



University of Technology
Engineering Department of Building and Construction
Final Exam 2013-2014



Subject: Engineering Surveying
Division: All Divisions
Examiner: Surveying Committee

Year: 2nd year
Time: Three hours
Date: 7 / 6 / 2014

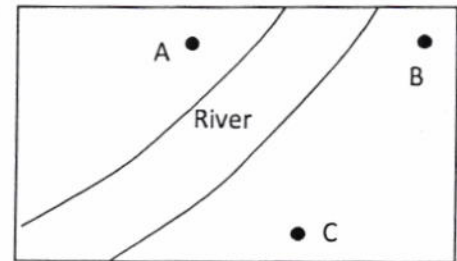
Answer Four Questions Only

Q1) For a precise computation of the horizontal distance (AC) shown in the figure, the following measurements were taken using a theodolite and steel tape:

Horizontal distance $D_{BC} = 162.153 \text{ m}$, 162.206 m , 162.124 m , 162.218 m

Horizontal Angle to the right $\angle ACB = 85^\circ 24' 35'' \mp 32''$

Theodolite station	Observed station	Telescope	H.C.R
B	C	D	$65^\circ 16' 05''$
	C	R	$245^\circ 16' 25''$
	A	D	$95^\circ 23' 35''$
	A	R	$275^\circ 23' 45''$



- A- Compute the most probable value of the horizontal distance [BC] and its standard error. (12 marks)
 B- Compute the most probable value of the horizontal angle to the right $\angle CBA$ and its standard error. (8 marks)
 C- Compute the horizontal distance [AC]. (5 marks)

Q2) A- The following table represent the field data for three routes (R_1 , R_2 , R_3) of differential leveling using the level and leveling rod.

Route	From	To	No. of level setup	Measured difference in elevation (m)	Elevation (m)
R_1	BM_1	A	12	+ 1.660	$BM_1 = 31.8 \text{ m}$
R_2	BM_2	A	6	- 0.074	$BM_2 = 33.5 \text{ m}$

The field data for route R_3 are:

Route	Level setup	Observed points	Rod reading (m)	Elevation (m)
R_3	1	BM_3	1.568	32.6
		TP_1	2.372	
	2	TP_1	1.825	
		A	0.182	

Compute the adjusted (Most Probable Value) elevation of point A and its standard error. (17 marks)

B- Simple circular horizontal curve having a radius $R = 137 \text{ m}$, the deflection angle $\Theta = 64^\circ$, and PI station = 12+40. Compute the [PC, PT] stations. (8 marks)

Q3) A- The following table represent the field data for the traverse [KAB] using theodolite and steel tape:

Measured Horizontal angle to the right	Measured Horizontal distance (m)
$\angle KAB = 85^\circ 32' 15''$	$KA = 123.568$
	$AB = 75.214$

Knowing that: Azimuth of the line $KA = AZ_{KA} = 136^\circ 15' 28''$
 $X_K = 263.845 \text{ m}$, $Y_K = 384.734 \text{ m}$

- 1- Compute the horizontal (X,Y) coordinates of points [A,B] (8 marks)
- 2- Compute the horizontal distance (KB) and its direction (AZ_{KB}). (4 marks)
- 3- Compute the Horizontal angle to the right $\angle BKA$. (3 marks)
- 4- Compute the deflection angle $\angle ABK$. (3 marks)

B- The following table represent the field data for topographic surveying by the radiation method using theodolite and leveling rod.

Theodolite Station	Observed Station	V. C. R	Rod reading (m)			Elevation (m)
			U	M	L	
A	K	87° 26' 25"		1.85		32.650
	B	274° 32' 15"	1.9	1.25	0.6	

(7 marks)

Knowing that: the Horizontal distance AK = 76.385m.

Compute the elevation (Z) of point (B).

Q4)A- The following table represent the final cross-section for a road having bed width $b=12$ m.

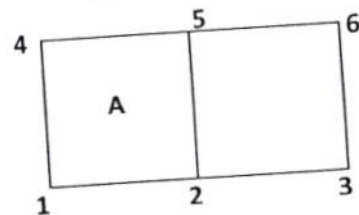
Station	Cross-section		
	Left	C.L	Right
14+50	$\frac{C1.3}{8.6}$	$\frac{C2.7}{0.0}$	$\frac{C1.6}{9.2}$

(7 marks)

Compute the area of the cross-section using the coordinates method.

B- The following table represent the ground elevation of the point of the (25 m × 25 m) grid shown in the figure below.

