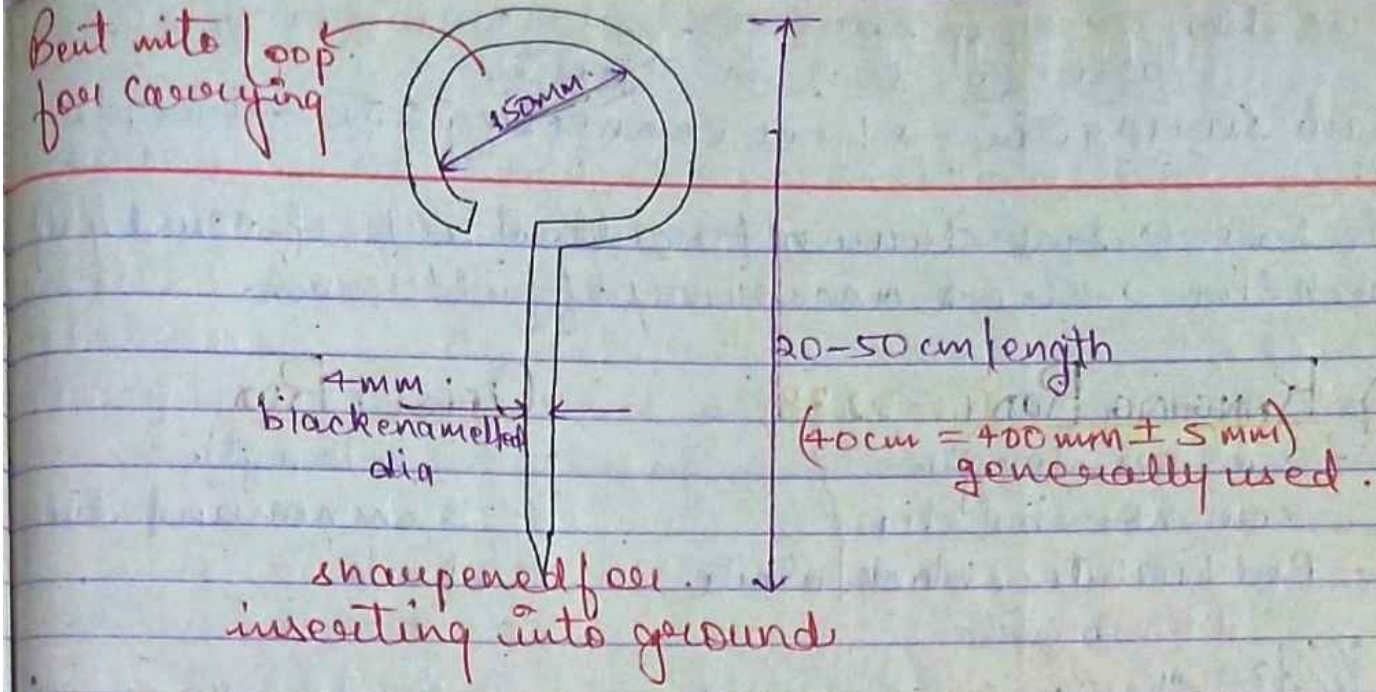
③ Steel tape —
- Consists of a strip of steel (6mm to 10mm wide, 3mm thick) and is more accurately graduated.
- 2m, 10m, 20m, 30m, 50m length available.
- steel tape is a delicate instrument & hence can't be used for rough usage.

NOTE: difficulty with steel and invar tape is that they can be easily bent and damaged and Hence they must be kept / wrapped on reels of large dia.

④ Invar tape —
- made of alloy of steel + nickel (≈ 36%)
- 6 mm wide and more accurately graduated.
- 20m, 30m, 100m length
- $\alpha_{invar} \simeq \frac{\alpha_{ms}}{10}$ (in range of 10^{-7} per °C)
- Used for base line.

3] ARROWS / MARKING PINS. (IS-1861)

It is inserted into the ground after every chain length measured on the ground.

