MAD 256 – SURVEYING **April 2nd, 2008**
1st MIDTERM EXAM – SOLUTIONS

(20 p) 1. a) Draw the broken line ABCD according to the followings (use the scale 1/2500);

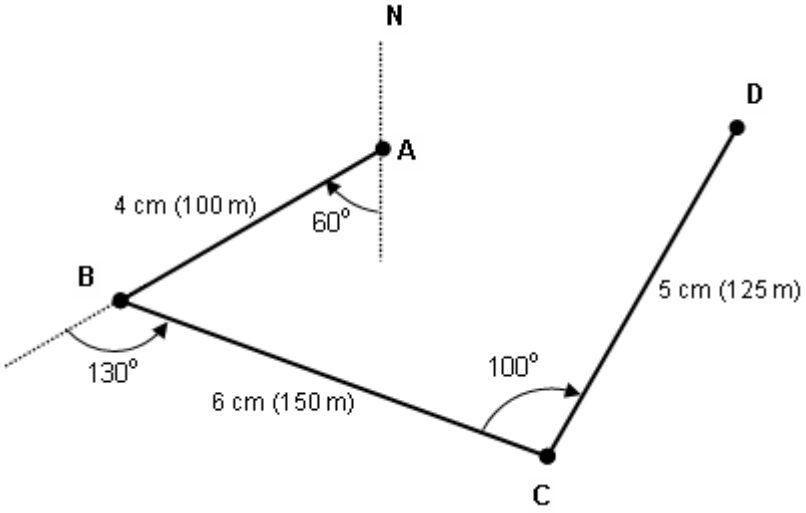
Bearing of AB	= S 60° W	Length of AB = 100 m
Deflection at B	= 130° L	Length of BC = 150 m
Angle to right at C	= 100°	Length of CD = 125 m

b) Find;

Azimuth of BC = ? Bearing of CD = ?

SOLUTION :

Length of AB = 10000/2500 = 4 cm
Length of BC = 15000/2500 = 6 cm
Length of CD = 12500/2500 = 5 cm



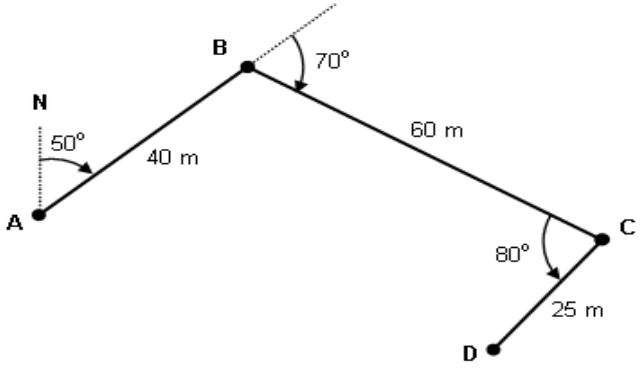
b) Azimuth of BC = Azimuth BA + (180°-130°) = 60°+50° = **110°**

To find the bearing of CD, find its azimuth first.

Azimuth of CD = Azimuth BC + 100°-180°) = 110°-80° = 30°, then

Bearing of CD = **N 30° E**

(20 p) 2. According to the figure, determine the distance between the points A and D.



SOLUTION :

To determine the distance, first we have to determine the departures (ΔE) and latitudes (ΔN) of each lines. Then;

Distance AD = $[(\Delta E_{AD})^2+(\Delta N_{AD})^2]^{1/2}$

Azimuth AB = 50°, Azimuth BC = 50+70 = 120°, Azimuth CD = 120+(180-80) = 220°

Departure of a line, ΔN=Line length*sin (azimuth)	Latitude of a line, ΔE=Line length*cos (azimuth)
Departure of AB = 40*sin 50° = 30.64 m	Latitude of AB = 40*cos 50° = 25.71 m
Departure of BC = 60*sin 120° = 51.96 m	Latitude of BC = 60*cos 120° = -30 m
Departure of CD = 25*sin 220° = -16.07 m	Latitude of CD = 25*cos 220° = -19.15 m

Departure of AD = 30.64+51.96+(-16.07) = 66.53 m
Latitude of AD = 25.71+(-30)+(-19.15) = -23.44 m
Distance AD = $[(66.53)^2+(-23.44)^2]^{1/2}$ = $[4975.67]^{1/2}$ = **70.54 m**

(10 p) 3. The true length of a 30 m tape is 29.98 m. The sides of a rectangular field were measured as 162 m and 346 m. Determine the correct area of the field in m^2.

