Tutorial: Adjustment computations
(Condition and Observation equations)

1) While measuring an angle *A* following observations were obtained. Compute the MPV of *A*.

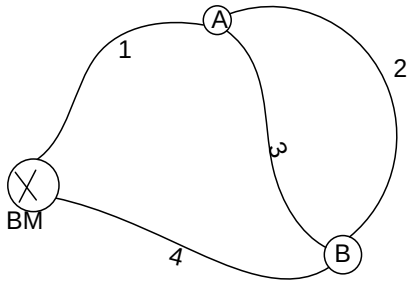
A = 99°57′20″	weight 4
2A = 199°54′48″	weight 4
4A = 399°48′10″	weight 5

[Ans: A = 99°57′6.64″]

2) For establishment of two temporary bench marks *A* and *B*, from the GTSBM the following observations, as shown in figure were obtained:

Line	Difference of elevation	Distance
1	A higher than BM by 8.350m	8km
2	B lower than A by 3.225m	2km
3	A higher than B by 3.145m	2km
4	B higher than BM by 5.245m	8km

Find out the most probable values of elevation of *A* and *B* above BM by observation equation method. Find also the standard error of an observation of unit weight.



3) To determine the most probable values of the tachometer constants following observations were made on field. What is the MPV of constants and their and their standard errors?

[Ans: K = 99.9; C = 0.250]

Stadia intercept (fixed)	Distance (measured)
0.500 m	50.200 m
0.800 m	80.170 m
1.100 m	110.140 m

4) In a triangle ABC, A and B are known points with coordinates (0, 0) and (X_B, 0) and C is an unknown point with coordinates (X_C, Y_C). Three angles of the triangle A, B, and C are measured as α1, α2, and α3. Identify *dimensions* and *elements* of all relevant matrices for solution by (a) Observation equation method (b) Condition equation method.

5) The following observations of three angles *A*, *B*, and *C* were taken at a station. Determine the MPVs of the angles *A*, *B*, and *C* when their observations are (a) equal weights and (b) unequal weights.

	Weights	
Angles	(i)	(ii)
A = 72°12′42.3″	1	3
B = 53°18′53.6″	1	4
C = 110°24′48.5″	1	2
A + B = 125°31′36.8″	1	2
B + C = 163°43′44.6″	1	2
A + B + C = 235°56′26.2″	1	1

[Ans: (i) A = 42.35″, B = 55.30, C = 47.65″ (ii) A = 42.45″, B = 54.17″, C = 49.35″ 49.48″]

6) The following observations refer to the values of the angles *A*, *B*, and *C* at a triangulation station. *A* = 20°18′20.4″; B = 36°28′14.8″; C = 56°46′44.5″. Fulfilling the condition that *A* + *B* = *C*, find the most probable values of A, B, and C

[Ans: A = 23.5″, B = 17.9″, C = 41.4″]

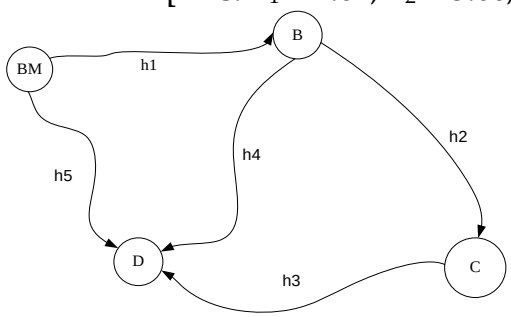
7) Along a straight line *AE*, segments *AB*, *BC*, *CD*, and *DE* are measured as 24.1, 35.8, 30.3 and 33.8 meters respectively. *AD* and *BE* are known to be exactly 90m and 100m respectively. *AD* and BE are known to be exactly 90m and 100m respectively. Calculate the most probable values of *AB*, *BC*, *CD* and *DE*.

[Ans: AB = 23.94m; BC = 35.78m; CD = 30.28m; DE = 33.94m]

8) In leveling a round of levels on field it was found that :
B was 4.71 m above B.M. distance 800m
C was 3.59 m above B distance 400m
C was 1.48 m below D distance 400m
D was 9.27 m above B.M. distance 400m
B was 5.12 m below D distance 800m

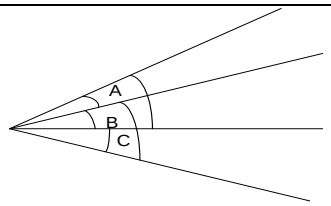
Determine the MPV of difference of elevations of B, C, and D with respect to B.M. and of the other observations by (i) Reduced observations equation method. (ii) Condition equation method.