Point	1	2	3	4	5	6
Elevation (m)	28.5	27.8	29.3	31.7	31.2	29.8



- Draw the contour line with elevation = 29.0 m using a horizontal scale = 1/1000. (9 marks)
- Compute the final elevation required to level the ground into a horizontal plane at which the volume of cut = volume of fill. (4 marks)
- Compute the volumes of earthwork (cut, fill) that is required to level sub grid A into elevation 29.5 m. (5 marks)

Q5)

A- The following table represents the field data for a part of profile leveling along the center line of a road:-

Level Setup	Observed Station	Rod Reading (m)
1	0+00	1.385
	0+10	2.456
	0+25	0.842
	BM1	1.360
2	BM1	0.673
	0+50	2.473
	1+00	1.328

Knowing that: The elevation of BM1 = 31.562 m
The grade elevation of Station 0+25 = 31.43 m
The proposed center line has gradient = +2%

(15 marks)

Compute the amount of cut or fill for all Center Line stations.

B- Two grade lines having gradients of $g_1 = +1.85\%$, $g_2 = -3.65\%$ to be connected by a symmetrical parabolic vertical curve.

Knowing that the BVC station = 11+75, the elevation of the vertex (V) = $Z_v = 27.5$ m, station V = 12+35.

(10 marks)

Compute the elevation of stations (12+00), (12+60) on the curve.



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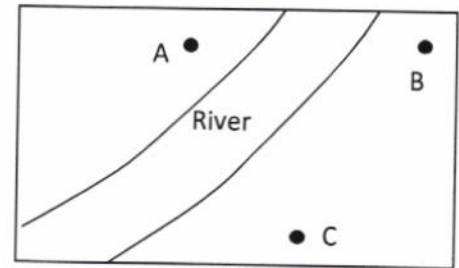
Answer Four Questions Only

Q1) For a precise computation of the horizontal distance (AC) shown in the figure, the following measurements were taken using a theodolite and steel tape:

Horizontal distance D_{BC} = 162.153 m, 162.206 m, 162.124 m, 162.218 m

Horizontal Angle to the right $\angle ACB = 85^\circ 24' 35'' \mp 32''$

Theodolite station	Observed station	Telescope	H.C.R
B	C	D	$65^\circ 16' 05''$
	C	R	$245^\circ 16' 25''$
	A	D	$95^\circ 23' 35''$
	A	R	$275^\circ 23' 45''$



A- Compute the most probable value of the horizontal distance [BC] and its standard error.

The answer :

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

$$D_{BC} = \frac{162.153 + 162.206 + 162.124 + 162.218}{4} = 162.1753m$$

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

$$v_1 = 162.153 - 162.1753 = -0.0223$$

$$v_2 = 162.206 - 162.1753 = 0.0307$$

$$v_3 = 162.124 - 162.1753 = -0.0513$$

$$v_4 = 162.218 - 162.1753 = 0.0427$$

$$\delta_{xi} = \pm \sqrt{\frac{\sum v^2}{n-1}} = \pm 0.044327m$$

$$\delta \bar{x} = \pm \frac{\delta_{xi}}{\sqrt{n}} = \pm 0.0221635 m$$

B- Compute the most probable value of the horizontal angle to the right $\angle CBA$ and its standard error.

Theodolite station	Observed station	Telescope	H.C.R	
B	C	D	$65^\circ 16' 05''$	$30^\circ 07' 30''$
	C	R	$245^\circ 16' 25''$	$30^\circ 07' 20''$
	A	D	$95^\circ 23' 35''$	
	A	R	$275^\circ 23' 45''$	

The answer :

$$x_1 = CBA1 = 95^\circ 23' 35'' - 65^\circ 16' 05'' = 30^\circ 07' 30''$$

$$x_2 = CBA2 = 275^{\circ}23'45'' - 245^{\circ}16'25'' = 30^{\circ}07'20''$$

$$CBA = \frac{X_1 + X_2}{2}$$

$$CBA = \frac{30^{\circ}07'30'' + 30^{\circ}07'20''}{2} = 30^{\circ}07'25''$$

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

$$v_1 = 30^{\circ}07'30'' - 30^{\circ}07'25'' = 5''$$

$$v_2 = 30^{\circ}07'20'' - 30^{\circ}07'25'' = -5''$$

$$\delta_{xi} = \pm \sqrt{\frac{\sum v^2}{n-1}} = \pm 7.07''$$

$$\delta \bar{x} = \pm \frac{\delta_{xi}}{\sqrt{n}} = \pm 5''$$

C- Compute the horizontal distance [AC].

