CE 331A GEOINFORMATICS

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Steps in triangulation

1. Reconnaissance
2. Erection of signals and towers
3. Measurement of baseline
4. Measurement of horizontal angles
5. Astronomical observations at Laplace stations
6. Computations

Reconnaissance

- Determination country to be surveyed
- Selection of suitable position of triangulation stations
- Selection of suitable site for baseline estimation
- Inter-visibility of station
- Height of signals and towers
- Amount of cutting and clearing
- Ensure that lien of sight is clear of obstructions
- Collection of information regarding:
  - Access to stations
  - Supply of food and water and other material
  - Site for camping

Factors for choosing control station

- Selected at higher elevations at commanding locations so that large area can be surveyed
- Stations should form well conditioned triangles ($30° < \text{all angles} < 120°$)
- Stations should be useful for detailed plotting
- Should be fixed such that the lengths of sight is neither too small nor very large since in both cases there will be problems of bisection
- Stations should be easily accessible
- Cost of cutting and clearing should be minimum
- Ensure intervisibility

Intervisibility of terrain

Conventional approach:

Height of instrument and signal depends upon:

- Distance between stations
- Relative elevations of stations
- Profile of intervening ground
- If there is no obstruction due to intervening ground, the distance of visible horizon from a station of known elevation above datum is:

h = height above datum

D = distance to visible horizon

R = mean earth radius

m = mean coefficient of refraction; 0.07 and 0.08 for sights above land and sea respectively.

$$h = \left(\frac{D^2}{R}\right)(1-2m)$$

For land, m = 0.07 and h (in m) and D (in km):