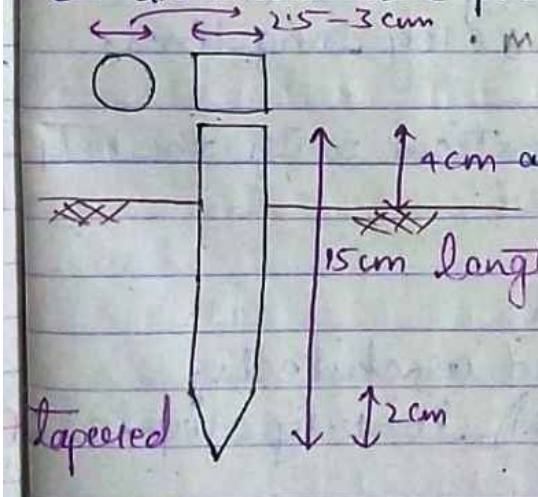


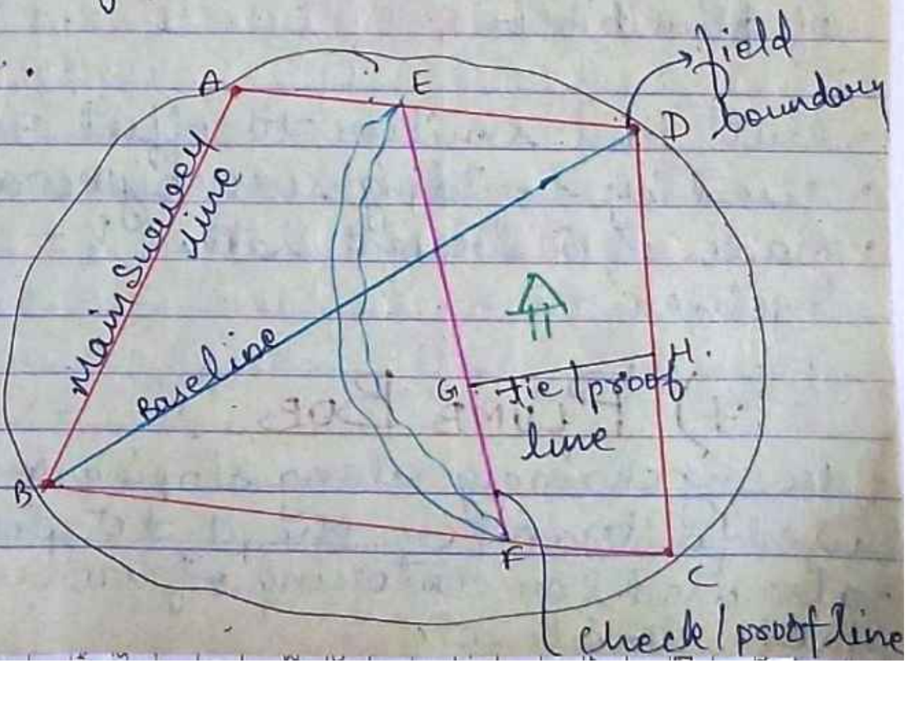
- Made of stout steel wire [Good Qlty, Hard & tempered (4mm dia)]
- 10 arrows are supplied with 1 chain.

4) WOODEN PAGS

are inserted into grounds to pt. of terminal stations.
or to mark the position of a survey line

- made of stout timber.
- Inserted by wooden hammer.





- Base line → Main survey line which divides total area @ least in 2 parts.
- Main survey line → Lines connecting 2 terminal pts.

- tie line → line drawn to collect info of nearby obj.
- Check line → check accuracy of field work.

5) Ranging Rod (IS-2288)

- 2m/3m length
- 3cm nominal dia
- Red/white, black/white Alternate bands

20cm · used for rough measure^t and to range intermediate pt. in survey line
20cm ·

Offset Rod

- 3m length.
- 3 cm nominal dia
- black
- used for measuring Rough offset
- set @ right ∠ to 1 another

6) Ranging Poles (4–8m) And Butt Rods

- Ranging poles are similar to Ranging rods except that they are longer and of large dia (6 cm–10 cm)
- Ranging poles are used in case of very long lines.
- ½m sunk into ground.
- Ranging poles being set quite vertical with the help of plumb bob.

