AAiT
Addis Ababa Institute of Technology
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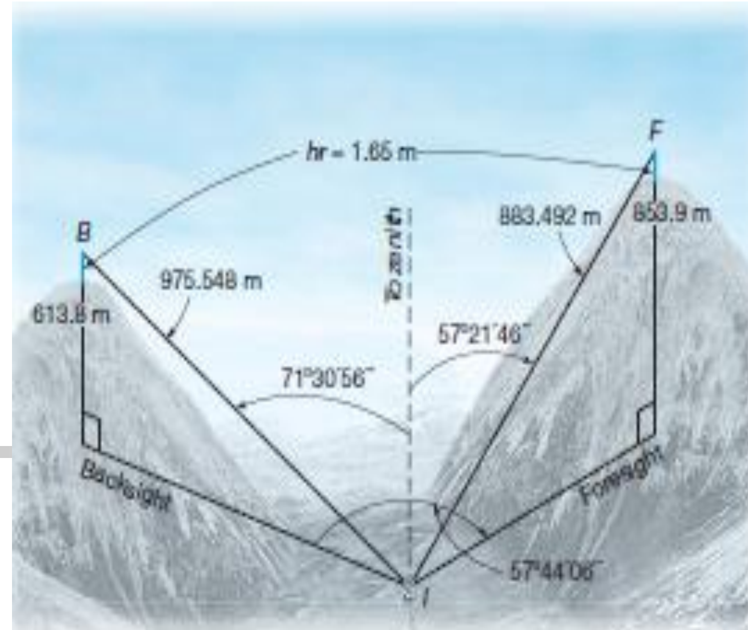
SCHOOL OF CIVIL AND ENVIROMENTAL ENGINEERING

Surveying II

CENG 2092

Chapter 1 Triangulation and Trilateration



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2nd Sem

To refresh Surveying I

The following data were collected while running a closed traverse ABCDA. Calculate the missing data.

Line	Length (m)	Bearing
AB	330	181°25′
BC	?	89°50′
CD	411	355°00′
DA	827	?

Control Survey

- The determination of the **precise position** of a number of stations, usually spread over a large area, is referred to as **control surveying**

- **Control surveys** can be horizontal (lat long or East North) or vertical (height with respect to mean sea level).

Horizontal control

- Traversing,
- Triangulation
- Trilateration
- Triangulateration
- Satellite positioning

Triangulation

- **A triangulation survey**: a network of triangles with one side length and all the angles are measured, other lengths will be computed
- The single measured line is the base line of the network

Triangulation surveys are carried out

1. to establish accurate control for plane and geodetic surveys covering large areas,
2. to establish accurate control for photogrammetric surveys for large areas,
3. to assist in the determination of the size and shape of the earth,

