UNIVERSITY OF RUHUNA

Faculty of Engineering

Semester 3 Examination in Engineering: August 2018

Module Number: CE3203 **Module Name: Engineering Surveying**

[Three Hours]

[Answer all questions. Each question carries **TWELVE** marks]
All Standard Notations denote their regular meanings

Q1 a) Consider a parameter A given by the division by of a by b (i.e A = (a/b)). Where a and b have standard errors of σ_a and σ_b. Find the error in A.

[4.0 Marks]

b) a, b, c, and d form a round of angle at a station so that their sum is equal to 360°. The observed values of these angles are;

a = 103° 27′ 20″
b = 91° 14′ 15″
c = 94° 23′ 50″
d = 70° 54′ 45″

The angle (b+c) was also measured separately twice and found to average 185° 38′ 10″. Find the most probable values of the four angles if all the measurements of individual angles are of the same accuracy.

[8.0 Marks]

Q2 a) Consider a closed clockwise traverse ABCD, whose stations have co-ordinates (E_1, N_1), (E_2, N_2), (E_3, N_3), and (E_4, N_4) relative to two axes with origin 'O'. Calculate the area enclosed by ABCD.

[4.0 Marks]

b) It is proposed to widen a highway by increasing the gradient of the side slope from 1 in 1.5 to 1 in 2.0 by keeping the top of the cut (Point B) at the same point (See Figure Q2-1). The difference in level between the bottom and top of the cut at a critical section was measured as 15.0 m. The length of the embankment along the side slope was measured as 29.872 m using a steel tape under a pull of 151 N at a temperature of 27°C. Determine the additional road width which will be available with the new slope.

The tape was standardized on the flat at 18°C under a pull of 47 N. The cross-sectional area of the tape is 6.5 mm^2, E = 20.8 × 10^4 MN/m^2 and $\alpha = 1.1 \times 10^{-5}$ per °C.

[8.0 Marks]

Q3 a) How do you level a theodolite or total station which has four foot-screws in the levelling head?

[3.0 Marks]

b) A link traverse (Figure Q3-1) commences from known stations, A and B, and connects to known stations C and D. Stations A, B, C and D are usually fixed to a higher order of accuracy. Co-ordinates of points B and C are (3,854.28 mE, 9,372.98 mN) and (7,575.56 mE, 8,503.21 mN), respectively. The WCB of AB and CD lines are 151° 27′ 38″ and 347° 37′4 1″ respectively. The Table Q3-1 indicates the lines, observed angles, and lengths of the legs of the link traverse. Calculate the final coordinates of all traverse points and find the accuracy of the traverse.

[9.0 Marks]

Q4 a) Derive a formula for the cross-sectional area of the level section as show in Figure Q4-1 in terms of formation width b, side slope given by 1: m and central line height h.

[2.0 Marks]

b) A road embankment is 8 m wide with side slope 1:2.5. The top (made) surface of a straight portion of this road embankment rises at a gradient of 1:120 along its center line in the longitudinal direction. At the start of this straight section, the reduced level of the center of the top (made) surface is 210.00 m above the datum. The reduced levels of the natural ground along the center line of the road embankment are given in Table Q4-1. Assume that the natural ground is level in the direction transverse to the center line. Calculate the volume of the earth-work (cutting and filling volume) contained in a length of 560 m.

[5.0 Marks]

c) The areas within the contour lines of a reservoir is measured with a planimeter from a plan drawn to a scale 1:1000 and show in Table Q4-2. If the lowest raw-off level is 56m and the maximum water level is 68m, estimate the full storage capacity of the reservoir and find the water level when reservoir is 50% capacity.

[5.0 Marks]

Q5 a) Explain the meaning of the following terms connected to levelling:

i. Datum
ii. Temporary Bench Mark
iii. Hight of Collimation
iv. Rise and Fall method

[4.0 Marks]

b) Levelling procedure was done between two known points (TBM 'A' and TBM 'B') which are having reduced levels of 120.842 m and 120.100 m from MSL, respectively. Least count for levelling staff is 5 mm. Table Q5-1 shows the level sheet with the readings taken during the levelling work.

i. Calculate the uncorrected reduced levels at all points using height of collimation method.
ii. Carry out the arithmetic check
iii. Calculate the error in the levelling work
iv. What is the allowable error?
v. If the error is in allowable range, distribute the error and calculate the corrected reduced levels for all points.

[8.0 Marks]