- Butt rod similar to offset rod.
- Used by building surveyors and architects.
- Made of 2 straight laths (½ – 1m) loosely riveted together · Generally used for measuring offset.
- Black Color.

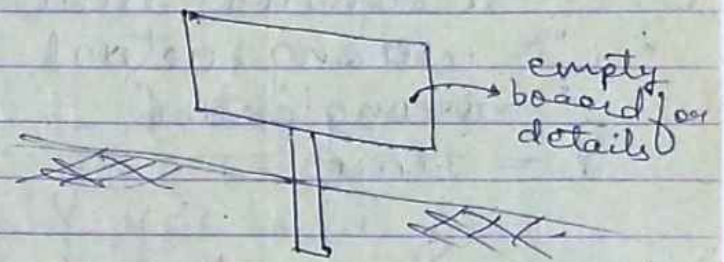
7) Plumb Bob

- during chaining along sloping ground, plumbbob is used to transfer the pt. to ground surface.
- also used for centering of surveying instruments; plane table, theodo, etc

8) PLASTERER'S LATH AND WHITES.

In open level ground, intermediate pts on a survey line may also be lined out with the help of straight lath. (½ M – 1 M), made of soft wood, light in color.

- Whites are having the same purpose as that of plasterer's lath.
- Whites are pieces of sharpened thin sheets cut from nearest edge, made of softwood, light in color.



Note: ① If two end pts are obstructed by rising ground b/w them, direct ranging is not used, in such cases indirect ranging is used which is also c/d as reciprocal ranging.

** ② If survey lines passes through a thick dense forest it is not possible to used direct or indirect ranging. In such cases, special Mthd, Random line Mthd is used.

③ line ranger is used when vision b/w 2 end pts. is not obstructed.

- Chaining on inclined ground Hypotenuse & Stepping Mthd

CORRECTION TO INCORRECT LENGTH

designated length = 30 m.

written	Measured	error	Corr^n
30 m	30.10 m	−0.10 m	+0.10 m
30 m	29.90 m	+0.10 m	−0.10 m

Length ↓ → error = +ve, → Corr^n = −ve
Length ↑ → error = −ve, → Corr^n = +ve

If L = designated / true length of tape (say 30 m)
L' = wrong / actual ——— (say 30.10 m)
l' = wrong / actual ——— line measured (say 2100 m)
l = true ——— (??)

{true × true = wrong × wrong}

$$L \times l = L' \times l'$$

$$l = \frac{2100 \times 30.10}{30}$$

$$\boxed{l = 2107\,m} \text{ Ans.}$$

$$\boxed{\text{true length} = \text{wrong length} \pm \text{corr}^n}$$

(1) Corr^n due to Standardisation :

- This corr^n is applied when

$$\boxed{\text{designated length} \neq \text{actual length}}$$

Corr^n per tape length $= \pm (L' - L)$

total Corr^n, $\boxed{C_{st} = \pm\left(\frac{L' - L}{L} \times l'\right)}$

$$\boxed{\text{true length} = l' \pm C_{st}}$$

error = Cumulative, ±

eg ⇒ $C_{st} = \left(\frac{30.10 - 30}{30} \times 2100\right) = 7\,m$

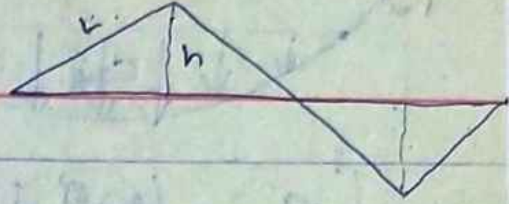
$l = 2100 + 7 = 2107$ Ans.