$$h = 0.06735D^2$$

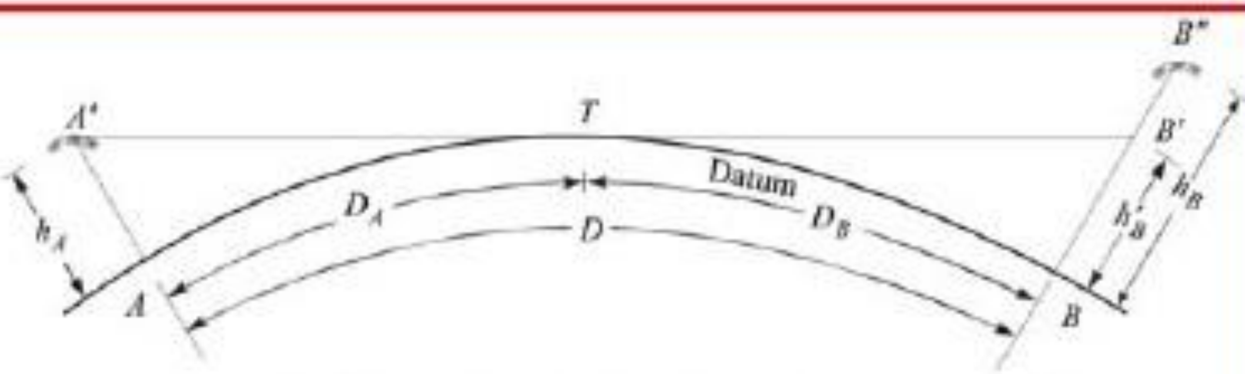


Fig. 1.17 Intervisibility not obstructed by intervening ground

Capt. McCaw's Approach

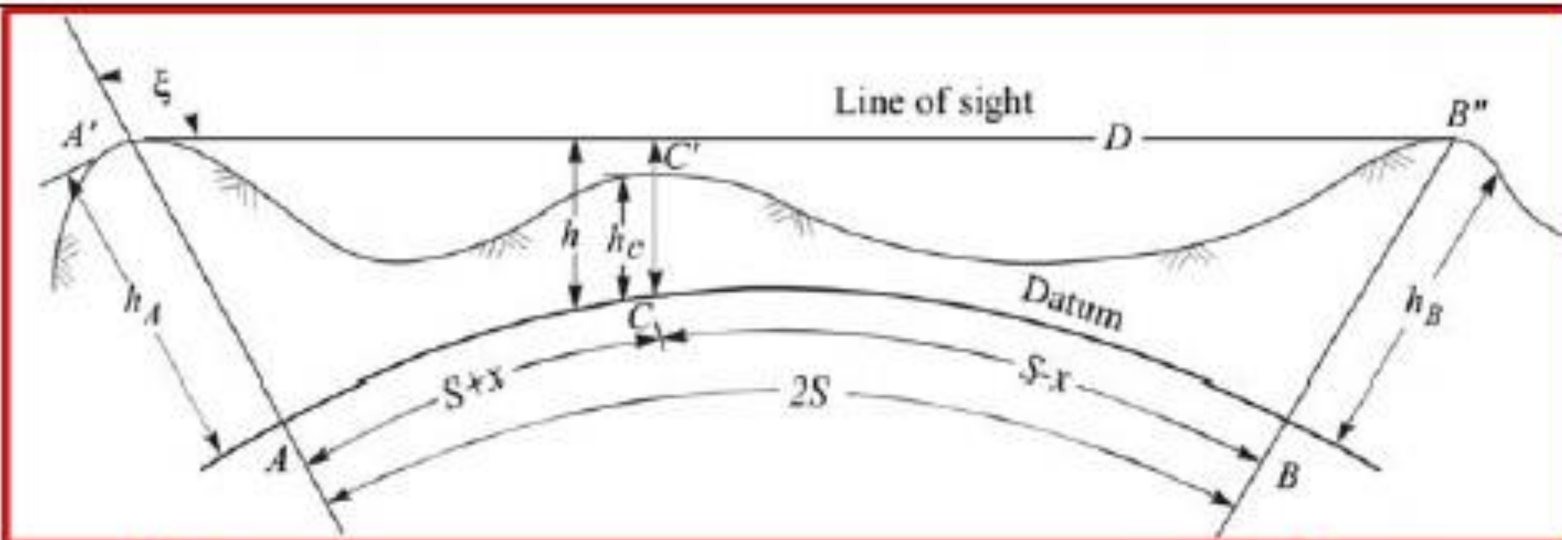
$$h = \frac{1}{2}(h_A + h_B) + \frac{1}{2}(h_B - h_A)\left(\frac{x}{s}\right) - \left(s^2 - x^2\right)\operatorname{cosec}^2\xi \left(\frac{(1-2m)}{2R}\right)$$

$$\operatorname{cosec}^2\xi = \left[1 + (h_B - h_A)^2 / 4s^2\right] \approx 1.0$$

h	= height of line of sight at obstruction C (m)
h_A	= height of A above datum (m)
h_B	= height of B above datum (m)
$2s$	= distance between A and B (km)
$(s + x)$	= distance of obstruction C from A (km)
$(s - x)$	= distance of obstruction C from B (km)
ξ	= zenith distance from A to B (90^0 – vertical angle)
R	= radius of earth (6370 km)

Where, x, s, R in km, and h_1, h_2, h in meter; $\operatorname{cosec}^2\xi$ can be taken approximately as unity. Therefore, on land

