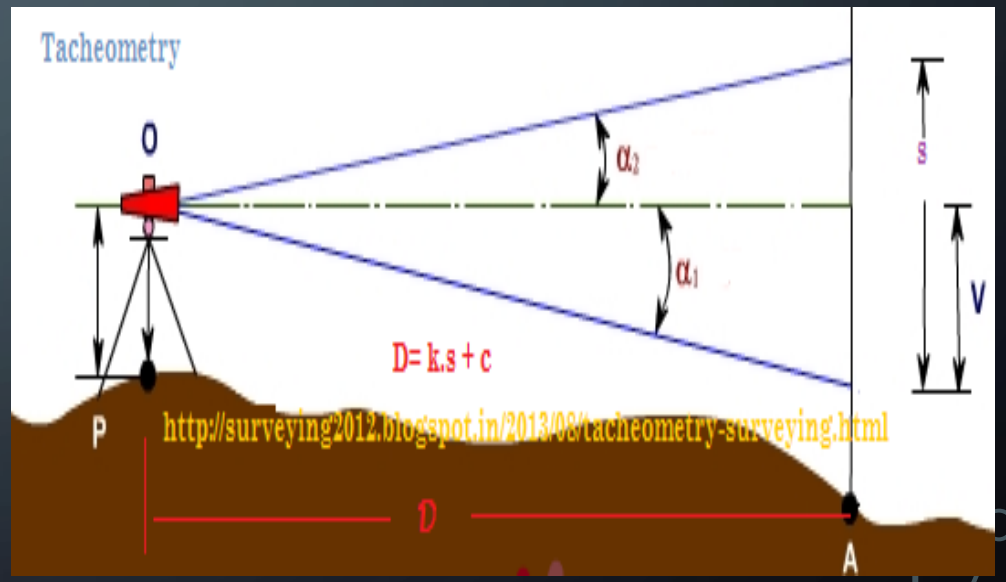
TACHEOMETRY

STEFFI STEPHEN

ASST. PROFESSOR, PHCET.

INTRODUCTION

- Tacheometry- branch of angular surveying in which the horizontal distances from the instrument station to the staff and vertical distances of points are determined from instrumental observation
- Chaining is completely eliminated
- Adopted in rough and difficult terrain
- Purpose
  - ➢ Preparation of contour maps
  - ➢Used in hydrographic survey
  - ➢Location survey of roads, railways, reservoirs etc
  - ➢Used for accurate measurements



PRINCIPLE

- To enable horizontal & vertical distances to be computed from readings upon a stadia rod & thus eliminate the chaining operation
- Statement – In isosceles triangles, ratio of the perpendiculars from vertex on their bases is constant

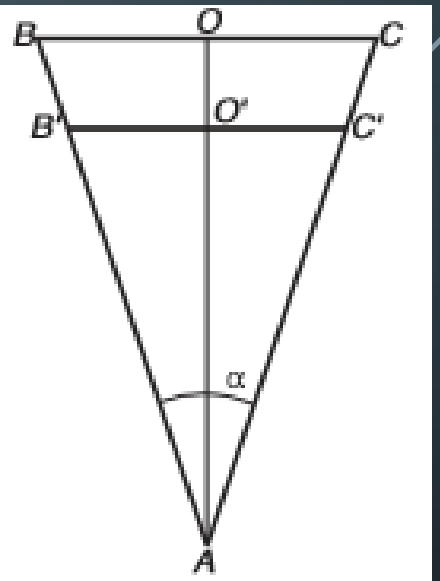
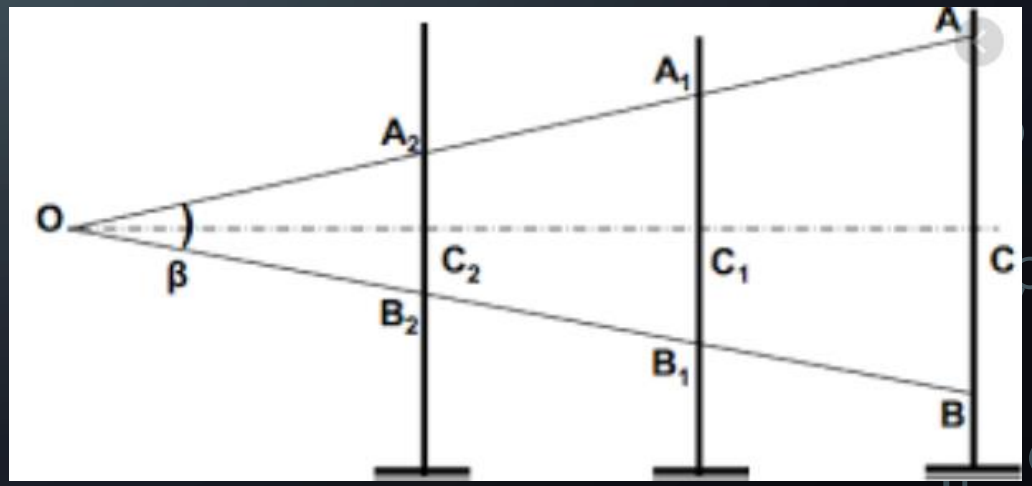