Classification of Triangulation system

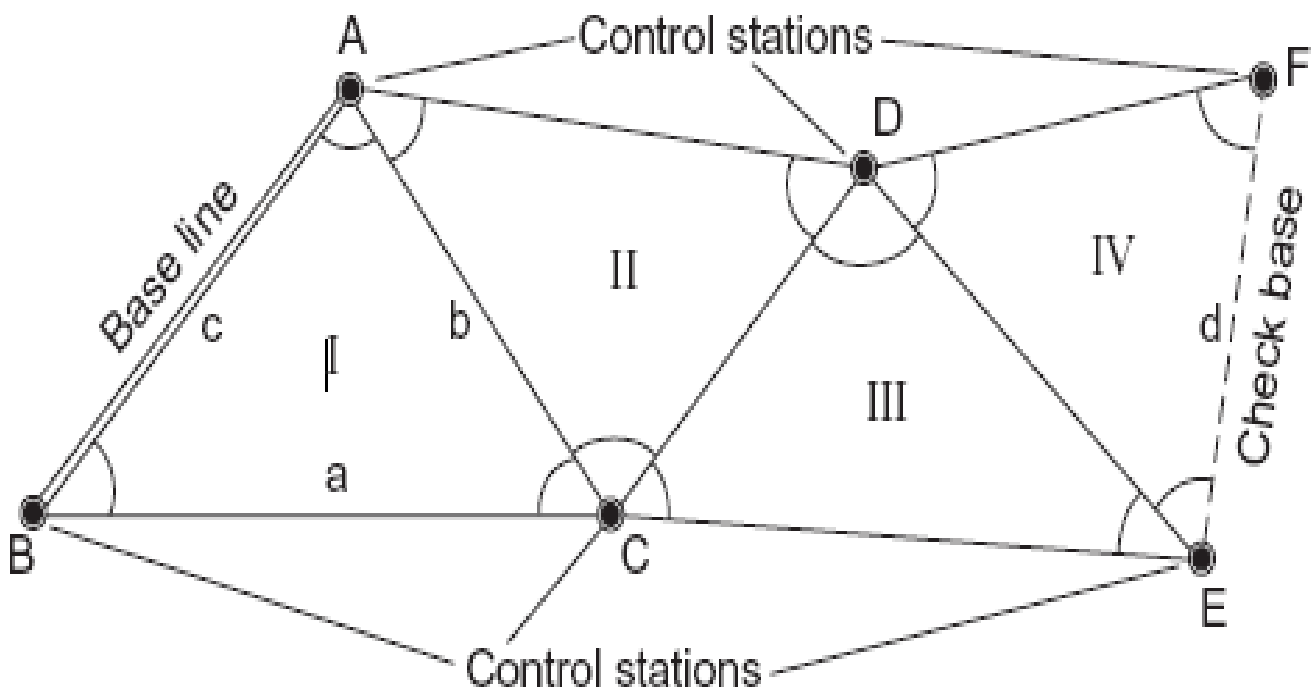
- Based on the accuracy desired for the work, triangulation system is divided into three class which are
- *First order* or *primary : **country***
- *Second order* or *secondary:* ***region***
- *Third order* or *tertiary:* ***local***

Triangulation Figures

i. Simple triangle should be preferably equilateral,
ii. Braced quadrilateral should be preferably approximate square,
iii. Centred polygon should be regular.

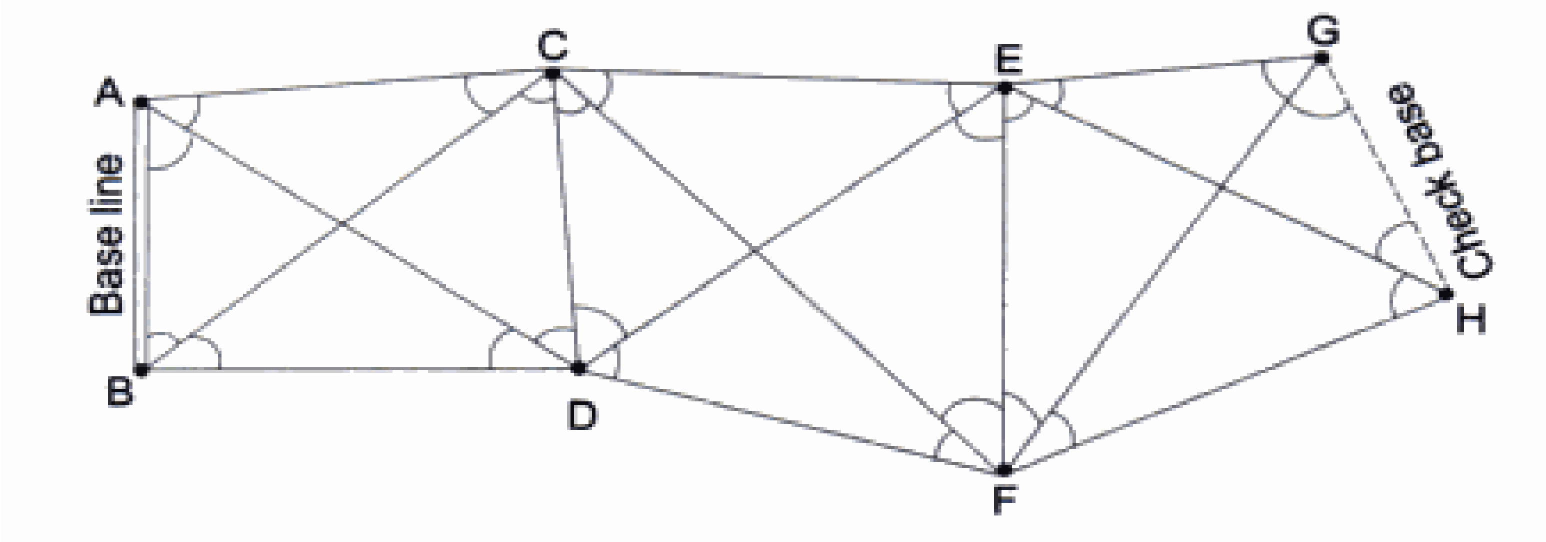
Chain of Triangles

- Rapid and economical when a narrow strip of terrain is to be surveyed, e.g. highway, river, valley, etc.