$(1\text{-}2m) / 2R = 0.06735$



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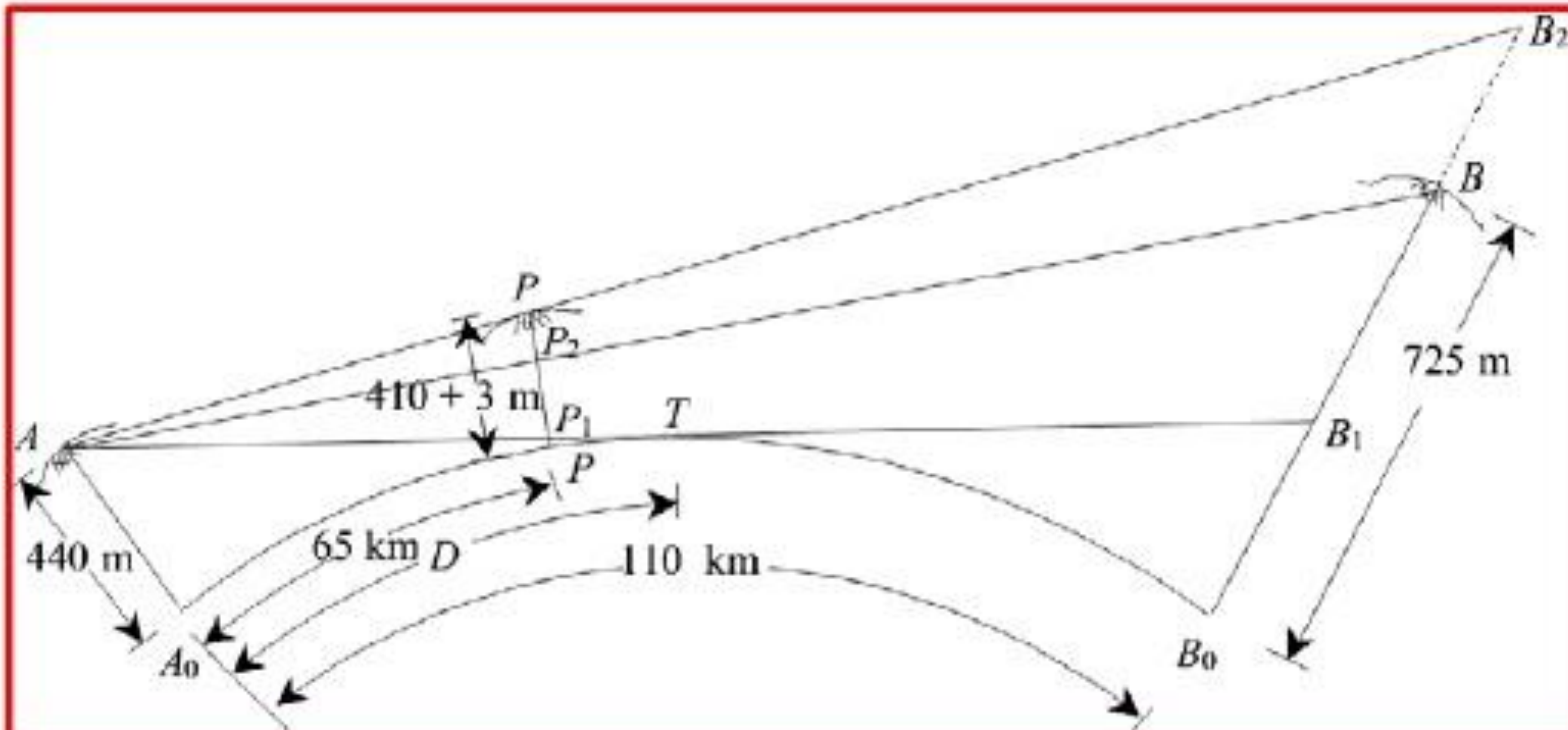
Therefore, on land (1-2m) /2R = 0.06735

Example

- In a triangulation survey, the altitudes of two stations A and B, 110 km apart, are respectively 440 m and 725 m. The elevation of a peak P situated at 65 km from A has an elevation of 410 m. Ascertain if A and B are intervisible, and if necessary, find by how much B should be raised so that the line of sight nowhere be less than 3 m above the surface of ground. Take earth's mean radius as 6400 km and the mean coefficient of refraction as 0.07.

Ans.



