



**Subject: Engineering Surveying**  
**Division: All Branches**  
**Examiner: Surveying Community**

**Time: 3 hour**  
**Date: 22/06/2013**

**Answer FOUR Questions Only**

**Q.1)**

The following table represent the field data in traversing using theodolite and steel tape:

Theodolite station	Observed station	Telescope	H.C.R	Horizontal Distance	
				Repetition	Measurement (m)
A	K	D	$21^{\circ} 26' 15''$	1	AB=123.537
	B	D	$86^{\circ} 51' 30''$	2	AB=123.486
	K	R	$201^{\circ} 26' 25''$	3	AB=123.585
	B	R	$266^{\circ} 52' 10''$	4	AB=123.456

Knowing that:

Azimuth of  $\overrightarrow{AK} = AZ_{AK} = 15^{\circ} 20' 00'' \mp 00''$ ,  $X_A = 367m \pm 0.04 m$ ,  $Y_A = 523m \pm 0.05m$

- 1) Compute the most probable value of the horizontal distance AB and its standard error. (10 Marks)
- 2) Compute the horizontal angle to the right  $\sphericalangle$  KAB and its standard error. (5 Marks)
- 3) Compute the horizontal coordinates [X, Y] of point [B]. (5 Marks)
- 4) Compute the Standard error for the [X] coordinate of point [B]. (5 Marks)

**Q.2)**

The following table represents the field data for profile leveling along the center line of a road using the level and the leveling Rod;

Level Setup	Observed Station	Rod Reading (m)	Elevation (m)
1	BM1	1.542	31.750
	TP1	1.784	
2	TP1	0.658	
	A	1.235	
3	A	1.748	
	0+00	1.845	
	0+25	1.376	
	0+50	1.635	
	0+75	1.457	
	1+00	1.538	
	BM2	1.437	

- 1) Compute the adjusted elevation of point A and its standard error. (10 Marks)
- 2) Compute the ground elevation of the road center line stations [0+00, 0+25, 0+50, 0+75, 1+00]. (5 Marks)
- 3) If the proposed center line having gradient = +2% and the grade elevation of station 0+50 = ground elevation of station [0+50]; compute the amount of cut or fill for all center line stations. (10 Marks)

**Q.3)**

A. The following table represent the field data for topographic surveying by the radiation method using theodolite and leveling Rod :

Theodolite station	Observed station	H.C.R	V.C.R	Rod Reading (m)		
				U	M	L
A	K	24° 15' 35"	87° 16' 35"		1.84	
	K		85° 32' 45"		2.34	
	B	61° 33' 15"	275° 32' 15"	1.70	1.05	0.40

Knowing that: Azimuth of  $\overline{AK} = AZ_{AK} = 24^\circ 15' 35''$

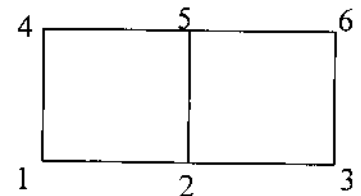
$X_A = 472$  m,  $Y_A = 635$  m,  $Z_K = 32.68$  m

Compute the horizontal coordinates [X, Y] and the elevation of point [B]. (10 Marks)

B. the following table represent the ground elevation of the points of the [20m x 20m] grid shown in the figure below

Point	1	2	3	4	5	6
Ground elevation (m)	30.6	29.9	31.4	33.8	33.3	31.9

- 1) List the contour lines that pass through the grid using contour interval = 0.5 m. (2 Marks)
- 2) Draw the 32.5 m contour line with a horizontal scale  $S_H = 1/500$ . (5 Marks)
- 3) Compute the volume of earth work required to level the ground into a final elevation = 32.5 m. (8 Marks)



**Q.4)**

A. The following table represent the final cross-sections of the transitional area of road having bed-width  $b = 14.0$  m

Station	Cross- Section				Area (m <sup>2</sup> )	
	Left	CL	Right	Cut	Fill	
6+50				46.58	0	
6+65	$\frac{f 2.5}{14.5}$ $\frac{f 1.3}{5.0}$	$\frac{0}{0}$	$\frac{C 1.65}{10.3}$			
7+00				0	38.26	

Compute the volume of earth work from station (6+50) to station (7+00) by End Area method.