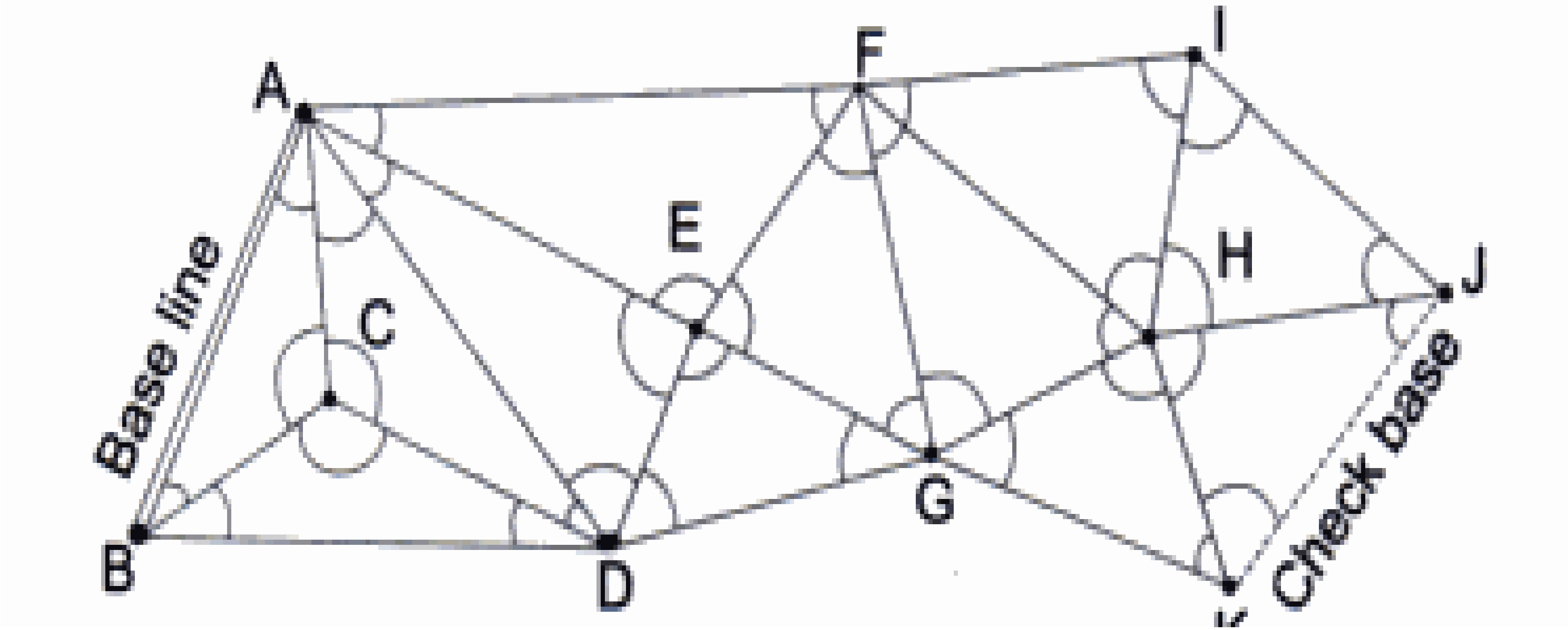
Braced Quadrilaterals

- An excellent system since the various combinations of sides and angles can be used to compute the lengths of the required sides and checks can be made frequently



Centred triangles and Polygons

- It is generally used when vast area in all directions is required to be covered.