SOLUTION :

The true length of 162 m. = (162/30)*29.98 = 161.89 m
The true length of 346 m. = (346/30)*29.98 = 345.77 m
The true area of the field = 161.89*345.77 = **55976.71 m^2**

(10 p) 4. Determine the missing parameters in the following questions.

a) Map distance of AB = 12 cm
Field distance of AB = 6 km
The scale of the map = ??

b) The scale of the map = 1/1000000
Field distance of CD = 7200 m
Map distance of CD = ?? mm

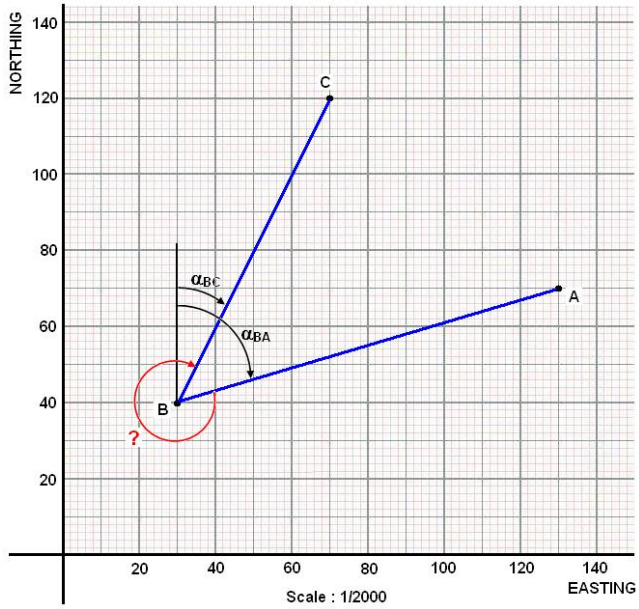
SOLUTION :

a) Scale = Map length/Field length = 12 cm / 600000 cm = **1/50000**
b) Map length = Field length/Scale = 7200000 mm / 1000000 = **7.2 mm**

(20 p) 5. The coordinates of the points ABC (a broken line) are given. Determine the angle to right at point B in degree unit.

	Coordinates (m)	
Point	Easting	Northing
A	130	70
B	30	40
C	70	120

SOLUTION :



Angle to right at point B can be determined after finding azimuth angles of the lines BC and BA. Then;

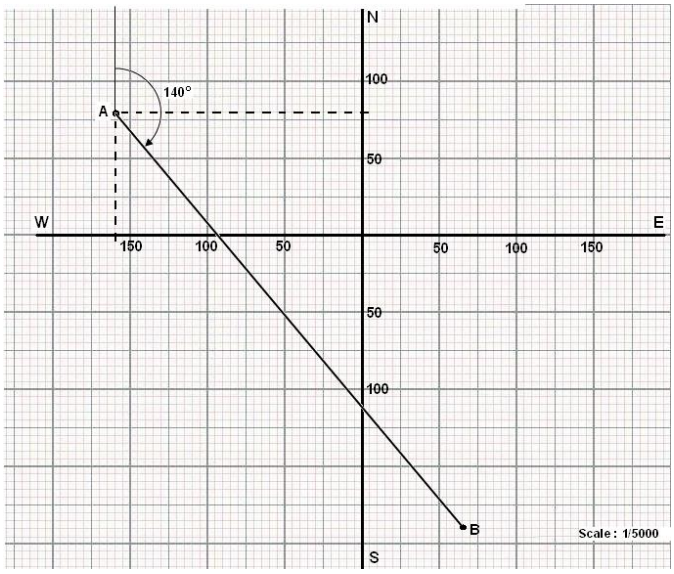
$\alpha_{BC} = \tan^{-1}(\Delta E/\Delta N) = \tan^{-1}[(E_c-E_B)/(E_c-E_B)]$
$= \tan^{-1}[(70-30)/(120-40)] = \tan^{-1}(40/80) = 26.56^o$