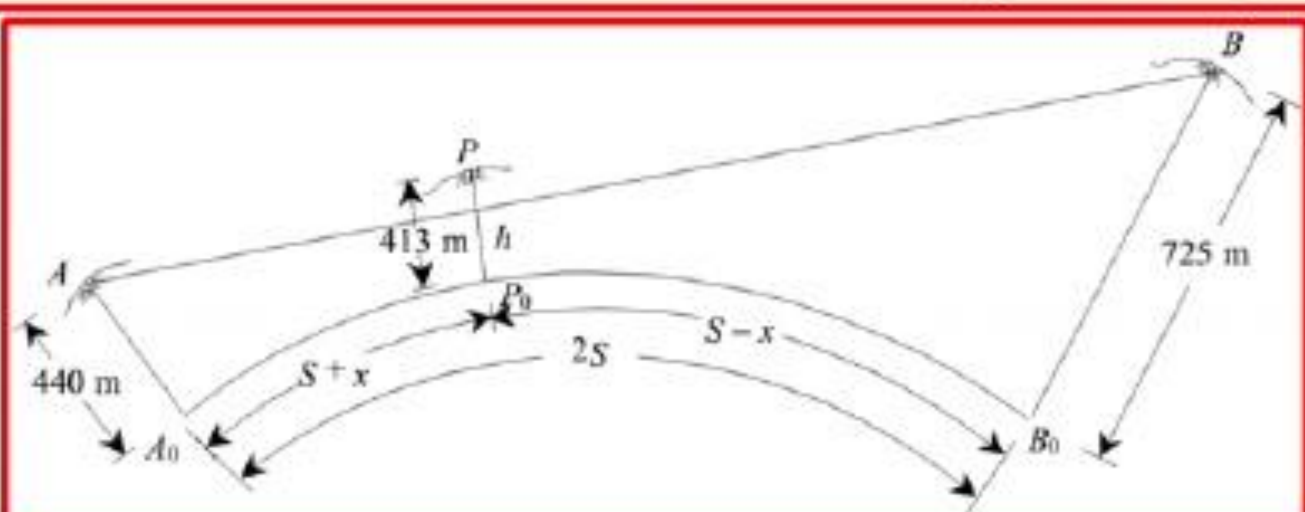
Capt. McCaw's formula

- $2S = 110$ km; $S = 55$; $S + x = 65$ km; $x = 65 - S = 65 - 55 = 10$ km.
- Here, h is same as P_2P_0 obtained in conventional approach. The line of sight fails to clear the line of sight by 413 – 411.89 = 1.11 m. The amount of raising BB_2 required at B is calculated now in a similar manner as earlier: (110×1.11)/65 = 1.88 m ~2m

$$h = \frac{1}{2}(h_A + h_B) + \frac{1}{2}(h_B - h_A)\left(\frac{x}{s}\right) - (s^2 - x^2)\operatorname{cosec}^2\xi\left(\frac{(1-2m)}{2r}\right)$$

$$\operatorname{cosec}^2\xi = 1 + (h_B - h_A)^2 / 4s^2$$

$$h = \frac{1}{2}(725+440) + (725-440)\left(\frac{10}{55}\right)(55^2 - 10^2)\times 1\times\left(\frac{(1-2\times 0.07)}{2\times 6400}\right)x1000 = 411.89$$



Satellite/Eccentric/False station

- In order to secure well conditioned triangles or better visibility, clearly identifiable objects at commanding locations are generally taken as triangle stations. However, no observations can be taken from objects such as church spires, flag poles, towers etc. (as the instrument cannot be set on these) although these are quite suitable as triangulation station.
- Hence, a subsidiary station is established near this station (the main station that one would have occupied). Observations are taken to other triangle stations from subsidiary station with same precision as would one have used in the measurement of angles at true station.
- Angles measured at subsidiary station are later corrected and reduced to what they would have been if the true station was occupied. This operation is called reduction to center.
- Such satellite station should be avoided as far as possible in primary triangles.