② Corr^n due to Alignment or Bad Ranging:

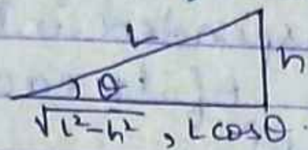
error = +ve, cummulative

Corr = −ve.

$$C_{al} = \frac{h^2}{2L}.$$



③ Corr^n due to Slope:



~~Corr^n = +ve~~ ~~error = +ve~~

• Corr^n per chain length of 100 links along a slope of

$$\boxed{\alpha^{\circ} = \frac{1.5\,\alpha^2}{100}}$$

If h is given

$$\boxed{C_{slope} = L - \sqrt{(L^2-h^2)}}$$

$$= L - L\left(1-\frac{h^2}{L^2}\right)^{1/2}$$

If θ is given

• --- $\alpha^{rad} = 100\alpha$

$$\boxed{C_{slope} = L - L\cos\theta}$$

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

$$\boxed{C_{slope} = 2L\sin^2\frac{\theta}{2}}$$

• --- Slope having rise of 1 Unit in n Horiz Units $\Rightarrow \frac{100}{n^2}$

On expanding by binomial;

$$(1-x)^n = 1 - xn + \frac{n^2}{2!}x^2 + \text{---}$$

$$C_{slope} \Rightarrow L - L\left[1 - \frac{1}{2}\frac{h^2}{L^2} + \frac{1}{4\times 2}\frac{h^4}{L^4} + \text{---}\right]$$

$$C_{slope} = L - L + \frac{h^2}{2L} - \frac{h^4}{8L^3}$$

$$\boxed{C_{slope} = \frac{h^2}{2L} - \cancel{\frac{h^4}{8L^3}}}$$

negligible for slope flatter than 1 in 25 m

④ Corr^n due to temperature:

$$\boxed{C_{temp} = L\,\alpha\,(T_m - T_0)}$$

α = Coeff. of thermal exp. (9×10^{-6} per°C − 50×10^{-6} per°C)

• Can be +ve or −ve.

• T_m = ~~time of~~ temp @ time of measurement

T_0 = temp @ time of standardisation

⑤ Corr^n due to pull:

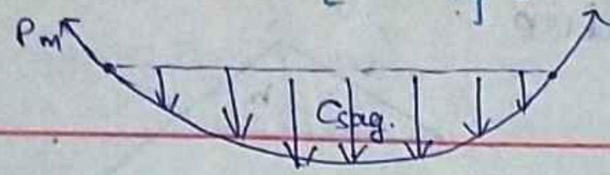
$$\boxed{\underset{(+,-)}{C_{pull}} = \frac{L(P_m - P_0)}{AE}}$$

Corr^n −ve, +ve

P_m = pull @ time of measurement

P_0 = pull @ time of standardisation

⑥** Corrⁿ due to Sag :



- C_{sag} = −ve only, error = +ve
- Curve → parabolic
- wt. of tape per m. run.

$W = wl$ = total wt. of tape.

by Conjugate beam Method

$$\left[C_{sag} = \frac{(wl)^2 \cdot l}{24 P_m^2}\right]$$

If cable is suspended into 'n' equal parts ∴ $l = n\,l_1$ of l_1 each

$$C'_{sag} = \frac{l_1 (w l_1)^2}{24 P_m^2}.$$

$$C_{sag} = n * C'_{sag}.$$
$$= \frac{n \cdot l_1 (w l_1)^2}{24 P_m^2}$$
$$= \frac{l (wl)^2}{n^2 24 P_m^2}$$

$$\boxed{C_{sag} = \frac{l W^2}{24 P_m^2 n^2}}$$

NOTE: The value of pull for which +ve pull corrⁿ & −ve sag corrⁿ becomes equal, is cld as normal pull or normal tension.

$$C_{pull}(+) = C_{sag}(-)$$
$$\frac{(P_M - P_0) L}{AE} = \frac{W^2 L}{24 P_m^2}$$

$$\boxed{\frac{P_M - P_0}{AE} = \frac{W^2}{24 P_m^2}}$$ → P_M = Normal tension

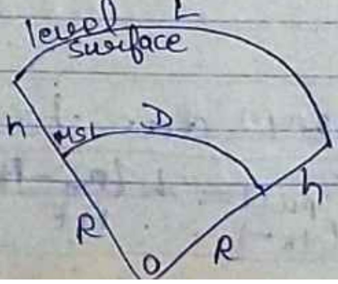
Solved by trial & error method.