$\alpha_{BA} = \tan^{-1}(\Delta E/\Delta N) = \tan^{-1}[(E_A-E_B)/(E_A-E_B)]$
$= \tan^{-1}[(130-30)/(70-40)] = \tan^{-1}(100/30) = 73.30^o$

Angle to right at B = $(\alpha_{BC}-\alpha_{BA}) + 360^o$
$= (26.56^o-73.30^o) + 360^o =$ **313.26^o**

(10 p) 6. Easting and Northing of point A is -160 m and 80 m respectively. The length of line AB is 250 m and its azimuth is 140^o. Determine the co-ordinates (Easting, Northing) of point B.

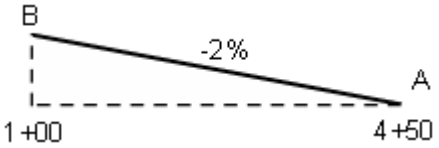
SOLUTION :



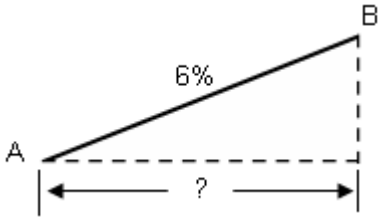
Departure of AB = 350*sin 140^o = 224.98 m
Easting of B = Easting of A + Dep.AB
= -160+224.98 = **64.98 m**

Latitude of AB = 350*cos 140^o = -268.12 m
Northing of B = Northing of A + Lat.AB
= 80 + (-268.12) = **-188.12 m**

(10 p) 7. Determine the missing parameters in the following questions.



a) Elevation of point A = 182 m
Elevation of point B = ??



b) Elevation of point B = 468 m
Elevation of point A = 417 m
Horizontal distance of AB = ??

SOLUTION :

a) Elevation difference between B and A = (450-100)*(-2/100) = -7 m
Elevation A = Elevation B + Difference ➔ 182 = El.B-7 then El.B = 182+7 = **189 m**

b) Elevation difference between A and B = 468-417 = 51 m
Elevation diff. = Horizontal distance*Grade ➔ Hor.dist. = 51*(100/6) = **850 m**

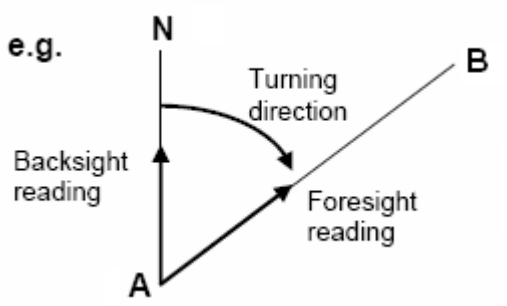
MAD 256 – SURVEYING **May 8th, 2008**
2nd MIDTERM EXAM – SOLUTIONS

(40 p) 1. Courses of an open traverse are measured. Foresight readings are taken after backsight ones by turning the instrument in clockwise direction. The readings are given in te following table. Determine;

a) The parameters missing in the table.

b) Distance between the points A and E.

c) The azimuth angle of course EA.



Pnt	Course	Length (m)	Backsight reading (gon)	Foresight reading (gon)	Angle to the right (gon)	Azimuth (gon)	Departure (m)	Latitude (m)	Easting (m)	Northing (m)
A			-	-	-				0.00	0.00
	AB	35				236	-18.75	-29.55		
B			340	52	112				-18.75	-29.55
	BC	58				148	42.28	-39.70		
C			140	264	124				23.53	-69.25
	CD	24				72	21.72	10.22		
D			82	216	134				45.25	-59.03
	DE	86				6	8.09	85.62		
E									53.34	26.59

86 GIVEN PARAMETERS

SOLUTION :

Angle to right at a point = Foresight reading-Backsight reading (Add 400^g if negative)
Angle to right at point B = (52-340)+400 = 112^g
Angle to right at point C = 264-140 = 124^g
Angle to right at point D = 216-82 = 134^g