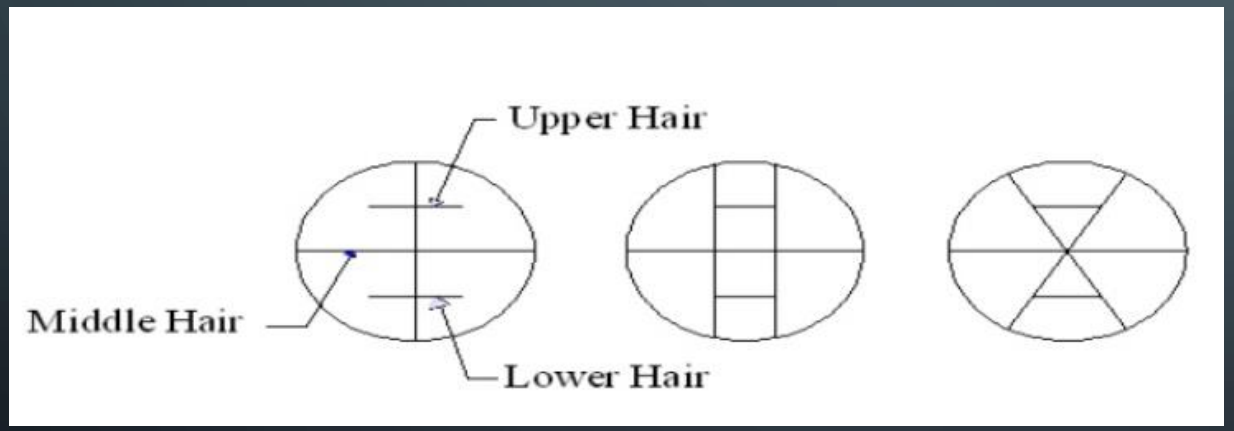
Fig. 13.2. Principle of tacheometry.

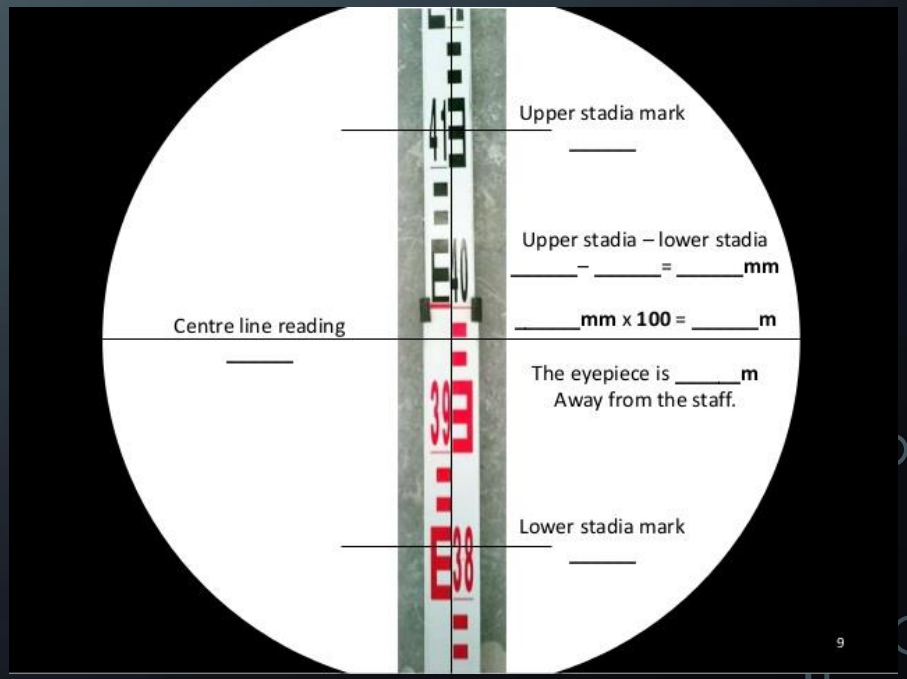
$$\frac{AO}{BC} = \frac{AO'}{B'C'} = 2 \cot \frac{\alpha}{2} = K,$$