⑦ CORRⁿ due to Reduction to MSL :

The measured Hori. disⁿ should be ↓red. to disⁿ @ MSL which is cld as geodatic disⁿ.

C_{MSL} = −ve $\quad \theta = \frac{D}{R} = \frac{L}{R+h}.$

$$D = \frac{L \cdot R}{R\left(1 + \frac{h}{R}\right)}$$



$$D = L\left(1+\frac{h}{R}\right)^{-1} = L\left(1-\frac{h}{R}+ - - -\right) \quad \boxed{D = L-\frac{Lh}{R}}$$

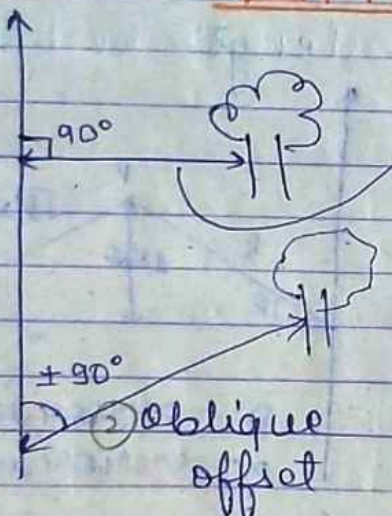
$$C_{MSL} = L - D \Rightarrow \cancel{L}-\cancel{L}+\frac{Lh}{R} \quad \boxed{C_{MSL}=\frac{hL}{R}} \text{ -ve.}$$

NOTE: ① field book (20cm×12cm) – is a book in which chain or tape measurements are entered.

- Single line FB is used for most detailed dimension work and comparatively large scale work.
- Double line FB is used for ordinary work, entries are made along 2 ∥ vertical lines of a page.

— OFFSET —

① Method of setting ⊥ offsets:
↳ less measurement req
↳ instruments → steel tape, Optical Sq., Cross Staff.

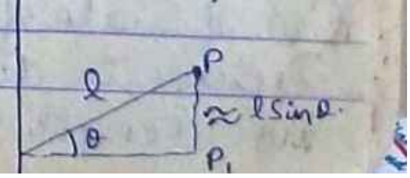


Offset (⊥ offset, lateral min dis^n of any object or ground feature from survey line)

offset ≤ 16m short offset
> 16m long offset.

- Max length / allowable or limiting length depends on → Nature of ground
  - ↳ Degree of accuracy
  - ↳ Method of setting out the ⊥
  - ↳ Scale adopted.

Case ① If error is in dir^n only –



θ = error in dir^n
l = length of offset.
P = actual position of obj on ground
P₁ = marked ——— drawing

Total error on ground $(PP_1) = l\sin\theta$ (m)

If scale of drawing is $\boxed{1\text{ cm} = S\text{ m}}$

then error on drawing $= \dfrac{l\sin\theta}{S}$ cm —— (A)

If above error is $\leq .25$ mm then above error is assumed to be negligible.

taking $\cdot 25$ mm $= \cdot 025$ cm as limit of accuracy.

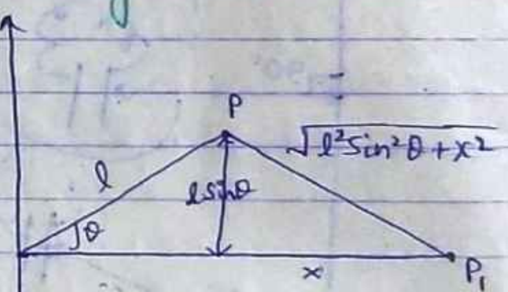
Max length of offset $= \dfrac{l\sin\theta}{S}$ (cm) ≤ 0.025 cm.

$$l = \frac{0.025\cdot S}{\sin\theta} = \frac{S}{40\sin\theta}.$$

$$\boxed{l = \cdot 025 S\ \mathrm{Cosec}\,\theta.}$$

Case (2) If above error is in length and direction both —

total error on ground $(PP_1) = \sqrt{l^2\sin^2\theta + x^2}$



If scale of drawing is $\Rightarrow$ 1 cm = S m

than the error on ~~ground~~ drawing $= \dfrac{\sqrt{l^2\sin^2\theta + x^2}}{S}$ cm —— (A).