Azimuth angle of a course = Azimuth angle of previous course+Angle to right
The result of this equation is checked according to table given in Basic Problem 3
Azimuth angle of BC = Azimuth angle of AB+Angle to right =236+112 =348-200 = 148^g
Azimuth angle of CD = Azimuth angle of BC+Angle to right =148+124 =272-200 = 72^g
Azimuth angle of DE = Azimuth angle of CD+Angle to right =72+134 =206-200 = 6^g

$Dep.AB = S_{AB} * Sin(Az_{AB}) = 35*Sin(236^g) = -18.75$ m. $Lat.AB = S_{AB} * Cos(Az_{AB}) = 35*Cos(236^g) = -29.55$ m.
$Dep.BC = S_{BC} * Sin(Az_{BC}) = 58*Sin(148^g) = 42.28$ m. $Lat.BC = S_{BC} * Cos(Az_{BC}) = 58*Cos(148^g) = -39.70$ m.
$Dep.CD = S_{CD} * Sin(Az_{CD}) = 24*Sin(72^g) = 21.72$ m. $Lat.CD = S_{CD} * Cos(Az_{CD}) = 24*Cos(72^g) = 10.22$ m.
$Dep.DE = S_{DE} * Sin(Az_{DE}) = 86*Sin(6^g) = 8.09$ m. $Lat.DE = S_{DE} * Cos(Az_{DE}) = 86*Cos(6^g) = 85.62$ m.

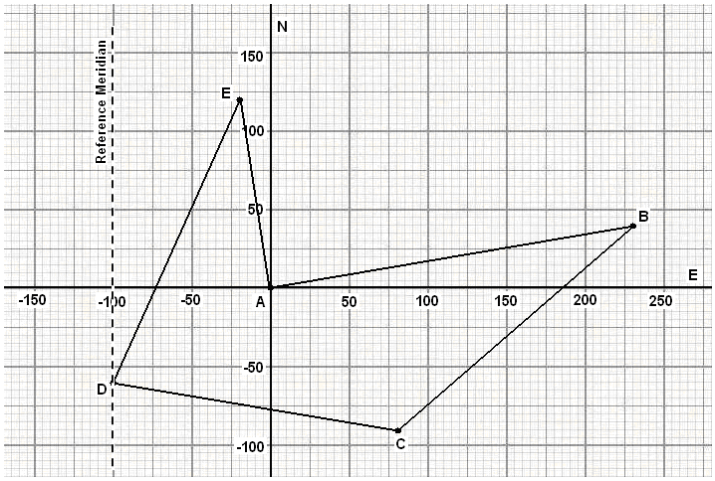
$E_B = E_A + Dep.AB = 0 + (-18.75) = -18.75$ m. $N_B = N_A + Lat.AB = 0 + (-29.55) = -29.55$ m.
$E_C = E_B + Dep.BC = -18.75+42.28 = 23.53$ m. $N_C = N_B + Lat.BC = -29.55-39.70 = -69.25$ m.
$E_D = E_C + Dep.CD = 23.53 + 21.72 = 45.25$ m. $N_D = N_C + Lat.CD = -69.25+10.22 = -59.03$ m.
$E_E = E_D + Dep.DE = 45.25+8.09 = 53.34$ m. $N_E = N_D + Lat.DE = -59.03+85.62 = 26.59$ m.

b) Distance between the points A and E = $[(E_E-E_A)^2+(N_E-N_A)^2]^{1/2} = [(53.34-0)^2+(26.59-0)^2]^{1/2} = 59.60$ m

c) The azimuth angle of AE = $\tan^{-1}[(E_A-E_E)/(N_A-N_E)] = \tan^{-1}[(0-53.34)/(0-26.59)] = 70.56^g+200 = 270.56^g$

(40 p) 2. The coordinates of the points of a five sided polygon are given. Determine the area of this polygon by using DMD method.

Point	Coordinates (m) Easting	Northing
A	0	0
B	230	40
C	80	-90
D	-100	-60
E	-20	120



SOLUTION :

Point D has the lowest Easting value that shows the most westerly point. Therefore reference meridian passes through D. Now, we determine departure and latitude values of the sides.