INSTRUMENTS

- Tacheometer – transit theodolite with stadia diaphragm
- Stadia rods

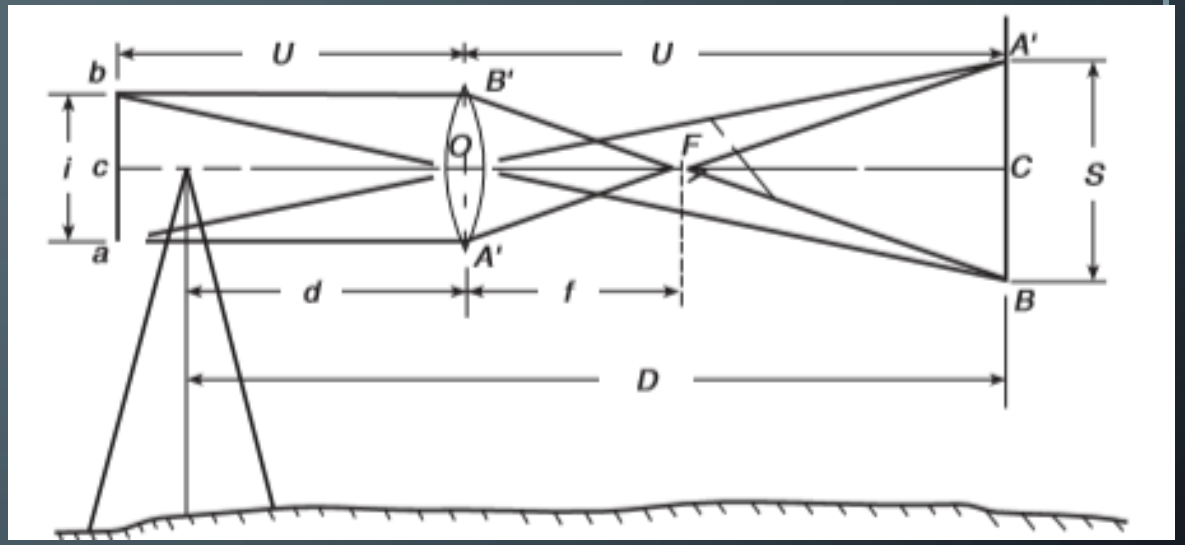




DIFFERNCE BETWEEN THEODOLITE & TACHEOMETER

Theodolite	Tacheometer
• It is used for measurement of horizontal & vertical angle.	• It is used for measurement of horizontal & vertical distances.
• In theodolite survey , distances are measured by chain or tape.	• In tacheomtric survey ,direct measurement of distances are possible.
• Suitable for plane & hilly area with less obstacles.	• Suitable in case obstacles like river broken ground.
• More stations are required in theodolite survey.	• Less stations are required in tacheometric survey.

TACHEOMETRIC CONSTANTS



- Multiplication constant,A (=f/i)
- Additive constant, B (=f+d)

where, f = focal length of image glass

i = length of image (stadia hair interval)

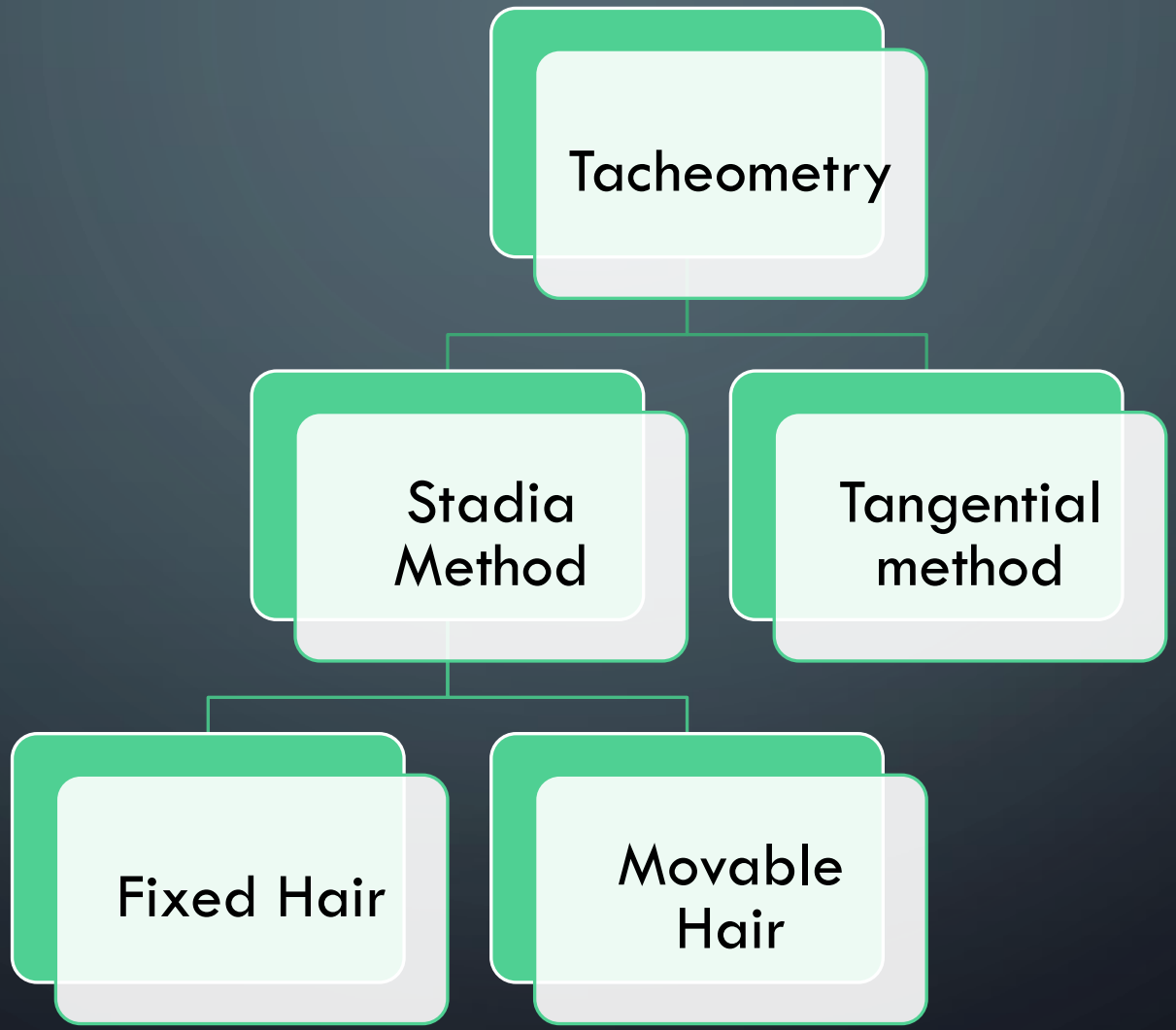
d = horizontal distance from optical center of object glass to vertical axis of tacheometer