The answer :

$$\angle BAC = 180 - 30^{\circ}07'25'' - 85^{\circ}24'35'' = 64^{\circ}28'00''$$

$$\frac{D_{AC}}{\sin \angle CBA} = \frac{D_{BC}}{\sin \angle BAC}$$

$$D_{AC} = \frac{D_{BC} \times \sin \angle CBA}{\sin \angle BAC} = \frac{162.1753 \times \sin 30^{\circ}07'25''}{\sin 64^{\circ}28'00''} = 90.1999 \text{ m}$$

Q2) A- The following table represent the field data for three routes (R_1 , R_2 , R_3) of differential leveling using the level and leveling rod.

Route	From	To	No. of level setup	Measured difference in elevation (m)	Elevation (m)
R_1	BM ₁	A	12	+ 1.660	BM ₁ =31.8 m
R_2	BM ₂	A	6	- 0.074	BM ₂ =33.5 m

The field data for route R_3 are:

Route	Level setup	Observed points	Rod reading (m)	Elevation (m)
R_3	1	BM ₃	1.568	32.6
		TP ₁	2.372	
	2	TP ₁	1.825	
		A	0.182	

Compute the adjusted (Most Probable Value) elevation of point A and its standard error.

The answer :

(17 marks)

Point	B.S	ELS	FS	Elevation (m)
BM3	1.568	34.168		32.6
TP1	1.825	33.621	2.372	31.796
A	1.748		0.182	33.439=X3

$$Y = \frac{X_1 * P_1 + X_2 * P_2 + X_3 * P_3}{P_1 + P_2 + P_3}$$

$$P_1 = \frac{1}{12}, P_2 = \frac{1}{6}, P_3 = \frac{1}{2}$$

$$X_1 = 33.46$$

$$X_2 = 33.426$$

$$Y = \frac{33.46 * \frac{1}{12} + 33.426 * \frac{1}{6} + 33.439 * \frac{1}{2}}{\frac{1}{12} + \frac{1}{6} + \frac{1}{2}} = 33.438 \text{ m}$$

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

$$v_1 = 33.438 - 33.46 = -0.022$$

$$v_2 = 33.438 - 33.426 = 0.012$$

$$v_3 = 33.438 - 33.439 = -0.001$$

$$\delta_{xi} = \pm \sqrt{\frac{\sum P v^2}{n-1}} = \pm 0.00569 \text{ m}$$

$$\delta \bar{x} = \pm \frac{\delta_{xi}}{\sqrt{P_1 + P_2 + P_3}} = \pm 0.0065 \text{ m}$$

B- Simple circular horizontal curve having a radius $R=137 \text{ m}$, the deflection angle $\Theta = 64^\circ$, and PI station = 12+40. **Compute the [PC, PT] stations.**

(8 marks)

The answer :

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

$$T = 137 \tan \frac{64}{2} = 85.607 \text{ m}$$

$$L = R \theta_{rad} = 137 \times 64 \times \frac{\pi}{180} = 153.030 \text{ m}$$

$$\text{Station PC} = \text{Station PI} - T = 1240 - 85.607 = 1154.393 = 11 + 54.393$$

$$\text{Station PT} = \text{Station PC} + L = 1154.393 + 153.030 = 1307.423 = 13 + 07.423$$

Q3) A- The following table represent the field data for the traverse [KAB] using theodolite and steel tape:

Measured Horizontal angle to the right	Measured Horizontal distance (m)
< KAB=85°32'15"	KA=123.568
	AB=75.214

Knowing that: Azimuth of the line KA = $AZ_{KA} = 136^\circ 15' 28''$

$$X_K = 263.845 \text{ m}, Y_K = 384.734 \text{ m}$$

1- Compute the horizontal (X,Y) coordinates of points [A,B]

The answer :

$$AZ_{AB} = AZ_{AK} + \angle KAB = 136^\circ 15' 28'' + 85^\circ 32' 15'' = 401^\circ 47' 43'' - 360 = 41^\circ 47' 43''$$

$$X_A = X_K + D_{AK} \sin AZ_{KA}$$

$$X_A = 263.845 + 123.568 \sin 136^\circ 15' 28'' = 349.281 \text{ m}$$

$$Y_A = Y_K + D_{AK} \cos AZ_{KA}$$

$$Y_A = 384.734 + 123.568 \cos 136^\circ 15' 28'' = 295.461 \text{ m}$$

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

$$X_B = 349.281 + 75.214 \sin 41^\circ 47' 43'' = 399.408 \text{ m}$$

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

$$Y_B = 295.461 + 75.214 \cos 41^\circ 47' 43'' = 351.535 \text{ m}$$

2- Compute the horizontal distance (KB) and its direction (AZ_{KB}).