Departure of DE = $E_E - E_D$

Dep.of DE = -20-(-100) = +80 (≡ E80) ...m
Dep.of EA = 0-(-20) = +20 (≡ E20) ...m
Dep.of AB = 230-0 = +230 (≡ E230) ...m
Dep.of BC = 80-230 = -150 (≡ W150) ...m
Dep.of CD = -100-80 = -180 (≡ W180) ...m

Total departure = +330-330 = 0, also ΣE=ΣW

Latitude of DE = $N_E - N_D$

Lat.of DE = 120-(-60) = +180 (≡ N180) ...m
Lat.of EA = 0-120 = -120 (≡ S120) ...m
Lat.of AB = 40-0 = +40 (≡ N40) ...m
Lat.of BC = -90-40 = -130 (≡ S130) ...m
Lat.of CD = -60-(-90) = +30 (≡ N30) ...m

Total latitude = +250-250 = 0, also ΣN=ΣS (check ok)

Departure of DE	= + 80	= ***DMD of DE***
Departure of DE	= + 80	
Departure of EA	= + 20	
	+ 180	= ***DMD of EA***
Departure of EA	= + 20	
Departure of AB	= + 230	
	+ 430	= ***DMD of AB***
Departure of AB	= + 230	
Departure of BC	= - 150	
	+ 510	= ***DMD of BC***
Departure of BC	= - 150	
Departure of CD	= - 180	
	+ 180	= ***DMD of CD*** Checking done

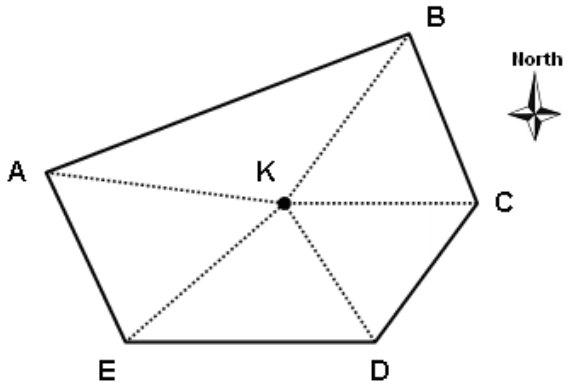
Course	Latitude	Departure	DMD	Double Areas +	Double Areas -
DE	N 180	E 80	+ 80	14400	
EA	S 120	E 20	+ 180		21600
AB	N 40	E 230	+ 430	17200	
BC	S 130	W 150	+ 510		66300
CD	N 30	W 180	+ 180	5400	
Total	0.00	0.00		37000	87900

Double area = Absolute(37000-87900) = 50900 m^2

Area of the field = 50900/2 = 25450 m^2

(20 p) 3. A theodolite was set up at point K that is within the limits of a five-sided property. Azimuth angles and distances to the property corners were determined as follows. Determine the area of the property by using triangulation method as Area of a triangle=1/2*s_1*s_2*sin α.

Course	Azimuth	Distance (m)
KA	320^g	64
KB	45^g	51
KC	108^g	46
KD	176^g	40
KE	257^g	52



SOLUTION :

Area of triangle AKB = [64*51*sin((400-320)+45)]/2 = 1507.77 m^2
Area of triangle BKC = [51*46*sin(108-45)]/2 = 980.40 m^2
Area of triangle CKD = [46*40*sin(176-108)]/2 = 806.20 m^2
Area of triangle DKE = [40*52*sin(257-176)]/2 = 994.03 m^2
Area of triangle EKA = [52*64*sin(320-257)]/2 = 1390.78 m^2

AREA OF PROPERTY = 5679.18 m^2

MAD 256 – SURVEYING **May 30th, 2008**
FINAL EXAM – SOLUTIONS

(10 p) 1. The interior angles of a triangle are measured as 75°12'16", 38°29'45" and 66°17'38". Determine the error in this measurement and then correct the angles.