Triangulation procedure

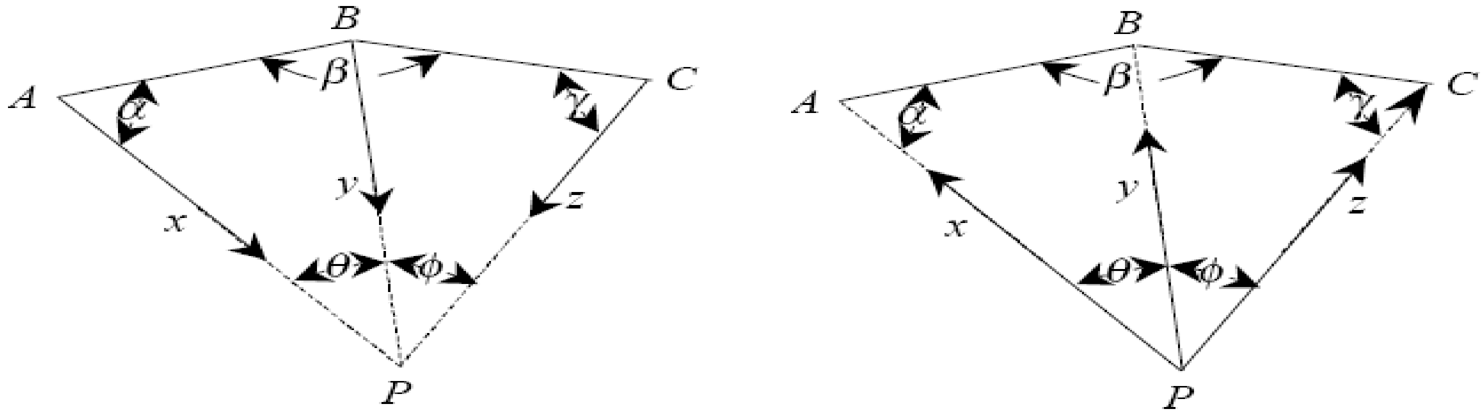
- Reconnaissance, select the locations of stations;
- Evaluation of the strength of figures;
- Erection of signals, and in some cases, tower for elevating the signals and /or instruments;
- Observation of directions or angles;
- Measurement of base lines;
- Astronomic observation at one or more locations,
- Computations including reduction to sea level, calculation of the lengths of all sides and coordinates for all stations, and adjustment of the triangulation network to provide the best estimates of co-ordinates of all points.

Trilateration

- When all the sides of a triangulation system are measured & the technique has been made possible by the development of EDM (Electronic Distance Measurement)
- However, the angular measurements define the shape of the triangulation system better than wholly linear measurements.
- So a combined triangulation and trilateration (Triangulateration) system in which all the angles by theodolite and all the sides are measured by EDM, represents the strongest network for creating horizontal control.

Location of points by intersection and resection

- The points located by observing directions from the points of known locations, are known as the ***intersected points***
- When a point is established by taking observations from the point (unknown) to the points of known locations, such points are known as the ***resected points***



(a) Intersected point

(b) Resected point

Location by intersection

- Determine c and A_{BD}

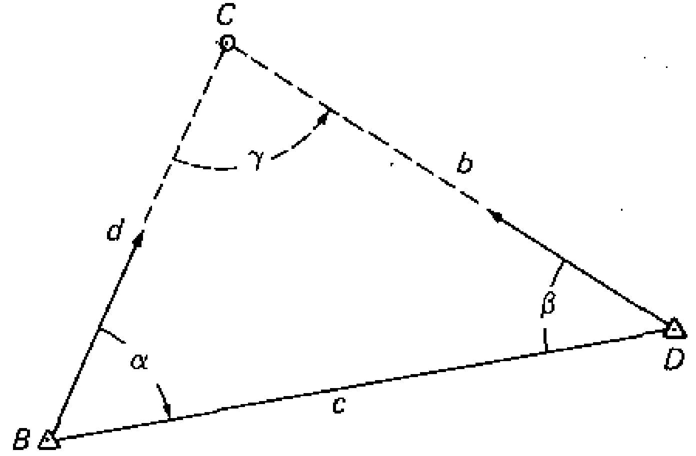
$$c = [\,(X_D - X_B)^2 + (Y_D - Y_B)^2\,]^{1/2}$$

$$\tan A_{BD} = \frac{X_D - X_B}{Y_D - Y_B}$$

Also in triangle DBC, $\gamma = 180° - (\alpha + \beta)$, so that

$$d = \frac{c \sin \beta}{\sin \gamma} \text{ and } b = \frac{c \sin \alpha}{\sin \gamma}$$