The answer :

$$D_{KB} = \sqrt{\Delta X^2 + \Delta Y^2} = \sqrt{(399.408 - 263.845)^2 + (351.535 - 384.734)^2} = 139.568 \text{ m}$$

$$AZ_{KB} = \tan^{-1} \frac{\Delta X}{\Delta Y} = \tan^{-1} \frac{399.408 - 263.845}{351.535 - 384.734} = 103^\circ 45' 38.6''$$

3- Compute the Horizontal angle to the right $\angle BKA$.

The answer :

$$\text{Horizontal angle to the right } \angle BKA = AZ_{KA} - AZ_{KB} = 136^\circ 15' 28'' - 103^\circ 45' 38.6'' = 32^\circ 29' 49.4''$$

4- Compute the deflection angle $\angle ABK$.

The answer :

$$\text{Horizontal angle to the right } \angle ABK = 180^\circ - \angle BKA - \angle KAB$$

$$= 180^\circ - 32^\circ 29' 49.4'' - 85^\circ 32' 15'' = 61^\circ 57' 55.1''$$

$$\text{the deflection angle } \angle ABK = 180^\circ - 61^\circ 57' 55.1'' = 118^\circ 2' 4.9''$$

B- The following table represent the field data for topographic surveying by the radiation method using theodolite and leveling rod.

Theodolite Station	Observed Station	V. C. R	Rod reading (m)			Elevation (m)
			U	M	L	
A	K	87° 26' 25"		1.85		32.650
	B	274° 32' 15"	1.9	1.25	0.6	

Knowing that: the Horizontal distance $AK = 76.385 \text{ m}$.

Compute the elevation (Z) of point (B).

The answer :

$$D_{AB} = K S \cos \phi^2 = 100 * (1.9 - 0.6) * \cos (274^\circ 32' 15'' - 270)^\circ = 129.186 \text{ m}$$

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

$$= 1.85 - 76.385 * \tan(90 - 87^\circ 26' 25'') = -1.564 \text{ m}$$

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

$$= 1.25 - 129.186 * \tan(274^\circ 32' 15'' - 270) = -9.002 \text{ m}$$

$$\text{Elev. B} = \text{Elev. K} + BS - FS$$

$$\text{Elev. B} = 32.650 + (-1.564) - (-9.002) = 40.088 \text{ m}$$

Q4)A- The following table represent the final cross-section for a road having bed width $b=12 \text{ m}$.

Station	Cross-section		
	Left	C.L	Right
14+50	C1.3	C2.7	C1.6
	8.6	0.0	9.2

Compute the area of the cross-section using the coordinates method.

The answer :

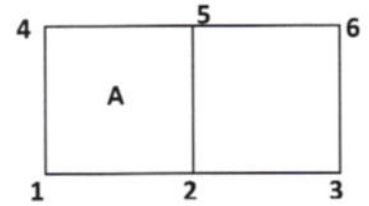
X	Y
6	0
9.2	1.6
0	2.7
-8.6	1.3
-6	0

$$A_{14+50} = \frac{1}{2} \sum_{j=1}^5 y_j (x_{j+1} - x_{j-1})$$

$$A_{14+50} = \frac{1}{2} [1.6 \times (0 - 6) + 2.7 \times (-8.6 - 9.2) + 1.3 \times (-6 - 0)] = 32.73 \text{ m}^2$$

B- The following table represent the ground elevation of the point of the (25 m × 25 m) grid shown in the figure below.

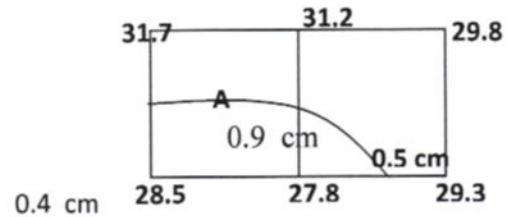
Point	1	2	3	4	5	6
Elevation (m)	28.5	27.8	29.3	31.7	31.2	29.8



- a) Draw the contour line with elevation= 29.0 m using a horizontal scale = 1/1000.

(9 marks)

The answer :



ابعاد المربع على الارض = 25 × 25

ابعاد المربع على الخارطة:

$$1/1000 = X/25$$

$$X = 2.5 \text{ cm}$$

- b) Compute the final elevation required to level the ground into a horizontal plane at which the volume of cut = volume of fill.