Note: if fitted with an anallatic lens, additive constant = 0

REQUIREMENTS OF A TACHEOMETER

- Multiplying constant = 100& error in the computed distance should not exceed 1 in 1000
- Central hair reading should be exactly midway between the stadia hair
- Telescope must be truly anallatic, i.e., additive constant = 0
- Telescope should be powerful having a magnification of 20 to 30 diameters

TACHEOMETRIC METHODS



STADIA METHOD

FIXED HAIR METHOD

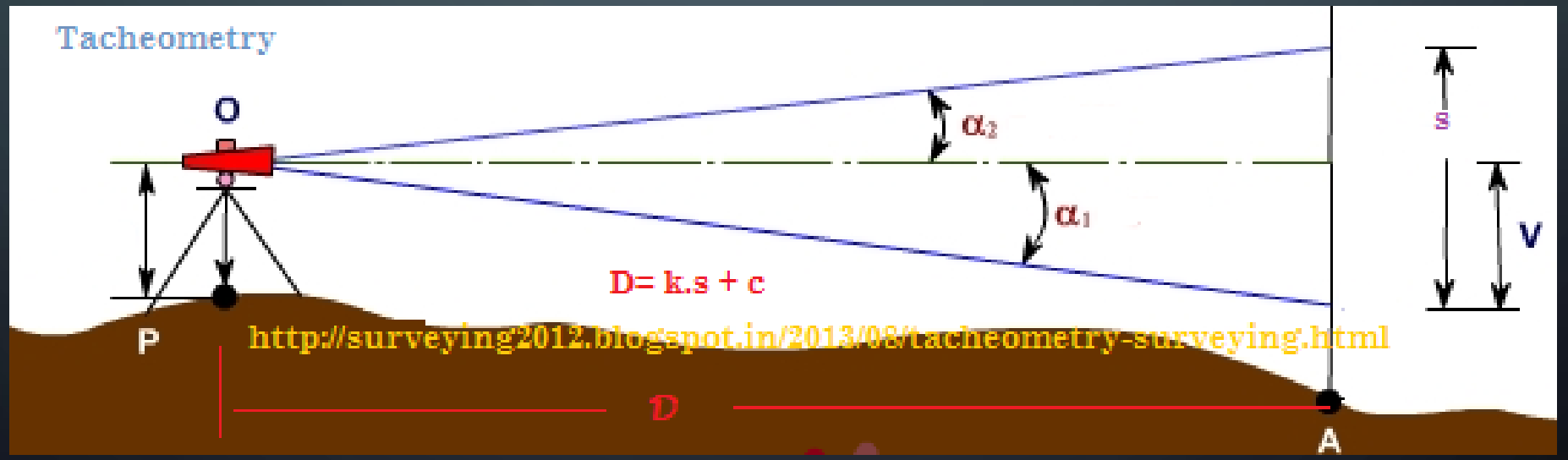
- Distance between stadia hairs is fixed
- Intercept on levelling staff varies
- Staff intercept (s)– difference between upper and lower stadia hair readings
- Method suitable for horizontal & inclined sights
- For inclined sights staff readings may be taken with staff vertical or normal to the line of sight
- Most common method

FIXED HAIR METHOD - CASES

- Three cases
    1. Line of sight is horizontal & staff is held vertical
    2. Line of sight is inclined & staff is vertical
    3. Line of sight is inclined & staff is held normal to the line of sight

1. LINE OF SIGHT HORIZONTAL

- Horizontal distance D = As +B, where s- staff intercept
- RL of staff station = HI – Central hair reading
- HI = RL of BM + BS



2. LINE OF SIGHT INCLINED; STAFF VERTICAL

Horizontal distance, D = $As cos^2\theta + B\ cos\theta$

Elevation formula:

V = As $\frac{\sin 2\theta}{2}$ + B sinθ

For angle of elevation:

RL of staff station = HI +V-h, h- central hair reading

For angle of depression:

RL of staff station = HI –V-h

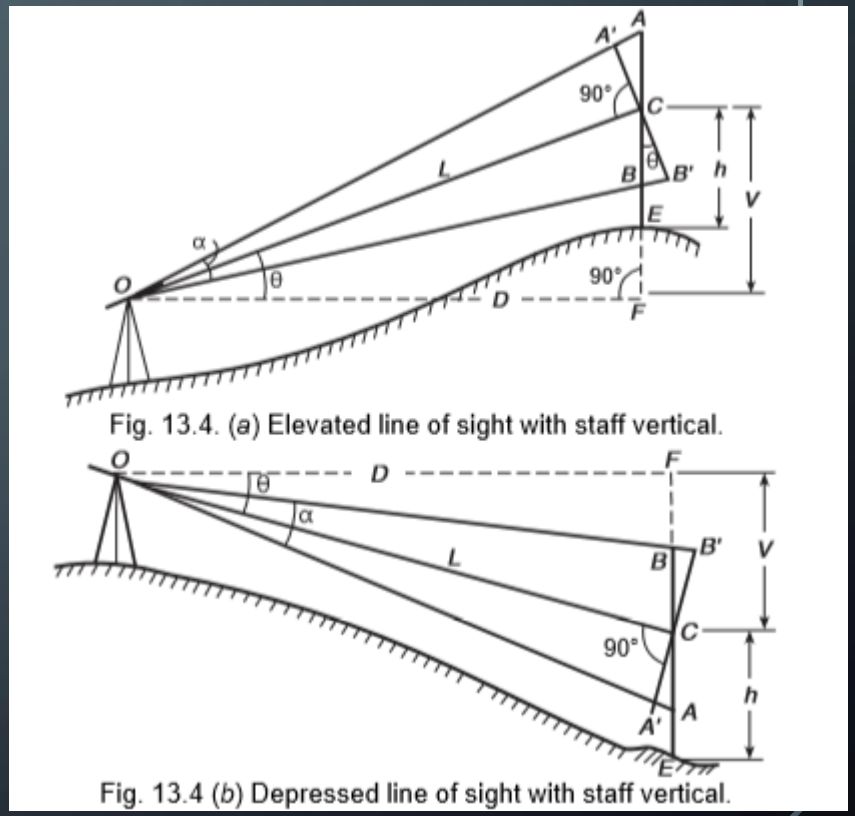


Fig. 13.4. (*a*) Elevated line of sight with staff vertical.

Fig. 13.4 (*b*) Depressed line of sight with staff vertical.

3. LINE OF SIGHT INCLINED; STAFF NORMAL

A. For angle of elevation

Horizontal distance, D = (As+B) cos$\theta + h\ sin\theta$

V = (As+B) sinθ

RL of staff station = HI +V-$h\ cos\theta$

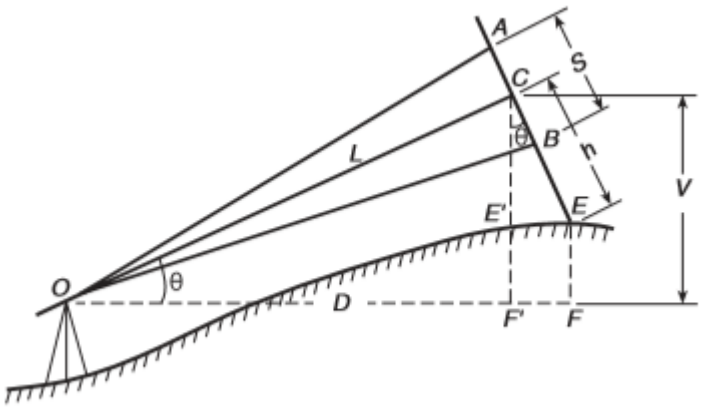


Fig. 13.5. Elevated line of sight with staff normal.

B. For angle of depression

Horizontal distance, D = (As+B) cos$\theta - h\ sin\theta$

V = (As+B) sinθ

RL of staff station = HI -V-$h\ cos\theta$

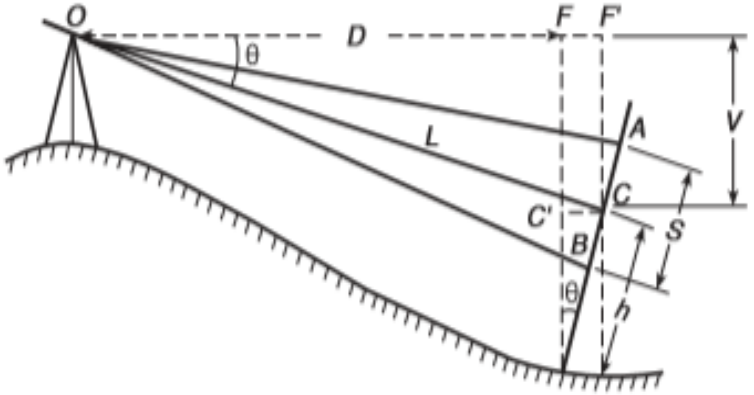


Fig. 13.6. Depressed line of sight with staff normal.

DETERMINATION OF TACHEOMETRIC CONSTANTS

- Measure line AB 100 m long on a fairly level ground and fix pegs at 25 m interval
- Set up instrument at A and centre it
- Obtain staff intercepts s1, s2, s3 and s4
- Substitute the different values of D and s in the equation, D = As+B, to get 4 quadratic equations
- Solve the equations in pair to get the values of tacheometric constants and take its mean