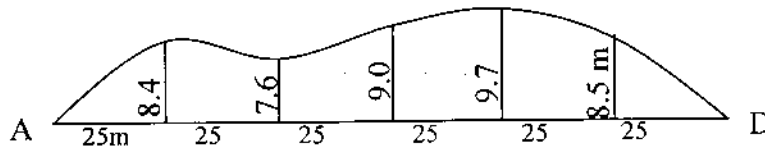
(18 Marks)

- B. Two grade lines having gradients of  $g_1 = + 1.25 \%$  ,  $g_2 = -2.75 \%$  to be connected by a symmetrical parabolic vertical curve having a length  $L = 165 \text{ m}$  , the elevation of the vertex  $(V) = Z_v = 32.8 \text{ m}$  and  $V \text{ station} = 12+36$  .  
 Compute the station and the elevation of the highest (lowest) point on the curve. (7 Marks)

Q.5)

- A. Simple circular horizontal curve having a radius of curvature  $R = 223.152 \text{ m}$  ,  $PC \text{ station} = 8+64$  and  $PI \text{ station} = 9+40$  .  
 Compute the incremental chords and the deflection angles required for laying out stations  $(8+80, 9+60)$  of the curve using  $[\frac{1}{5}]$  station . (18 Marks)

- B. Find the Area of the parcel shown in figure below using the trapezoidal rule [All units in meter].



(7 Marks)

Q1)

1)

$$D_{AB} = \frac{X_1 + X_2 + X_3 + X_4}{4}$$

$$D_{AB} = \frac{123.537 + 123.486 + 123.585 + 123.458}{4} = 123.516m$$

$$v_i = \bar{x} - x_i$$

$$v_1 = 123.537 - 123.516 = 0.021$$

$$v_2 = 123.486 - 123.516 = -0.03$$

$$v_3 = 123.585 - 123.516 = 0.069$$

$$v_4 = 123.458 - 123.516 = -0.06$$

$$\delta_{xi} = \pm \sqrt{\frac{\sum v^2}{n-1}} = \pm 0.056868269m$$

$$\delta \bar{x} = \pm \frac{\delta_{xi}}{\sqrt{n}} = \pm 0.028434134 m$$

2)

$$x_1 = K_{AB1} = 86^{\circ}51'30'' - 21^{\circ}26'15'' = 65^{\circ}25'15''$$

$$x_2 = K_{AB2} = 266^{\circ}52'10'' - 201^{\circ}26'25'' = 65^{\circ}25'45''$$

$$K_{AB} = \frac{X_1 + X_2}{2}$$

$$K_{AB} = \frac{65^{\circ}25'15'' + 65^{\circ}25'45''}{2} = 65^{\circ}25'30''$$

$$v_i = \bar{x} - x_i$$

$$v_1 = 65^{\circ}25'30'' - 65^{\circ}25'15'' = 15''$$

$$v_2 = 65^{\circ}25'30'' - 65^{\circ}25'45'' = -15''$$

$$\delta_{xi} = \pm \sqrt{\frac{\sum v^2}{n-1}} = \pm 21.21''$$

$$\delta \bar{x} = \pm \frac{\delta_{xi}}{\sqrt{n}} = \pm 15''$$

3)

$$AZ_{AB} = AZ_{AK} + \sphericalangle K_{AB} = 15^{\circ}20'00'' + 65^{\circ}25'30'' = 80^{\circ}45'30''$$

$$X_B = X_A + D_{AB} \sin AZ_{AB}$$

$$X_B = 367 + 123.516 \sin 80^{\circ}45'30'' = 488.912 \text{ m}$$

$$Y_B = Y_A + D_{AB} \cos AZ_{AB}$$

$$Y_B = 523 + 123.516 \cos 80^{\circ}45'30'' = 542.836 \text{ m}$$

4)

$$X_B = X_A + D_{AB} \sin AZ_{AB}$$

$$AZ_{AB} = AZ_{AK} + \alpha_{KAB} = 15^{\circ}20'00'' + 65^{\circ}25'30'' = 80^{\circ}45'30''$$