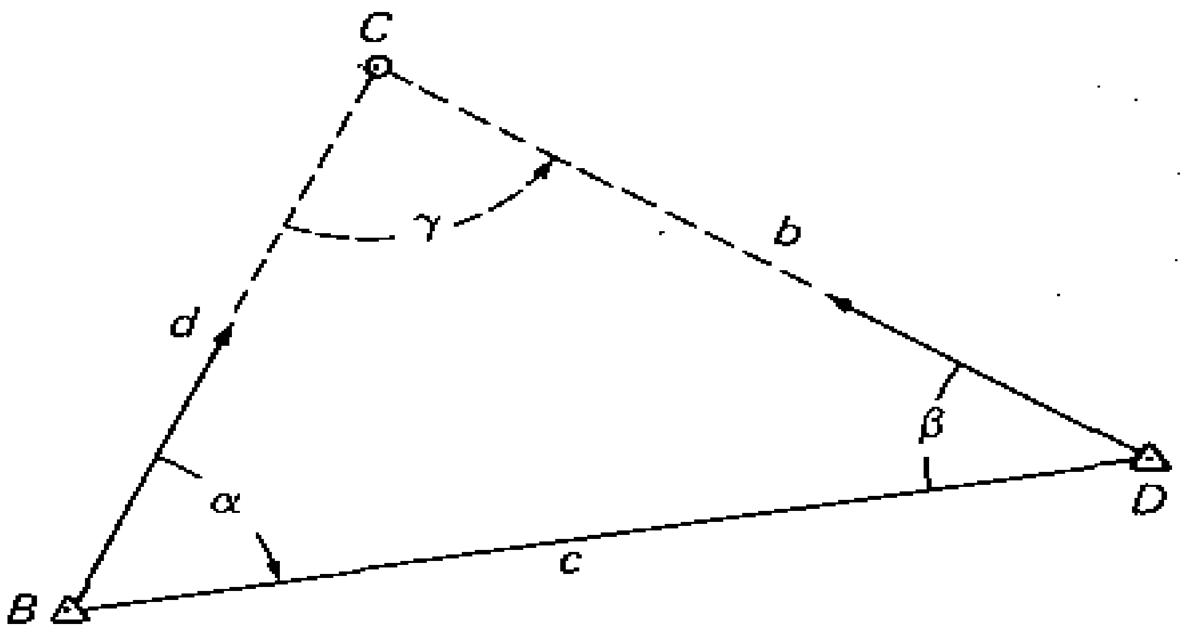
- Azimuth of BC and DC can be calculated
- $A_{BC} = A_{BD} - \alpha$
- $A_{DC} = A_{DB} + \beta$
- Then the coordinates can be calculated:
- $X_C = X_B + d.\mathrm{Sin}(A_{BC})$
- $Y_C = Y_B + d.\mathrm{Cos}(A_{BC})$



Intersection by the base solution

$$X_C = \frac{(Y_B - Y_D) + X_D \cot\alpha + X_B \cot\beta}{\cot\alpha + \cot\beta}$$

