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SVG513: Adjustment Computations II

Examination in 2018/2019 Academic Year

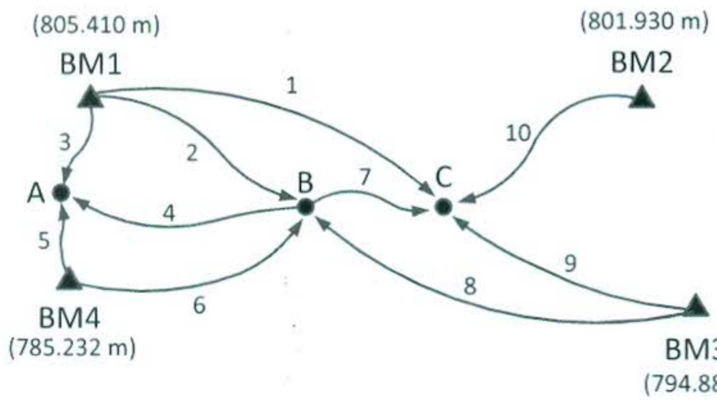
Instructions

1. Answer any **three (3)** questions
2. Time allowed for the examination is **2 hours 30 minutes**

Question 1

In the levelling network depicted in Figure 1 and Table 1 below the marks BM1, BM2, BM3 and BM4 are the existing benchmarks and A, B and C are the new benchmarks being established. The heights of the existing benchmarks are shown in Figure 1 in parentheses near the benchmarks. The routes of the levelling are labelled from 1 to 10. The arrows in the diagram indicate the directions of levelling. Perform a least-squares adjustment of the network, paying attention to the following requirements:

a) Use Gaussian elimination with partial pivoting to solve the normal equations.
b) Look for evidence of ill-conditioning or lack of it in the normal matrix.



New benchmark	Approximate height (m)
A	792.984
B	796.235
C	799.745

Figure 1

Table 1

Route No.	Distance (km)	Route No.	Distance (km)
1	3.2	6	2.0
2	2.0	7	0.5
3	1.5	8	3.4
4	1.7	9	1.0
5	1.6	10	1.1

Question 2

Table 2 is a record of angles measured round the circle at a station.

Table 2

Measured angle	Measured value			Number of times measured
	°	′	″	
1	97	40	35	3
2	35	35	33	2
3	122	46	34	3
4	103	57	14	3
1+2	133	16	07	2
3+4	226	43	52	2
4+1	201	37	50	2
2+3+4	262	19	23	1
1+2+3+4	360	00	00	1001

Find the most probable values of angles 1, 2, 3 and 4 by the method of least squares, paying attention to the following requirements:

a) Use the observation equations method of adjusting the observations.
b) Use the given information to determine an appropriate weighting scheme for the observations.
c) Solve the normal equations using both LU decomposition of the normal matrix.
d) Indicate the precisions with which the parameters of interest have been determined.

Question 3

a) Describe the conditions under which the Cholesky decomposition of a matrix may exist and describe the procedure for obtaining such a decomposition.

b) Obtain the Cholesky decompositions of the following matrices. Take only positive square roots when selecting nonzero diagonal elements. Determine in each case if the original matrix is positive definite, singular positive semidefinite or neither of these.

$$\begin{pmatrix} 9 & -3 & 3 \\ -3 & 2 & 1 \\ 3 & 1 & 6 \end{pmatrix}, \begin{pmatrix} 4 & -2 & 2 \\ -2 & 1 & -1 \\ 2 & -1 & 5 \end{pmatrix}, \begin{pmatrix} 1 & 2 & -1 \\ 2 & 5 & 1 \\ -1 & 1 & 9 \end{pmatrix}$$

Question 4

a) Find the values of k for which the following equations are consistent:

$$\begin{aligned} x + (k+1)y + 2z &= -10 \\ 2kx + 5y - 4z &= -14 \\ 3x + 7y + 2k &= 2 \\ 5x - 4ky + 7z &= 9 \end{aligned}$$

Among the admissible values of k, choose one value for k and use the method of determinants to solve the above equations for x, y and z.

b) Discuss in about a page the relevance of the concept of consistency or inconsistency of equations to the adjustment problems in surveying and geoinformatics.

c) Find the angles between $\theta = 0$ and $\theta = \pi$ that satisfy the equation

$$\begin{vmatrix} 1+\sin^2\theta & \cos^2\theta & 4\sin 2\theta \\ \sin^2\theta & 1+\cos^2\theta & 4\sin 2\theta \\ \sin^2\theta & \cos^2\theta & 1+4\sin 2\theta \end{vmatrix} = 0$$

Question 5

Two rectangular coordinate systems A and B are related through translation and rotation. For the 2-dimensional case in transforming from system A to system B, the following expressions apply:

$$\begin{aligned} x_b &= a_0 + a_1 x_a - a_2 y_a \\ y_b &= a_3 + a_2 x_a - a_1 y_a \end{aligned}$$

Measurements on five points in each coordinate system were recorded as follows:

Point	x_a	y_a	x_b	y_b
1	2.020	4.107	8.457	16.740
2	5.132	1.098	12.472	15.292
3	0.080	6.204	5.863	17.865
4	7.483	0.109	15.155	15.367
5	4.206	8.128	8.818	21.333

Solve for the transformation coefficients a_0, a_1, a_2, and a_3 using singular value decomposition (SVD), assuming that all the measurements are of the same unit, are uncorrelated, and of equal standard deviation 0.002. Within the ambit of SVD, look for evidence of ill-conditioning in the system.