$$\delta X_B^2 = \left(\frac{\partial X_B}{\partial X_A}\right)^2 \delta X_A^2 + \left(\frac{\partial X_B}{\partial D_{AB}}\right)^2 \delta D_{AB}^2 + \left(\frac{\partial X_B}{\partial AZ_{AB}}\right)^2 \delta AZ_{AB}^2$$

$$\frac{\partial X_B}{\partial X_A} = 1$$

$$\frac{\partial X_B}{\partial D_{AB}} = \sin AZ_{AB}$$

$$\frac{\partial X_B}{\partial AZ_{AB}} = D_{AB} \cos AZ_{AB}$$

$$\delta AZ_{AB} = 0.0 + 15 = 15''$$

$$\delta X_B^2 = 1 \times 0.04^2 + (0.987)^2 \times 0.028434134^2 + (19.836)^2 \left(\frac{15}{3600} \times \frac{\pi}{180}\right)^2 = 0.00239$$

$$\delta X_B = 0.04888 \text{ m}$$

Q2)

1)

Point	B.S	ELS	FS	Elevation (m)
BM1	1.542	33.292		31.750
TP1	0.658	32.166	1.784	31.508
A	1.748	32.679	1.235	30.931=X1
BM2			1.437	31.242 -31.230 e=0.012

$$Y = \frac{X_1 * P_1 + X_2 * P_2}{P_1 + P_2}$$

$$P_1 = \frac{1}{2}, P_2 = \frac{1}{1}$$

$$X1=30.931$$

$$X_2 = X_1 - e = 30.919$$

$$Y = \frac{30.931 * \frac{1}{2} + 30.919 * \frac{1}{1}}{\frac{1}{2} + \frac{1}{1}} = 30.923 \text{ m}$$

$$v_i = \bar{x} - x_i$$

$$v_1 = 30.923 - 30.931 = -0.008$$

$$v_2 = 30.923 - 30.919 = 0.004$$

$$\delta_{x_i} = \pm \sqrt{\frac{\sum P v^2}{n-1}} = \pm 0.008944272 \text{ m}$$

$$\delta \bar{x} = \pm \frac{\delta_{x_i}}{\sqrt{P_1 + P_2}} = \pm 0.004472136 \text{ m}$$

2)

Level setup	Observed station	Rod reading m	Adjusted Elevation m	E.L.S M	Weight P
1	A	1.748	30.923	$x_1 = 32.671$	$P_1 = \frac{1}{1} = 1$
	BM2	1.437	31.230	$x_2 = 32.667$	$P_2 = \frac{1}{1} = 1$

$$\therefore \text{E.L.S}_1 = \frac{P_1 x_1 + P_2 x_2}{P_1 + P_2} = \frac{(1 * 32.671) + (1 * 32.667)}{1 + 1} = 32.669 \text{ m}$$

station	B.S m	E.L.S m	F.S m	I.F.S m	Ground Elevation m
A	1.748				30.923
0+00				1.845	30.824
0+25				1.376	31.293
0+50		32.669		1.635	31.034
0+75				1.457	31.212
1+00				1.538	31.131
BM2			1.437		31.230

3)

station	B.S m	E.L.S m	F.S m	I.F.S m	Ground Elevation m	grade Elevation m	Cut M	Fill m
A	1.748				30.923			
0+00				1.845	30.824	30.034	0.79	
0+25				1.376	31.293	30.534	0.759	
0+50		32.669		1.635	31.034	31.034	0	
0+75				1.457	31.212	31.534		-0.322
1+00				1.538	31.131	32.034		-0.903
BM2			1.437		31.230			

Q3)