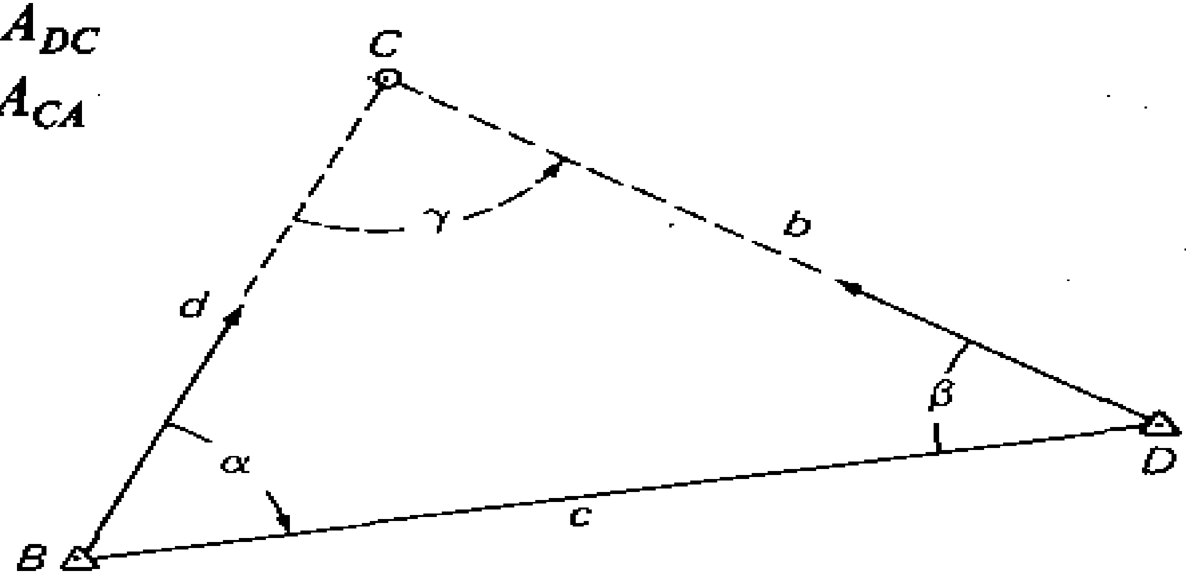
$$Y_C = \frac{(X_D - X_B) + Y_D \cot\alpha + Y_B \cot\beta}{\cot\alpha + \cot\beta}$$



Intersection when azimuths are given

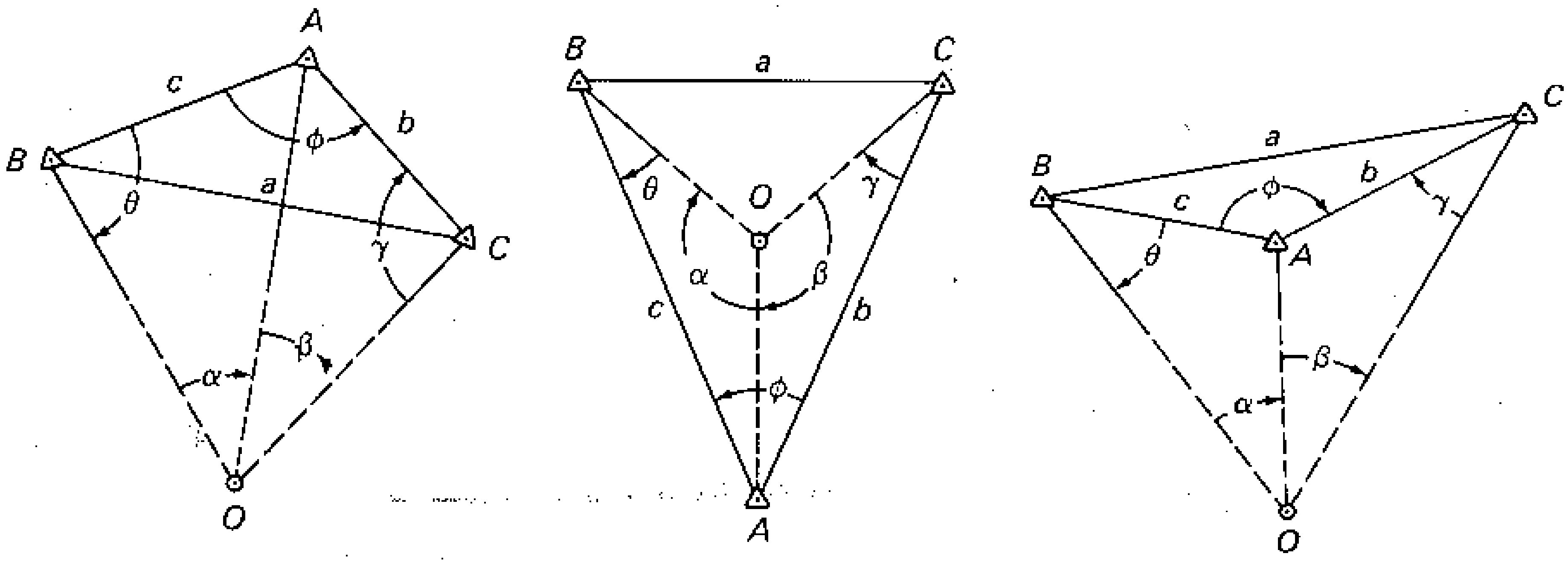
$$X_C = \frac{(Y_D - Y_B) - X_D \cot A_{DC} + X_B \cot A_{BC}}{\cot A_{BC} - \cot A_{DC}}$$

$$Y_C = Y_D + (X_C - X_D)\cot A_{DC}$$
$$Y_C = Y_B + (X_C - X_B)\cot A_{CA}$$



- When azimuth of BC and DC known or calculated

Resection/satellite station



(a) (b) (c)