[Ans: $h_1 = 4.67$; $h_2 = 3.60$; $h_3 = 1.49$; $h_4 = 5.09$; $h_5 = 9.76$]



9) Following angles were measured at a triangulation station O:

A = 30°20′20″
B =10°40′20″
C = 28°30′20″
A + C = 41°00′43″
B + C = 39°10′43″



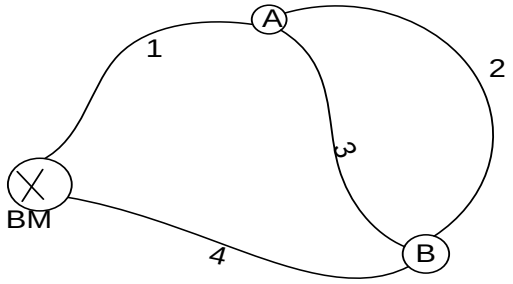
Find out the most probable values of the angles by condition equation method of adjustment

[Ans: A = 30°20′20.75″; B = 10°40′21.50″; C = 28°30′20.75″]

10) For establishment of two temporary bench marks A and B, from the GTSBM the following observations, as shown in figure were obtained:

Line	Difference of elevation	Distance
1	A higher than BM by 8.350m	8km
2	B lower than A by 3.225m	2km
3	A higher than B by 3.145m	2km
4	B higher than BM by 5.245m	8km

Find out the most probable values of elevation of A and B above B.M. by condition equation method. Find also the standard error of an observation of unit weight.



[Ans: h_1 = 8.3876m; h_2 = -3.1803m; h_3 = -3.1803m; h_4 = 5.2074m]

11) The height *h* of a survey station *A* above the instrument center at *B* is to be determined with a standard deviation of 0.010m from measurements of the slope distance *s*, the vertical angle α and the target height *t*. The function used is:

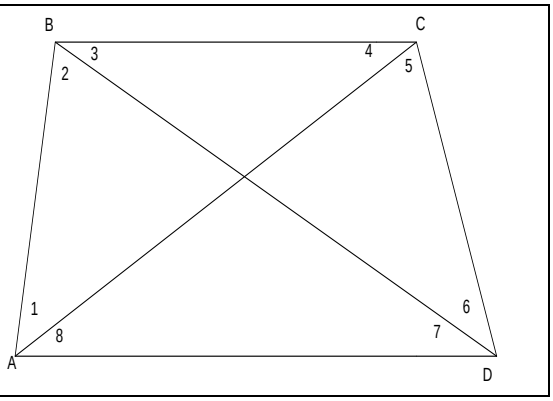
$$h = s\sin\alpha - t$$

When each input measurement contributes equally to the accuracy of the end result, the measurements are said to have balanced accuracies. For the purpose of *pre-analysis*, estimated values for *s* and α are 400m and 30^0, respectively (a) Evaluate the standard

deviation in measuring *s*, α, and *t*, assuming balanced accuracies (b) if the standard deviation in measuring α is limited by the instrument used to 5.0″, re-evaluate the standard deviation in measuring *s* and *t* to accommodate this limitation in α.

12) Find out the MPV of the observed angles for the braced quadrilateral shown in the figure by Condition equation method of adjustment.

	Angle	Corr angle (Ans)
1 =	42°8′40″	45.69
2 =	69°11′10″	34.91
3 =	35°21′30″	16.76
4 =	33°17′40″	4.71
5 =	61°13′30″	12.94
6 =	50°7′20″	20.81
7 =	37°11′10″	57.99
8 =	31°28′20″	46.12
	TOTAL	**359° 59′ 59.9″**

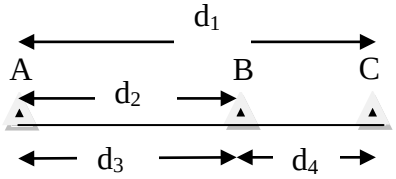


13) From the following observations, **identify** relevant matrices for solution by **condition equation method**.

$a = 20^0\ 10'\ 5''$	wt. 1
$\beta = 40^0\ 15'\ 6''$	wt. 1
$\gamma = 60^0\ 20'\ 7''$	wt. 1
$a + \beta = 60^0\ 25'\ 12''$	wt. 2
$\beta + \gamma = 1\ 00^0\ 35'\ 15''$	wt. 2
$a + \beta + \gamma = 120^0\ 45'\ 20''$	wt. 2

14) Following uncorrelated measurements between the stations, shown in the figure, were obtained during a field survey:

$d_1 = 3400.090\ m \pm 0.025\ m$
$d_2 = 2275.050\ m \pm 0.025\ m$
$d_3 = 2275.070\ m \pm 0.025\ m$
$d_4 = 1125.010\ m \pm 0.025\ m$



Find out the most probable values of the distance between A and C and the measured distances and also the variance covariance in each case by using observation equation method and the matrix solution.