A)

$$D_{AK} = \frac{Rm2 - Rm1}{\tan \alpha_2 - \tan \alpha_1}$$

$$\alpha_1 = 90 - 87^\circ 16' 35'' = 2^\circ 43' 25''$$

$$\alpha_2 = 90 - 85^\circ 32' 45'' = 4^\circ 27' 15''$$

$$= \frac{2.340 - 1.840}{\tan 4^\circ 27' 15'' - \tan 2^\circ 43' 25''} = 16.488 \text{ m}$$

$$D_{AB} = K S \cos \phi^2 = 100 * (1.7 - 0.40) * \cos (275^\circ 32' 15'' - 270) = 128.789 \text{ m}$$

$$\angle KAB = 61^\circ 33' 15'' - 24^\circ 15' 35'' = 37^\circ 17' 40''$$

$$AZ_{AB} = AZ_{AK} + \angle KAB = 24^\circ 15' 35'' + 37^\circ 17' 40'' = 61^\circ 33' 15''$$

$$X_B = X_A + D_{AB} \sin AZ_{AB}$$

$$X_B = 472 + 128.789 \sin 61^\circ 33' 15'' = 585.240 \text{ m}$$

$$Y_B = Y_A + D_{AB} \cos AZ_{AB}$$

$$Y_B = 635 + 128.789 \cos 61^\circ 33' 15'' = 696.345 \text{ m}$$

$$BS_{AK} = Rm - D_{AK} * \tan \alpha$$

$$= 1.84 - 16.488 * \tan(90 - 87^\circ 16' 35'') = 1.055 \text{ m}$$

$$FS_{AB} = Rm - D_{AB} * \tan \alpha$$

$$= 1.05 - 128.789 * \tan(275^\circ 32' 15'' - 270) = -11.436 \text{ m}$$

$$Elev. B = Elev. K + BS - FS$$

$$= 32.68 + (1.055) + (-11.436) = 22.299 \text{ m}$$

B)

1)

30

30.5

31

31.5

32

32.5

33

33.5

2)

$$\frac{1}{500} = \frac{X}{2000}$$

$$X = 4 \text{ cm} \quad \text{إبعاد المربع على الخارطة}$$

$$\text{THE CONTOR LINE} = 32.5 \text{ m}$$

$$\frac{33.8 - 30.6}{20} = \frac{33.8 - 32.5}{\times 1}$$

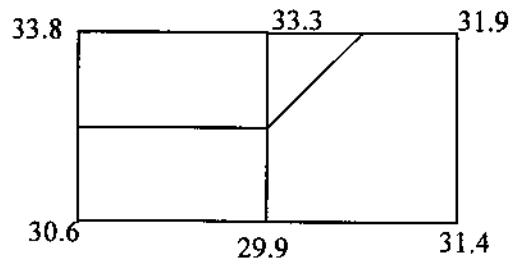
$$X_1 = 1.6 \text{ cm}$$

$$\frac{33.3 - 29.9}{20} = \frac{33.3 - 32.5}{\times 2}$$

$$X_2 = 0.9 \text{ cm}$$

$$\frac{33.3 - 31.9}{20} = \frac{33.3 - 32.5}{\times 3}$$

$$X_3 = 2.3 \text{ cm}$$



3)

Point	1	2	3	4	5	6
Cut or fill (m)	-1.9	-2.6	-1.1	1.3	0.8	-0.6

$$V_{F1} = \frac{[1.9+2.6]^2}{[1.9+2.6+1.3+0.8]} * \frac{20*20}{4} = \frac{4.5^2}{6.6} * 100 = 306.818m^3$$

$$V_{C1} = \frac{[1.3+0.8]^2}{[1.9+2.6+1.3+0.8]} * \frac{20*20}{4} = \frac{2.1^2}{6.6} * 100 = 66.818m^3$$

$$V_{F2} = \frac{[2.6+1.1+0.6]^2}{[2.6+0.8+1.1+0.6]} * \frac{400}{4} = \frac{4.3^2}{5.1} * 100 = 362.549m^3$$

$$V_{C2} = \frac{[0.8]^2}{[2.6+0.8+1.1+0.6]} * \frac{400}{4} = \frac{0.8^2}{5.1} * 100 = 12.549m^3$$

$$V_{cut} = \sum_{i=1}^4 V_{ci} = V_{c1} + V_{c2}$$

$$\therefore V_{cut} = 66.818 + 12.549 = 79.367m^3$$

$$V_{fill} = \sum_{i=1}^4 V_{fi} = V_{f1} + V_{f2}$$

$$\therefore V_{fill} = 306.818 + 362.549 = 669.367m^3$$

Q4)