θ = error in dir^n

x = error in length

If above error is $\leq \cdot 025$ cm

error is neglected.

Max/limiting length of offset $= \dfrac{\sqrt{l^2\sin^2\theta + x^2}}{S} = \cdot 025$

$$\boxed{\cancel{l = \sqrt{\frac{S^2 - x^2}{(40\sin\theta)^2}}}} \qquad \boxed{l = \sqrt{\frac{(\cdot 025 S)^2 - x^2}{\sin^2\theta}}}$$

Q(1) If Scale of drawing 1 cm = 45 m and permissible error in dir^n in setting out an offset is $4°$, Calculate max length of offset. $l = \cdot 025 \times 45 \times \mathrm{Cosec}\,4° = 16\cdot 127$ cm

Q(2) If ~~max error~~ in setting out an offset in dirⁿ is 3° and length of offset is to be measured not $\leq$ .10cm (doubt). If scale of drawing is 1cm = 60m. Calculate max length of offset.

$$l = \sqrt{\frac{(.025(60))^2 - (.10)^2}{\sin^2 3^\circ}} \qquad l = 28.60\text{m Ans}$$

$$l = \sqrt{\frac{60^2 - (.10)^2}{(.40\sin 3^\circ)^2}} = 28.66\text{m Ans}$$

A. INSTRUMENTS FOR SETTING OUT ⊥ar and angles :→

① Optical Square – Used for setting out angle of 90° w.r.t. to a survey line. → more accurate than prism square.

- double reflection concept is used
- Shape is like penta prism (glass surfaces)
- ∠ of intersⁿ of 2 plane mirrors of an optical sq. = 45°

② prism Square – similar to optical square, i.e., used for setting out ∠s of 90° w.r.t. a survey line

- Advantages
  ↳ No adjustment is req. ∵ ∠ b/w reflecting surfaces is constant i.e., 45°.

③ Site Square – shape is like a theodolite.

- Consists of 2 telescope @ Right ∠ w.r.t. eachother
- used for setting out main lines and offset lines @ 90° w.r.t. another lines.
- Costlier than Optical and prism square.

④ Cross Staff – Consists of 2 pairs of vertical slits and is mounted on a pole-shot for fixing into the ground.

a) Open Cross Staff ; used for setting out the offset lines @ 90° w.r.t each other.
↳ It is observed that the pt. to which offset is to be taken is bisected or not. If not bisected, cross staff is moved forward or backward till line of site also passes through that point.

b) French Cross Staff; Consist of hollow octagonal box
↳ Vertical slits are cut in the middle of each face.
↳ used for setting out the ∠s of either 45° or 90° wrt any line.

c) Adjustable Cross Staff; Consist of 2 cylinders placed 1 over another.
↳ used for setting out any angle

NOTE ① CROSS STAFF SURVEY

- It is done to locate the field boundaries & to determine area.
- Chain line run through area's centre, total area is determined by subdividing the total area into no. of geometric fig. such as △s, □s, ⏢, etc.
- The instruments used for cross staff survey are
  → Cross staff → Chain
  → Offset Rod → Arrows, etc.

Q① A 30m chain is used for measurement of a base line under a pull of 100N in 3 equal parts. Calculate Sag corrⁿ per tape length. Wt of tape = .078 N/cm³ ar. of tape = 0.08 cm².

$n = 3$ of 10m each.