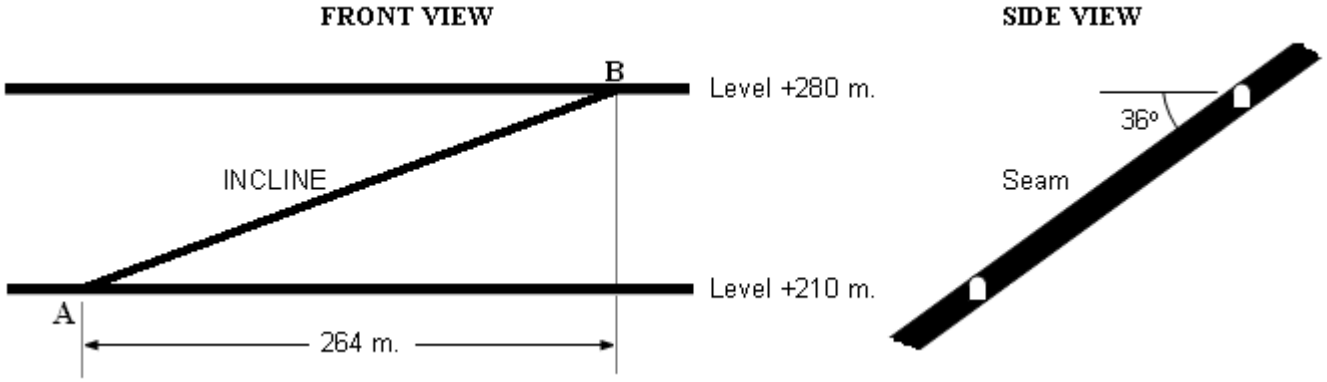
SOLUTION :

Total measured angle = 75°12'16"+38°29'45"+66°17'38" = 179°59'39"
Error = measured-true = 179°59'39"-180° = 179°59'39"-179°59'60" = -21"
Correction for each = -error/3 = -(-21"/3) = +7"
Corrected angles;

75°12'16"+7" = 75°12'23"
38°29'45"+7" = 38°29'52"
66°17'38"+7" = 66°17'45"
---
sum 179°58'120"=179°60' = 180°

(10 p) 2. As seen from the figure, two level drifts in an inclined coal seam are connected at points A and B with an inclined drift. Determine:

a) Apparent dip of the incline AB,
b) True length of the incline AB.



SOLUTION :

a) Vertical distance between levels = 280-210 = 70 m.
Horizontal distance between levls = 70/tan 36° = 96.35 m
Apparent length of incline = $(264^2 + 96.35^2)^{1/2}$ = 281.03 m.
Apparent dip of incline = $\tan^{-1}(70/281.03) \cong 14^o$
b) True length of the incline AB = $(70^2 + 281.03^2)^{1/2}$ = 289.62 m.

(10 p) 3. If the following data were obtained from a trigonometric leveling measurement, determine the elevation at point B.

Elevation of point A = 428 m. Vertical angle, α = -32° Distance to rod, S = 90 m.
Height of instrument, h_i = 1.32 m. Rod Reading, RR = 2.56 m.

SOLUTION :

Elevation of point B = 428 +1.32 +90*sin (-32) -2.56 = 379.07 m.

(10 p) 4. Following measures were obtained from a triangular property with the corners A, B and C. Determine its area in m^2 by using $S=1/2*a*b*\sin\alpha$

Azimuth AB = 206° Azimuth AC = 253° Azimuth BC = 285° Side AB = 60 m.

SOLUTION :

Angle A = 253-206 = 47°
Angle B = (360-285) + (206-180) = 75+26 = 101°
Angle C = 180-(101+47) = 32°

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$ where a=BC, b=AC, c=AB then

BC = AB*(sin A/sin C) = 60*(sin 47/sin 32) = 60*0.73/0.53 = 60*1.38 = 82.81 m.
Area of ABC = 1/2*AB*BC*sin α = ½*60*82.81*sin 101 = 2484.3*0.982 = 2438.66 m^2