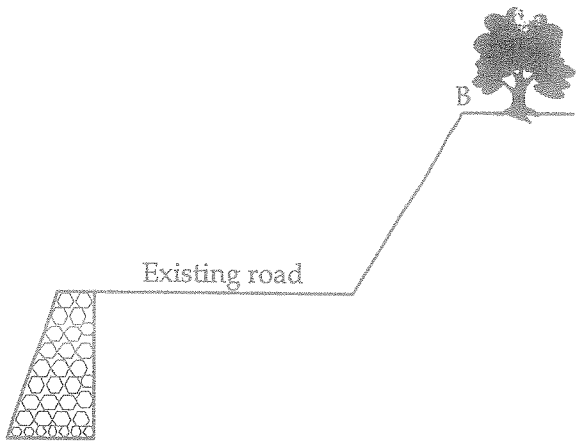

Figure Q2-1: Cross Section of existing road

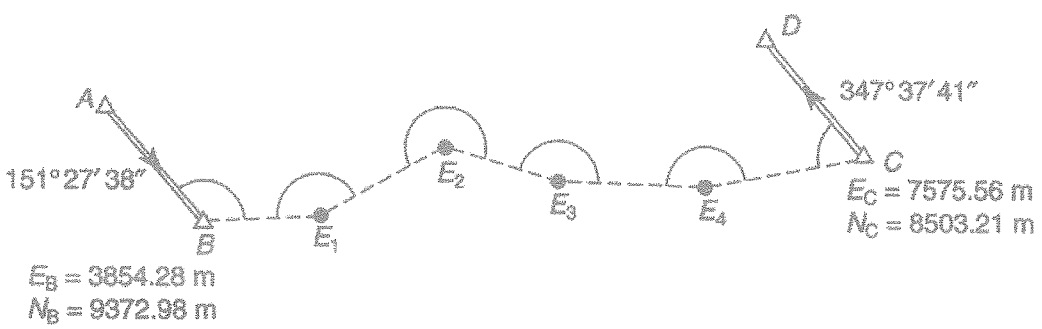

Figure Q3-1: Cross Section

Table Q3-1: Data for link traverse

Station		Observed angle			Length (m)
From	To	°	′	″	
A	B				
		143	54	47	
B	E_1				651.16
		149	08	11	
E_1	E_2				870.92
		224	07	32	
E_2	E_3				522.08
		157	21	53	
E_3	E_4				1,107.36
		167	05	15	
E_4	C				794.35
		74	32	48	
C	D				

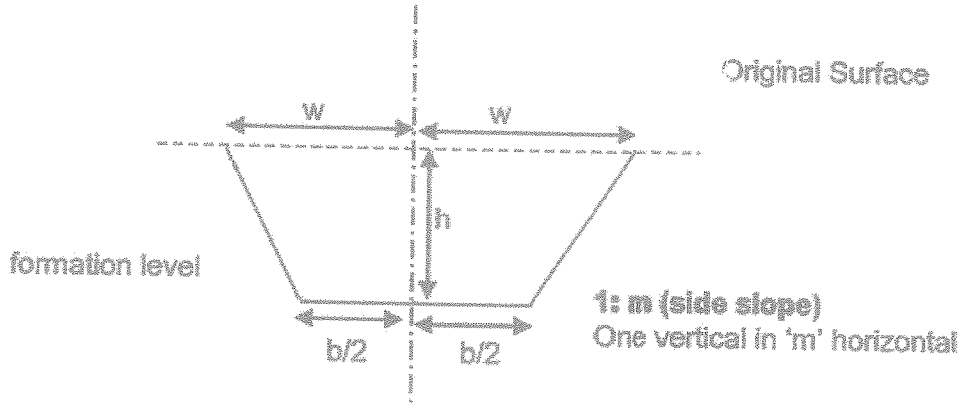

Figure Q4-1: Cross Section

Table Q4-1: The reduced levels of the natural ground along the center line

Chainage (m)	0	40	80	120	160	210	260
Existing RL (m)	216.56	215.23	214.25	213.35	211.33	209.92	210.17

Chainage (m)	310	360	460	560
Existing RL (m)	211.16	211.98	211.52	213.56

Table Q4-2: The reduced levels of the natural ground along the center line

Contour level (m)	68	66	64	62	60	58	56
Area (mm²)	84960	80050	70500	62030	57100	39880	17200

Useful Equations

$$t_a = \frac{C_t}{KL} + t_s$$

$$C_t = KL\Delta t$$

$$E_F = \frac{K_1E_A + K_2E_B + K_3E_c}{K_1 + K_2 + K_3}$$

$$N_F = \frac{K_1N_A + K_2N_B + K_3N_c}{K_1 + K_2 + K_3}$$

$$\sigma_{\bar{x}} = \frac{S}{\frac{1}{n^2}}$$

$$C_T = L\frac{\Delta T}{AE}$$

$$C_\theta = -\frac{h^2}{2L}$$

$$C_M = -\frac{LH}{R}$$

$$S = \left(\frac{\sum(x_i - \bar{x})^2}{n-1}\right)^{\frac{1}{2}}$$

$$K_3 = \frac{1}{(\cot c - \cot z)}$$

$$C_s = -\frac{w^2L^3}{24T^2}$$

$$C_s = -\frac{w^2L^3}{24}\left(\frac{1}{T_A^2} - \frac{1}{T_S^2}\right)$$

$$K_1 = \frac{1}{(\cot a - \cot x)}$$

$$W \propto \frac{1}{\sigma_x^2}$$

$$C_\theta = -L\,(1 - cos\theta)$$

$$K_2 = \frac{1}{(\cot b - \cot y)}$$

(NOTE: Detach Table Q5-1 and attach it to answer script)

Table Q5-1: The level sheet

Back-sight	Inter. sight	Fore-sight						Remarks
1.361								TBM 'A'
	2.844							
	2.018							
0.855		3.015						
	0.611							
2.741		1.805						
2.855		1.711						
	1.362							
	2.111							Invert level
	0.856							
		2.015						TBM 'B'
Arithmetic. Check:								
				Error				
Allowable error				Correction				