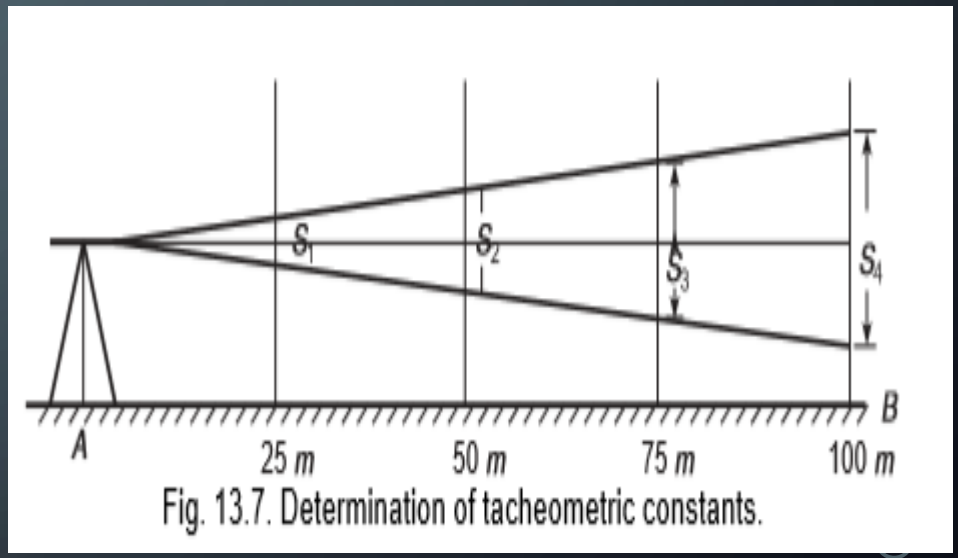
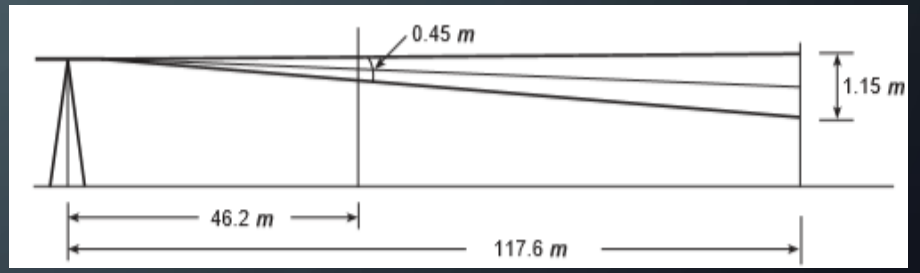


Fig. 13.7. Determination of tacheometric constants.

Q1)

Example 13.2. *A staff was held vertically at a distance of 46.2 m and 117.6 m from the centre of a theodolite fitted with stadia hairs and the staff intercepts with the telescope horizontal were 0.45 m and 1.15 m respectively. The instrument was then set over a station P of RL. = 150 m, the height of instrument axis being 1.38 m. The stadia hair readings on a staff held vertically at a station Q were 1.2 m, 1.93 m and 2.65 m respectively, while the vertical angle was –9° 30′. Find the distance PQ and RL. of Q.*



Step 1: Calculation of tacheometric constants

Substituting the values in eqn, D = As+B we get

46.2 = Ax0.45+B

117.6 = A x1.5+B

On solving these two eqns, we get

A = 102, B =0.3

Step 2: Calculation of distance PQ & RL of Q

Horizontal distance, PQ = $As cos^2\theta + B\ cos\theta$

s=2.65-1.20 = 1.45 m

$\theta = 9°30'$

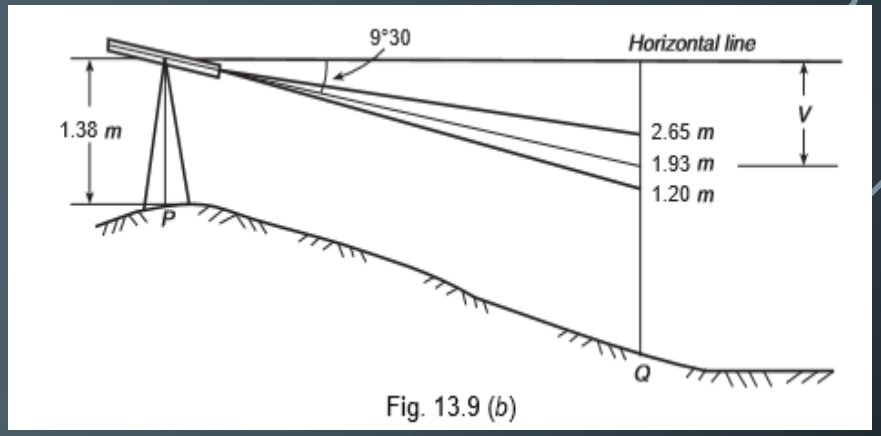


Fig. 13.9 (*b*)

Substituting the values in above eqn, we get, PQ =144.17 m

Vertical Component, V =As $\frac{\sin 2\theta}{2}$ + B sinθ

= 24.13 m

RL of Q = RL of P +height of line of sight –V-h

= 150+1.38-24.13-1.93

= 125.32 m

Q2)

Example 13.4. *A tacheometer was set up at an intermediate station C of the line AB and following readings were obtained :*

Staff Station	*Vertical angle*	*Staff readings*		
A	*– 6° 20′*	*0.445*	1.675	2.905
B	*+ 4° 20′*	*0.950*	1.880	2.810

The instrument was fitted with an anallatic lens and the constant was 100. Find the gradient of the line joining station A and station B.