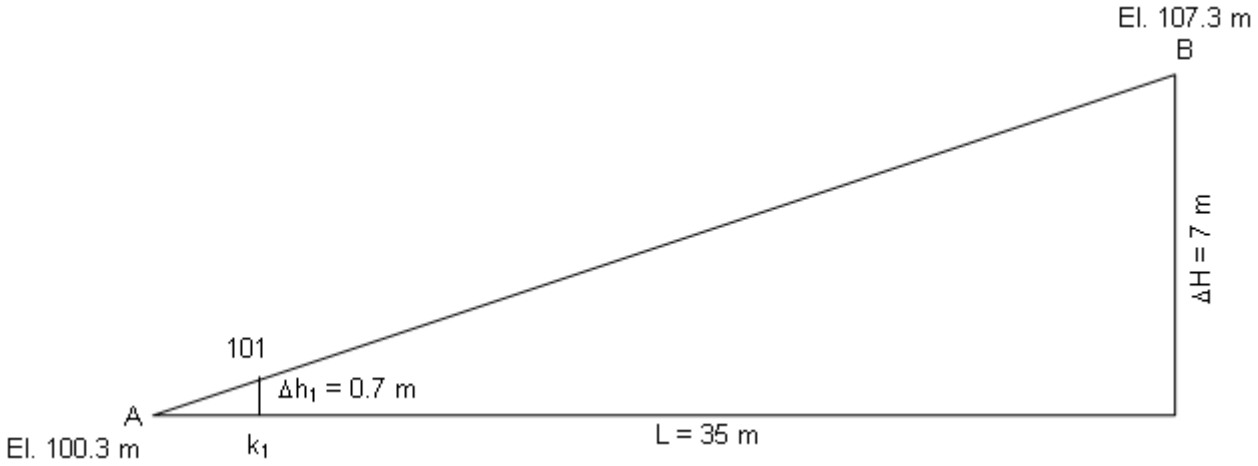
(15 p) 5. Points A and B have elevations 100.3 m and 107.3 m respectively. Horizontal distance between the points is 35 m. Determine the positions of elevation contours (101 m, 102 m, etc) on the horizontal line. That is their distances from point A.

SOLUTION :

For line AB:

7/35 = $\Delta h_1/k_1$ unknown k_1 can be easily computed.

k_1 = 0.7*(35/7) = 3.5 m. (for 101 contour)
k_2 = 1.7*(35/7) = 8.5 m. (for 102 contour)
k_3 = 2.7*(35/7) = 13.5 m. (for 103 contour)
k_4 = 3.7*(35/7) = 18.5 m. (for 104 contour)
k_5 = 4.7*(35/7) = 23.5 m. (for 105 contour)
k_7 = 5.7*(35/7) = 28.5 m. (for 106 contour)
k_8 = 6.7*(35/7) = 33.5 m. (for 107 contour)



(20 p) 6. Reduce the accompanying set of profile notes (HI, ΔH, Elevation) and perform the arithmetic check. (Show details of your calculations, write the results on table)

Station	BS (m)	HI (m)	IS (m)	FS (m)	ΔH (m)	Elevation (m)
BM 20	3.27	303.05				299.78
TP #1	4.21	304.66		2.60	0.67	300.45
0 + 00			3.30		0.91	301.36
0 + 50			2.60		0.70	302.06
0 + 80			3.71		-1.11	300.95
1 + 00			1.10		2.61	303.56
TP #2	2.33	305.33		1.66	-0.56	303.00
1 + 50			3.80		-1.47	301.53
2 + 00			2.97		0.83	302.36
BM 21				3.88	-0.91	301.45
TOTAL	**9.81**			**8.14**	**1.67**	

SOLUTION:

$\Delta H = BS-FS$ or $\Delta H = IS_{prev}-IS_{itself}$

HI at BM20 = 299.78+3.27 = 303.05
HI at TP#1 = 303.05-2.60+4.21 = 304.66
HI at TP#2 = 304.66-1.66+2.33 = 305.33 305.33-3.88 = 301.45 checked

Arithmetic check ➔ $\Sigma BS-\Sigma FS$ = 9.81-8.14 = 1.67 m. is equal to $\Sigma\Delta H$ = 1.67 m.
Also BM21-BM20 = 301.45-299.78 = 1.67 m.