$\rho = 0.078 \frac{N}{cm^3} = \frac{W}{V}$

$W = w\, l_1 = 0.078 \frac{N}{cm^3} \times 0.08\,cm^2 \times 10 \times 100\,cm = 6.24N$

$C_{sag} = \frac{W^2 l}{24 P_m^2 n^2} = \frac{6.24^2 \times 10}{24 \times 100^2 \times 3^2}$

$C_{sag} = 3\, C'_{sag}$

$C_{sag} = \frac{3 \times 6.24^2 \times 10}{24 \times 100^2} = -.000486\,m$ Ans.

Q(2) 20m tape is std @ 54°C. is used for measurement of base line under pull 10kg. temp @ time of measurement 65°C pull exerted is 16 kg. Cal. per tape length.
wt. of tape = 7.86 g/cm³, total wt of tape = 0.8 kg.
$E = 2.1 \times 10^6$ kg/cm² $\alpha = 6.5 \times 10^{-6}$ /°C.

Solⁿ :→ $T_0 = 54°C$ Chain = 20 m.

$T_m = 65°C$

$P_0 = 10$ kg.

$P_m = 16$ kg.

(i) $C_{temp} = (65-54) 20 \times 6.5 \times 10^{-6} = +.00143$ m.

(ii) $C_{sag} = \dfrac{20 \times .8^2}{24 \times 16^2} = -.00208$ m.

(iii) $C_{pull} = \dfrac{(16-10) \times 20}{A (2.1 \times 10^6)} = .00116$ m

A = .051

$W = \rho V$

$.8 \text{ kg} = 7.86 \dfrac{g}{cm^3} \times A \times 20 \times 100 cm \times 10^{-3}$ (cm²)

$A = 0.051 cm^2$

$\boxed{C_{total} = .00051 \text{ m}}$

Q(3) A 20m tape standardised @ 84°C is used for measurement of a base line. The avrg temp during measurement is found to be 65°C. Measured length is 882.10 m. calculate true length of line if α 65 × 10⁻⁷ /°C. and following are the value of slopes 2° 16' for 100 m.

4° 24' for 150

3° 0' for 50 m.

4° 12' for 200 m

5° 18 for 300 m.

5° 0' for 82.10 cm.

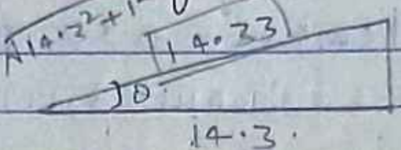
Solⁿ :→ (i) $C_{temp} = (65° - 84°) 882.10 \times 65 \times 10^{-7} = -0.109$ m.

(ii) $C_{slope} = [100(1-\cos 2°16') + 150(1-\cos 4°24') + 50(1-\cos 3°0') + 200(1-\cos 4°12') + 300$

$C_{total} = -0.109 - 2.719 = -2.828\,m.$

true length of line $\rightarrow 882.10 - 2.828 = 879.27\,m$ Ans.

Q(4) Calculate Slope Correcⁿ for 30m tape for a gradient of 1 in 14.3.



Solⁿ: $\rightarrow$ $1 = 14.3$

$\tan\theta = \frac{1}{14.3} =$

$\boxed{\theta = 4^\circ}$.

for 14.33 m $\xrightarrow{\text{fall in gradient}}$ 1.

30 m $\longrightarrow \frac{1}{14.33} \times 30 = 2.09\,m.$

$C_{slope} = \frac{2.09^2}{2 \times 30} = -0.073\,m$ Ans.

- $C_{slope} = L - L\cos\theta = 30 - 30(\cos 4^\circ) = -.073\,m$ Ans.

Q(5). 30m tape found to be 18cm long after chaining dist. of 1450 m. and found to be 38 cm long after chaining 3000m. Calculate true length if chain was correct before starting of work.

$l' \times L' = l \times L$

(1) 0m – 1450 m.

$L' = \frac{30 + 30.18}{2} = 30.09\,m.$

$l_1 = \frac{1450 \times 30.09}{30} = 1454.3\,m.$

(2) 1450 – 3000m

$L' = \frac{30.18 - 30.38}{2} = 30.28\,m.$

$l_2 = \frac{30.28 \times 1550}{30} = 1564.46\,m$

$l = l_1 + l_2 = 3018.76\,m$ Ans.