Figure for satellite station

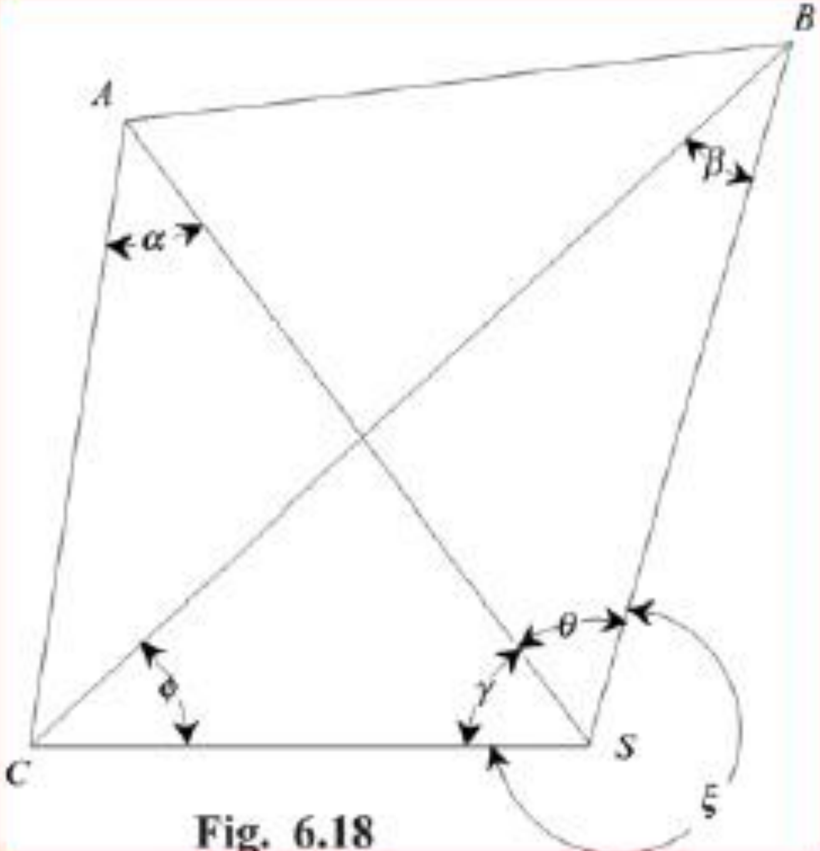


Fig. 6.18

- S is Satellite station
- A, B, C Triangulation station,
- Cannot fix instrument on C: prominent point, say church pier
- Hence, observation are taken at S and are then reduced to C