Step 1: staff held at A

s1 = 2.905-0.445 = 2.460 m; $\theta 1 = -6°20'$

Distance CA = A$s cos^2\theta + B\ cos\theta$

= 243 m

Vertical Component V1 = As $\frac{\sin 2\theta}{2}$ + B sinθ

= 26.971 m

Step 2: staff held at B

s2 =1.860 m; $\theta 2 = 4°20'$

Distance CB = $As cos^2\theta + B\ cos\theta$

= 184.94 m

Vertical Component V2 = As $\frac{\sin 2\theta}{2}$ + B sinθ

= 14.014 m

Distance AB = CA +CB = 427.94 m

Step 3: Calculation of Gradient

Let X be the RL of trunnion axis

RL of A = X-V1-h1 = X – 26.71-1.675 = X -28.646

RL of B = X+V2-h2=X+14.014-1.880=X+12.134

Difference in elevation =RL of B-RL of A = 40.780 m

Gradient of line AB = $\frac{Horizontal\ distance}{Difference\ in\ level}$ =1 in 10.49

Q3)

Example 13.5. *Determine the gradient from a point A to a point B from the following observations made with a fixed hair tacheometer fitted with an anallatic lens, the constant of the instrument being 100.*

	Bearing	Reading of stadia hairs	Reading of axial hair	Vertical angle
To A	345°	0.750 2.120	1.435	+15°
To B	75°	0.625 3.050	1.835	+10°

Let the instrument station be T

s1= 1.370 m, s2= 2.425 m

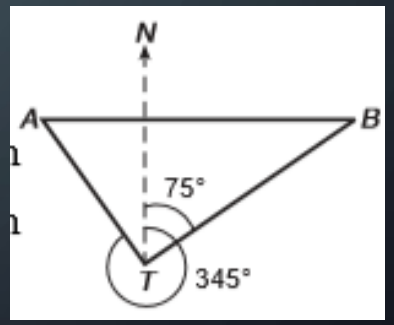
Distance TA = $As cos^2\theta + B\ cos\theta$ =127.82 m

Distance TB = 235.19 m

Angle ATB = Bearing of TB – Bearing of TA =90°

Distance AB = $\sqrt{TA^2 + TB^2}$

= 267.68 m



Note, Distance formula: $PQ^2 = OP^2 + OQ^2 - 2\ OP.OQ \cos POQ$

Vertical Components

V1 = 34.25 m

V2 = 41.47 m

Let X be the RL of trunnion axis

RL of A = X+V1-h1

RL of B =X+V2-h2

Difference in elevation between B and A = RL of B – RL of A

= 6.820 m, B being higher

Gradient = 1 in 39.25

Q4)

Example 13.12. *In a tacheometer survey made with an instrument whose constants are 100 and 0.5, the staff was inclined so as to be normal to the line of sight for each reading. Two sets of readings were as given below. Calculate the gradient between the staff stations P and Q and the reduced level of each if that of R is 41.800 m.*

Instrument Station	*Height of Instrument Axis*	*Staff Station*	*Bearing*	*Vertical Angle*	*Stadia Reading*
R	*1.600*	*P*	*85°*	*+ 4° 30′*	*1.000 1.417 1.833*
		Q	*135°*	*– 4° 00′*	*1.000 1.657 2.313*

(*a*) **Staff Station P**

Staff interval $S_1 = 1.833 - 1.000 = 0.833$ m

Central wire reading= 1.417 m

Substituting the values of S and θ in Eqns. (*i*) and (*ii*), we get

$$H_1 = (100 \times 0.833 + 0.5) \cos 4° 30' + 1.417 \times \sin 4° 30'$$
$$= 83.8 \times 0.996917 + 1.417 \times 0.0784592$$
$$= 83.54 + 0.11$$
$$= 83.65 \text{ m}$$

and $$V_1 = (100 \times 0.833 + 0.5) \sin 4° 30'$$
$$= 83.8 \times 0.07846$$
$$= 6.575 \text{ m.} \quad \text{...(ii)}$$

$\therefore$ Ground level at $P = 41.800 + 1.600 + 6.575 - 1.417 \cos 4° 30'$
$= 41.800 + 1.600 + 6.575 - 1.413$
$= 48.562$ m

(*b*) **Staff Station Q**

Staff interval $S_2 = 2.313 - 1.000 = 1.313$

Central wire reading= 1.657

Substiuting the values of S and θ, in Eqs. (*i*) and (*ii*), we get

$$H_2 = (100 \times 1.313 + 0.5) \cos 4° - 1.657 \sin 4°$$
$$= 131.8 \times 0.997564 - 1.657 \times 0.06976$$
$$= 131.48 - 0.12 = 131.36 \text{ m}$$
$$V_2 = 131.8 \sin 4° = 131.8 \times 0.0697566$$
$$= 9.194 \text{ m}$$

$\therefore$ Ground level at

$$Q = 41.800 + 1.600 - 9.194 - 1.657 \times \cos 4°$$
$$= 41.800 + 1.600 - 9.194 - 1.653$$
$$= 32.553 \text{ m}$$

Difference in level of P and Q = 48.562 – 32.553 = 16.009 m

Angle PRQ = Bearing of RQ – Bearing of RP = 135° - 85° = 50°

Applying cosine formula to ΔRPQ , we get

$$PQ^2 = (83.65)^2 + (131.36)^2 - 2 \times 83.65 \times 131.36 \cos 50°$$
$$= 69,97.32 + 172,55.45 - 2 \times 479.46 \times 0.642788$$
$$= 10126.520$$
$$PQ = 100.63 \text{ m.}$$

The gradient between P and Q

$$= \frac{100.63}{48.562 - 32.553}$$
$$= \frac{100.63}{16.009} = 1 \text{ in } 6.286 \text{ fall.}$$

Q5)

