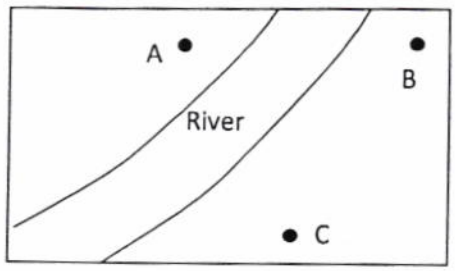
University of Technology
Engineering Department of Building and Construction
Final Exam 2013-2014

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 m, 162.206 m, 162.124 m, 162.218 m
Horizontal Angle to the right $\prec ACB = 85^\circ\ 24'\ 35'' \mp 32''$



Theodolite station	Observed station	Telescope	H.C.R
B	C	D	65°16'"05
	C	R	245°16'25"
	A	D	95°23'35"
	A	R	275°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 $\prec CBA$ 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 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. **(17 marks)**

B- Simple circular horizontal curve having a radius R=137 m, the deflection angle Θ= 64°, 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)
≺KAB=85°32'15"	KA=123.568
	AB=75.214

Knowing that: Azimuth of the line KA = AZ_{KA}=136°15'28"
X_K=263.845 m, Y_K=384.734 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 ≺BKA. **(3 marks)**
4- Compute the deflection 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	

Knowing that: the Horizontal distance AK= 76.385m. **(7 marks)**

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.

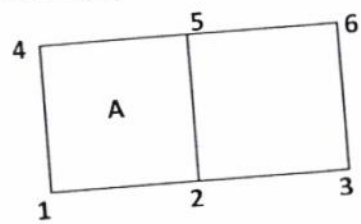
Station	Cross –section		
	Left	C.L	Right
14+50	$\frac{C1.3}{8.6}$	$\frac{C2.7}{0.0}$	$\frac{C1.6}{9.2}$

(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



a) Draw the contour line with elevation= 29.0 m using a horizontal scale =1/1000. **(9 marks)**

b) Compute the final elevation required to level the ground into a horizontal plane at which the volume of cut = volume of fill. **(4 marks)**

c) 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 apart 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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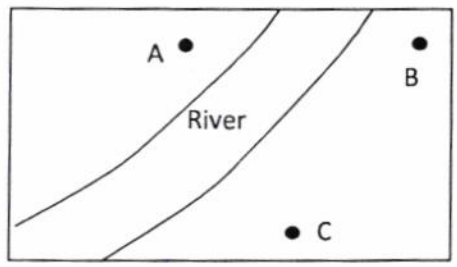
Horizontal Angle to the right $\prec ACB = 85^\circ\ 24'\ 35'' \mp 32''$



Theodolite station	Observed station	Telescope	H.C.R
B	C	D	65°16'"05
	C	R	245°16'25"
	A	D	95°23'35"
	A	R	275°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 $\prec CBA$ and its standard error.

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

The answer :

$x_1 = CBA1 = 95^O23'35"\text{-}65^O16'05" = 30^O07'30"$

$x_2 = CBA2 = 275^o23'45"\text{-}245^o16'25" = 30^o07'20"$

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

$$CBA = \frac{30^o07'30" + 30^o07'20"}{2} = 65^o25'25"$$

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

$$v_1 = 65^o25'25\text{-}30^o07'30 = -5"$$

$$v_2 = 65^o25'25"\text{-}30^o07'30" = 5"$$

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

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

C- Compute the horizontal distance [AC].

The answer :

$$\measuredangle BAC = 180 - 65^o25'25" - 85^\circ\ 24'\ 35'' = 29^\circ\ 10'\ 00''$$

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

$$D_{AC} = \frac{D_{BC} \times \sin \measuredangle CBA}{\sin \measuredangle BAC} = \frac{162.1753 \times \sin 65^o25'25"}{\sin 29^\circ\ 10'\ 00''} = 302.622 \text{ m}$$

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. **(17 marks)**

The answer :

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

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

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

X1=33.46

X2= 33.426

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

$v_i = \bar{x} - x_i$

$v_1 = 33.438 - 33.46 = -0.022$

$v_2 = 33.438 - 33.426 = 0.012$

$v_3 = 33.438 - 33.439 = -0.001$

$$\delta_{xi} = \pm\sqrt{\frac{\sum Pv^2}{n-1}} = \pm 0.017\ m$$

$$\delta\bar{x} = \pm\frac{\delta_{xi}}{\sqrt{P_1 + P_2 + P_3}} = \pm 0.019\ m$$

B- Simple circular horizontal curve having a radius R=137 m, the deflection angle Θ= 64°, and PI station = 12+40. **Compute the [PC, PT] stations.**