Station	Area Cut m <sup>2</sup>	Area fill m <sup>2</sup>	Cross-section			
			Left	CL	Right	
6+50	46.58	0				
6+65			$\frac{f2.5}{14.5}$	$\frac{f1.3}{5.0}$	$\frac{0}{0}$	$\frac{c1.65}{10.3}$
7+00	0	38.26				

$$A = \frac{1}{2} \sum_{i=1}^n y_i (x_{i+1} - x_{i-1})$$

$$A_{fill\ 6+65} = \frac{1}{2} (18.85 + 5) = 11.925 m^2$$

$$A_{cut\ 6+65} = \frac{1}{2} (1.65(7 - 0)) = 5.775 m^2$$

$$V_{1cut} = (46.58 + 5.775) * \frac{15}{2} = 392.662 m^3$$

$$V_{1fill} = \frac{L}{3} * A_{fill} = \frac{15}{3} * 11.925 = 59.625 m^3$$

l2=35

$$V_{2cut} = \frac{L}{3} * A_{cut} = 67.375 m^3$$

$$V_{2fill} = (11.925 + 38.26) * \frac{35}{2} = 439.11875 m^3$$



$$V_{cut} = 392.662 + 67.375 = 460.037 \text{ m}^3$$

$$V_{fill} = 59.625 + 439.1187 = 498.743757 \text{ m}^3$$

B)

$$BVC \text{ Station} = V. \text{Sta.} - \frac{L}{2} = 1236 - 165/2 = 1153.5 = 11 + 53.5$$

$$Z_{BVC} = Z_v - g_1 * \frac{L}{2} = 32.8 - \frac{1.25}{100} * 165/2 = 31.768 \text{ m}$$

$$r = \frac{g_2 - g_1}{L} = \frac{\frac{1.25}{100} - \frac{(-2.75)}{100}}{165} = \frac{4}{16500} = 0.0002424$$

$$X = -\frac{g_1}{r}$$

$$X = -\frac{\frac{1.25}{100}}{0.0002424} = 51.567 \text{ m}$$

$$\text{station} = 1153.5 + 51.567 = 12 + 05.067$$

$$Z_i = Z_{BVC} + g_1 * X + \frac{1}{2} * r * x^2$$

$$Z_i = 31.768 + \frac{1.25}{100} * 51.567 + \frac{1}{2} * 0.0002424 * 51.567^2 = 32.73488 \text{ m}$$

Q5)

A

$$T = 940 - 864 = 76 \text{ m}$$

$$T = R \tan \frac{\theta}{2}$$

$$76 = 223.152 * \tan \frac{\theta}{2}$$

$$\frac{\theta}{2} = \tan^{-1} \frac{76}{223.252}$$

$$\theta = 37^{\circ}36'54.4''$$

$$l_1 = 880 - 864 = 16 \text{ m} \qquad l = \frac{1}{5} * 100 = 20 \text{ m}$$

$$d_1 = \frac{l_1}{R} * \frac{180}{\pi} = 4^{\circ}6'29.2''$$

$$C_1 = 2R \sin \frac{d_1}{2} = 2 * 223.152 * \sin 4^{\circ}6'29.2''/2 = 15.9966 \text{ m}$$

$$l = 20 \text{ m} \longrightarrow d = \frac{l}{R} * \frac{180}{\pi} = \frac{20}{223.152} * \frac{180}{\pi} = 5^{\circ}8'6.5''$$

$$C = 2R \sin \frac{d}{2} = 2 * 223.152 * \sin 5^{\circ}8'6.5''/2 = 19.9933m$$

STATION	Chord (m)	Deflection angle
PC= 8+64		
8+80	15.9966	$\frac{d_1}{2} = 2^{\circ}3'14.6''$
9+00		
9+20		
9+40		
9+60	19.9933	$\frac{d_1}{2} + \frac{4d}{2} = 12^{\circ}19'27.56''$

B)

$$Area = \frac{25}{2} * (0 + 0 + 2 * (8.4 + 7.6 + 9.0 + 9.7 + 8.5)) = 25 * 43.2 = 1080 m^2$$