The answer :

$$\bar{Z}_G = \frac{\sum_{i=1}^K (Z_i * n_i)}{4 * m}$$

$$\bar{Z}_G = \frac{\sum_{i=1}^9 (Z_i * n_i)}{4 * m}$$

$$\bar{Z}_G = \frac{(n_1 * Z_1) + (n_2 * Z_2) + (n_3 * Z_3) + (n_4 * Z_4) + (n_5 * Z_5) + (n_6 * Z_6) + (n_7 * Z_7) + (n_8 * Z_8) + (n_9 * Z_9)}{n_1 + n_2 + n_3 + n_4 + n_5 + n_6 + n_7 + n_8 + n_9}$$

$$\bar{Z}_G = \frac{P_1 Z_1 + P_2 Z_2 + \dots + P_9 Z_9}{P_1 + P_2 + \dots + P_9}$$

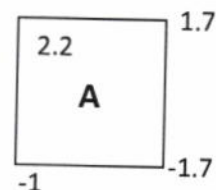
$$P_1 = n_1 = 1, P_2 = n_2 = 2, P_3 = n_3 = 1, P_4 = n_4 = 2, P_5 = n_5 = 4, P_6 = n_6 = 2, P_7 = n_7 = 1,$$

$$P_8 = n_8 = 2, P_9 = n_9 = 1$$

$$\therefore \bar{Z}_G = \frac{(1 * 31.7) + (2 * 31.2) + (1 * 29.8) + (1 * 28.5) + (2 * 27.8) + (1 * 29.3)}{1 + 2 + 1 + 1 + 2 + 1}$$

$$\bar{Z}_G = 29.662m$$

- c) Compute the volumes of earthwork (cut, fill) that is required to level sub grid A into elevation 29.5 m.
d) **The answer :**



$$V_{F4} = \frac{[1 + 1.7]^2}{[2.2 + 1.7 + 1 + 1.7]} * \frac{25 * 25}{4} = 172.585m^3$$

$$V_{C4} = \frac{[2.2 + 1.7]^2}{[2.2 + 1.7 + 1 + 1.7]} * \frac{25 * 25}{4} = 360.085m^3$$

Q5)

A- The following table represents the field data for a part of profile leveling along the center line of a road:-

Level Setup	Observed Station	Rod Reading (m)
1	0+00	1.385
	0+10	2.456
	0+25	0.842
	BM1	1.360
2	BM1	0.673
	0+50	2.473

	1+00	1.328
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Knowing that: The elevation of BM1 = 31.562 m

The grade elevation of Station 0+25 = 31.43 m

The proposed center line has gradient = +2%

Compute the amount of cut or fill for all Center Line stations.

The answer :

Station	BS	ELS	IFS	Ground elev.	Grade elev,	Cut	Fill
BM1	1.360			31.562			
0+00			1.385	31.537	30.93	0.607	
0+10		32.922	2.456	30.466	31.13		0.664
0+25			0.842	32.08	31.43	0.65	
BM1	0.673			31.562			
0+50		32.235	2.473	29.762	31.93		-2.168
1+00			1.328	30.907	32.93		-2.023

B- Two grade lines having gradients of $g_1 = +1.85\%$, $g_2 = -3.65\%$ to be connected by a symmetrical parabolic vertical curve.

Knowing that the BVC station = 11+75, the elevation of the vertex (V) = $Z_V = 27.5$ m, station V = 12+35.

Compute the elevation of stations (12+00), (12+60) on the curve.

The answer :

$$B.V.C = V - \frac{L}{2} = 1235 - \frac{L}{2} = 11.75$$

$$L = 120$$

$$r = \frac{g_2 - g_1}{L} = \frac{-3.65}{100} - \frac{1.85}{100} = -0.00045 \quad \text{or} \quad -4.58 \times 10^{-4}$$

$$Z_V = Z_{B.V.C} + \left(g_1 \times \frac{L}{2} \right)$$

$$\therefore Z_{B.V.C} = Z_V - \left(g_1 \times \frac{L}{2} \right) = 27.5 - \left(\frac{1.85}{100} \times \frac{120}{2} \right) = 26.39m$$

Station	X_i (m)	$g_1 X_i$ (m)	$1/2 r X_i^2$ (m)	Curve Elevation Z_i (m)
BVC = 11+75	0.0	0.0	0.0	26.39
12+00	25	0.4625	-0.143125	26.7094
12+60	85	1.5725	1.6545-	26.308