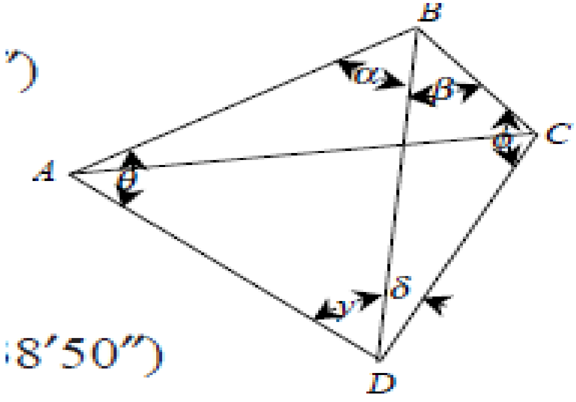
Example 1

In a triangulation survey, four triangulation stations *A*, *B*, *C*, *and D were tied* using a braced quadrilateral *ABCD shown in Fig*. *below. The length of the diagonal AC was measured* and found to be 1116.40 m long. The measured angles are as below:

$\alpha = 44^\circ\ 40'59''$ $\gamma = 63^\circ\ 19'28''$

$\beta = 67^\circ\ 43'55''$ $\delta = 29^\circ\ 38'50''$.

Calculate the length of *BD*.



Example 2

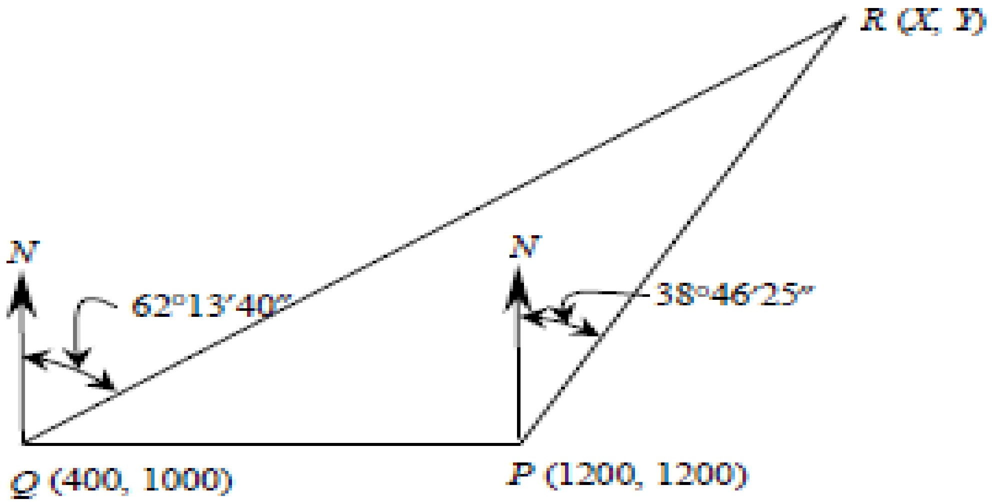
Determine the coordinates of a point R from the following data:

Coordinates of P = E1200 m, N1200 m

Coordinates of Q = E400 m, N1000 m

Bearing of PR = $62^\circ\ 13'40''$

Bearing of QR = $38^\circ\ 46'25''$.



Example 3

In a triangulation survey, the station C could not be occupied in a triangle ABC, and a satellite station S was established north of C. The angles as given in Table below were measured at S using a theodolite.

Pointing on	Horizontal circle reading
A	14°43′27″
B	74°30′35″
C	227°18′12″

Approximate lengths of AC and BC were found by estimation as 17495 m and 13672 m, respectively, and the angle ACB was deduced to be 59° 44′53″. Calculate the distance of S from C.

QUESTIONS?