Example

Q. From a satellite station S, 12 m from the main station A, the following bearings were observed:

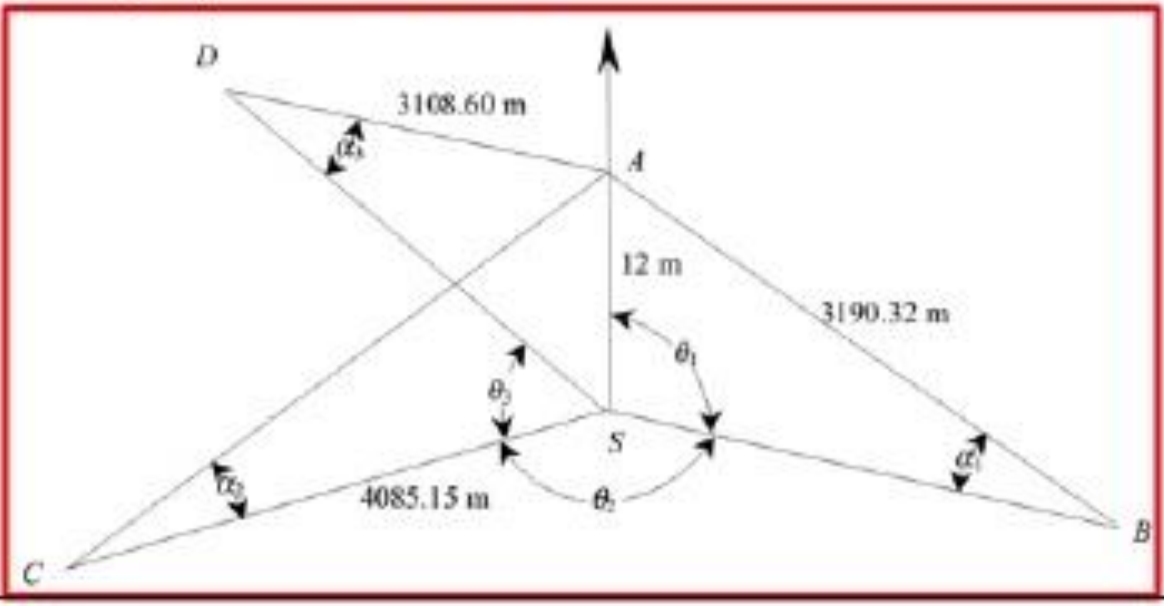
A = 0°00′00″

B = 143°36′20″

C = 238°24′48″

D = 307°18′54″

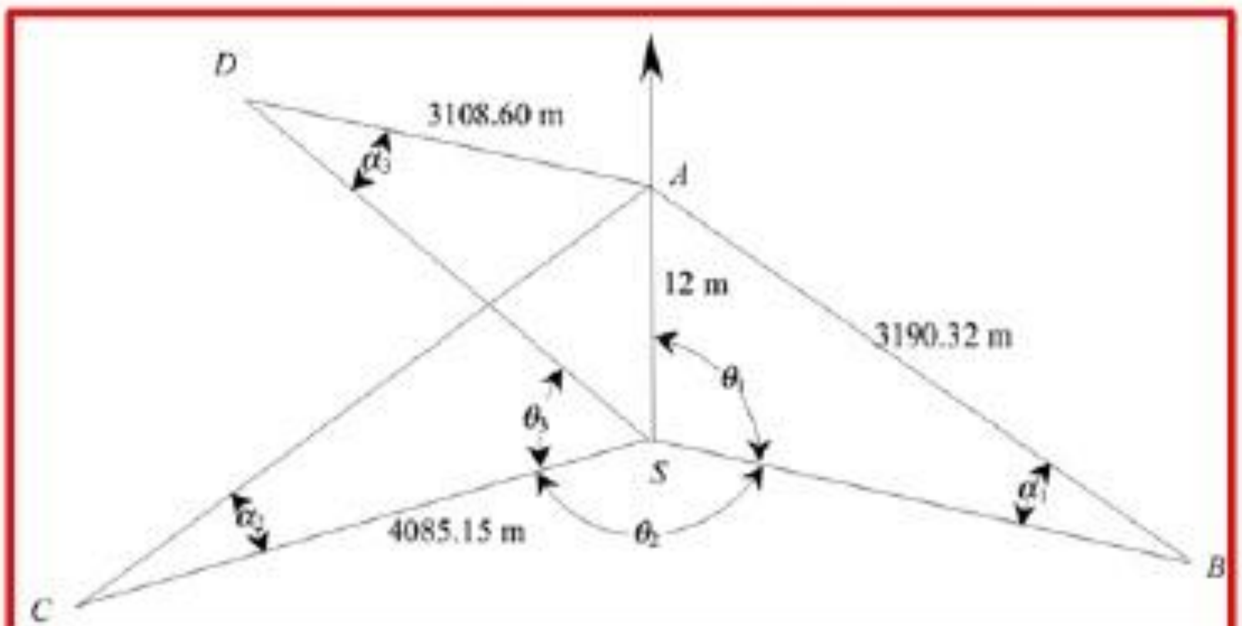
Lengths of lines AB, AC, and AD were measured and found to be 3190.32 m, 4085.15, and 3108.60 m, respectively. Determine the directions of B, C, and D from A.



Ans

- If α_1, α_2, and α_3 are the corrections to the observed directions, the required directions from the stations A will be $(\theta_1 + \alpha_1)$ for B, $(\theta_2 + \alpha_2)$ for C, and $(\theta_3 + \alpha_3)$ for D.
- Since the distances SB, SC, and SD are quite large compared to the distance SA, the distances AB, AC, and AD, respectively can be taken equal to them. The corrections to any direction is given by (β) can be computed from the following relationship

$$\beta = (d \sin\theta) / D \sin 1'' \text{ seconds}$$



$$\alpha_1 = 206265 \times \frac{12}{3190.32} \sin 143°36'20''$$
$$= 460.34'' = 7'40.34''$$

$$\alpha_2 = 206265 \times \frac{12}{4085.15} \sin 238°24'48''$$
$$= -516.13'' = -8'36.13''$$

$$\alpha_3 = 206265 \times \frac{12}{3108.60} \sin 307°18'54''$$
$$= -633.24'' = -10'33.24''.$$

Therefore, the directions from *A* to:

B = 143°36′20″ + 7′40.34″ = 143°44′00.34″
C = 238°24′48″ – 8′36.13″ = 238°16′11.87″
D = 307°18′54″ – 10′33.24″ = 307°08′20.76″.