(8 marks)

The answer :

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

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

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

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

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

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°15'28"

X_K=263.845 m, Y_K=384.734 m

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

The answer :

$AZ_{AB} = AZ_{AK} + \sphericalangle KAB = 316^O15'28"+85^O32'15=401^O47'43 - 360 = 41^O47'43"$

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

$X_A = 263.845 + 123.568\sin 136^O15'28 = 349.281\ m$

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

$Y_A = 384.734 + 123.568 \cos 136^O 15'28 = 295.461\ m$

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

$X_B = 349.281 + 75.214 \sin 41^O 47'43" = 399.408\ m$

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

$Y_B = 295.461 + 75.214 \cos 41^O 47'43" = 351.535\ m$

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

The answer :

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

$$AZ_{KB} = \tan^{-1}\frac{\Delta X}{\Delta Y} = \tan^{-1}\frac{399.408 - 263.845}{351.535 - 384.734} = 103^O45'38.6"$$

3- Compute the Horizontal angle to the right <BKA.

The answer :

Horizontal angle to the right $\prec BKA = AZ_{KA} - AZ_{KB} = 136^O15'28 - 103^O45'38.6" = 32^O29'49.4"$

4- Compute the deflection angle <ABK.

The answer :

Horizontal angle to the right $\prec ABK = 180 - \prec BKA - \prec KAB$

$= 180 - 32^O29'49.4" - 85^O32'15 = 61^O57'55.1"$

the deflection angle $\prec ABK = 180 - 61^O57'55.1" = R118^O2'4.9"$

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= 76.385m.

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

The answer :

$D_{AB} = K\,S\,\cos\emptyset^2 = 100 * (1.9 - 0.6) * \cos(274^O32'15" - 270)^2 = 129.186\ m$

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

$= 1.85 - 76.385 * \tan(90 - 87^O26'25") = -1.564\ m$

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

$= 1.25 - 129.186 * \tan(274^O32'15" - 270) = -9.002\ m$

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

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

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	$\frac{C1.3}{8.6}$	$\frac{C2.7}{0.0}$	$\frac{C1.6}{9.2}$

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

The answer :

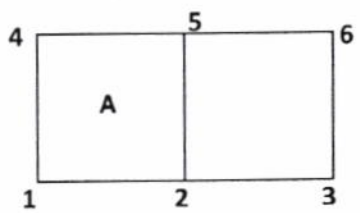
X	Y
6	0
9.2	1.6
0	2.7
-8.6	1.3
-6	0

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

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

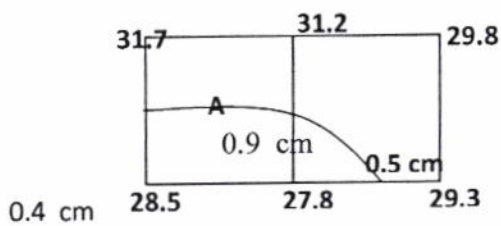
B- The following table represent the ground elevation of the point of the (25 m × 25 m) grid shown in the figure below.

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 x 25

ابعاد المربع على الخارطة:

1/1000=X/25

X=2.5 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 :

$$\overline{Z_G} = \frac{\sum_{i=1}^{K}(Z_i * n_i)}{4*m}$$

$$\overline{Z_G} = \frac{\sum_{i=1}^{9}(Z_i * n_i)}{4*m}$$

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

$$\overline{Z_G} = \frac{P_1Z_1+P_2Z_2+.....+P_9Z_9}{P_1+P_2+.....+P_9}$$

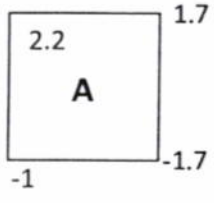
$$P_1=n_1=1, P_2=n_2=2, P_3=n_3=1, P_4=n_4=2, P_5=n_5=4, P_6=n_6=2, P_7=n_7=1,$$
$$P_8=n_8=2, P_9=n_9=1$$

$$\therefore \overline{Z_G} = \frac{(1*31.7)+(2*31.2)+(1*29.8)+(1*28.5)+(2*27.8)+(1*29.3)}{1+2+1+1+2+1}$$

$$\overline{Z_G} = 29.662m$$

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 apart 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%

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 :

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

$$L = 120$$

$$r = \frac{g_2 - g_1}{L} = \frac{\frac{-3.65}{100} - \frac{1.85}{100}}{120} = -0.00045 \quad or \quad -4.58 \times 10^{-4}$$

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

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

Station	X_i (m)	g1 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	-0.28625	26.566
12+60	85	1.5725	-3.25125	24.71125