Example 13.1. *A tacheometer has a diaphragm with three cross hairs spaced at distances 1.15 mm. The focal length of the object glass is 23 cm and the distance from the object glass to the trunnion axis is 10 cm. Calculate the tacheometric constants.*

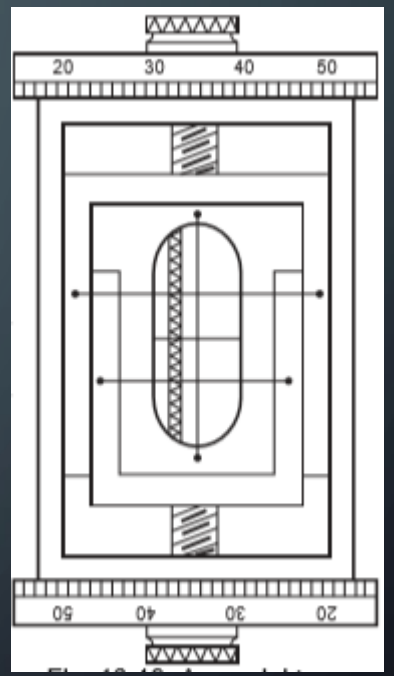
i = 2 x 1.15 = 2.30 mm =0.23 cm

A = $\frac{f}{i}$=$\frac{23}{0.23}$ =100

B = (f+d) =(23 +10) =33 cm =0.33 m

MOVABLE HAIR METHOD

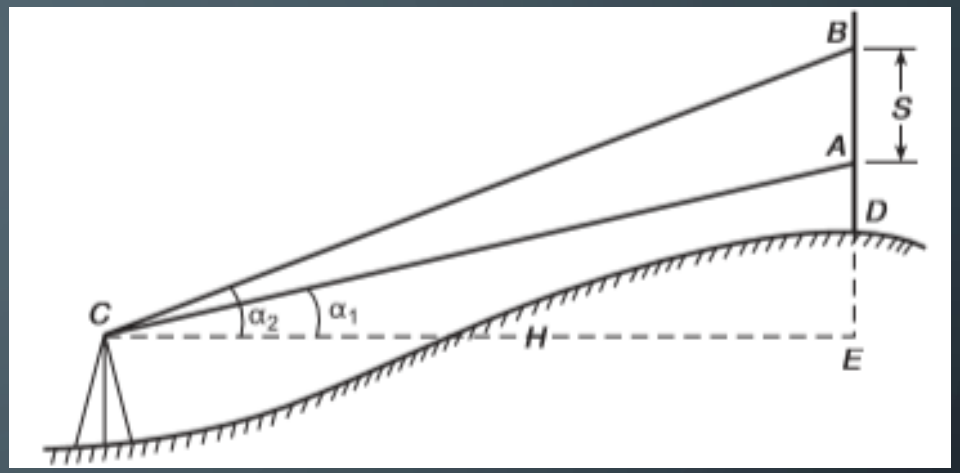
- Stadia interval is variable
- Instrument is fitted with a stadia diaphragm which can be moved
- Staff intercept kept constant
- In this method, variable stadia interval is measured first. From this, horizontal distance is calculated
- This method is not commonly used
- Distance formula, $$D = \frac{A}{m} S + B$$

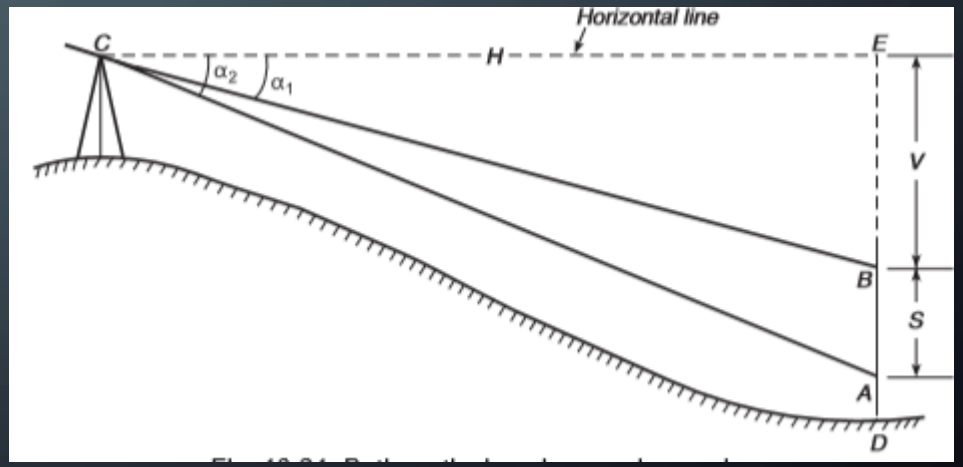


where m is the number of revolutions of the micrometer of pitch p

TANGENTIAL METHOD

- When telescope is not fitted with stadia diaphragm, then tangential method is preferably adopted
- In this method, a staff is fitted and provided with two targets at fixed distance apart and the vertical angles to the two vanes are taken
- Then horizontal distance and RLs are calculated





RADIAL CONTOURING

- In case of hilly areas, radial contouring method is adopted
- Tacheometer is set at a point approximately at the centre of the area.
- Radial lines are set making angles with either the magnetic meridian or with the first radial line
- On each radial line staff readings are observed at different points
- When all radial line observations are taken, it is then plotted on a sheet to a suitable scale