(35 p) 7. A four sided closed traverse was measured and the following readings were obtained. The instrument was adjusted at a point, to find the interior angles, first foresight angle and next backsight angle were measured by turning the instrument in clockwise direction.

a) Calculate angular misclose and then adjust the interior angles.
b) Compute azimuth angles according to adjusted interior angles.
c) Compute the coordinates of each point starting with given coordinates of point A and find lineer misclose at point A.
d) Determine accuracy of the measurement.
e) Adjust departure (ΔE) and latitude (ΔN) for each side according to compass rule.
f) Determine corrected coordinates of the points.

Azimuth of AB = 60^g Northing of A : 120 m. Easting of A : -84 m.

Point	Foresight (grad)	Backsight (grad)	
A	362	65	Distance AB = 40 meter
B	218	327	Distance BC = 90 meter
C	103	151	Distance CD = 70 meter
D	372	116	Distance DA = 43 meter

SOLUTION:

a) First we find the interior angles. In general;
Interior angle=Backsight angle+Foresight angle (!Add 400^g if negative)
Interior angle at point A= (65-362)+400=103^g
Interior angle at point B= (327-218)=109^g
Interior angle at point C= (151-103)=48^g
Interior angle at point D= (116-372)+400=144^g
SUM OF THE INTERIOR ANGLES=103+109+48+144=404^g
Sum of these angles should satisfy 200*(n-2). Therefore;
200*(4-2) = 400^g Then **Angular misclose = 404^g-400^g = 4^g**
Correction for each interior angle= $-4^g/4= 1^g$ (equally distributed)
Adjusted interior angle at point A = 103^g–1^g= 102^g, and the similar calculations for the others.

b) Azimuth of AB= 60^g Azimuth of a side= Previous azimuth $\pm 200^g$-Interior angle
Az. BC= 60^g+200^g–108^g= 152^g Az. CD= 152^g+200^g–47^g= 305^g
Az. DA= 305^g+200^g–143^g= 362^g Az. AB= 362^g-200^g–102^g= 60^g **(to check)**

c) Departure = Side length * sin (Az.) Latitude = Side length * cos (Az.)

For AB, Dep.=40*sin 60	= 32.361 m.	Lat.=40*cos 60	= 23.511 m.
For BC, Dep.=90*sin 152	= 61.609 m.	Lat.=90*cos 152	= -65.607 m.
For CD, Dep.=70*sin 305	= -69.784 m.	Lat.=70*cos 305	= 5.492 m.
For DA, Dep.=43*sin 362	= -24.170 m.	Lat.=43*cos 362	= 35.564 m.

ΣDeparture = 0.016 m. ΣLatitude = -1.039 m. (Error in closure)
Linear misclose = $[(0.016)^2+(1.039)^2]^{1/2}$= **1.039 meter**
Computed Easting = Computed Easting of Previous Point+Departure= -84+32.361= -51.639 m.
Computed Northing = Computed Northing of Previous Point+Latitude= 120+23.511= 143.511 m.

d) **Accuracy =** 1 : (243/1.039)= **1:234**

e) Correction according to compass rule (Bodwitch Method)

For side AB;	Corr.for dep. = ΔDep.*length/total perimeter	= 40*(-0.016/243)	= -0.003 m.
	Corr.for lat. = ΔLat.*length/total perimeter	= 40*(1.039/243)	= 0.171 m.
For side BC;	Corr.for dep. = ΔDep.*length/total perimeter	= 90*(-0.016/243)	= -0.006 m.
	Corr.for lat. = ΔLat.*length/total perimeter	= 90*(1.039/243)	= 0.385 m.
For side CD;	Corr.for dep. = ΔDep.*length/total perimeter	= 70*(-0.016/243)	= -0.005 m.
	Corr.for lat. = ΔLat.*length/total perimeter	= 70*(1.039/243)	= 0.299 m.
For side DA;	Corr.for dep. = ΔDep.*length/total perimeter	= 43*(-0.016/243)	= -0.003 m.
	Corr.for lat. = ΔLat.*length/total perimeter	= 43*(1.039/243)	= 0.184 m.

Adjusted Departure =Departure+Correction for Departure = 32.361-0.003 = 32.358 m.
Adjusted Latitude =Latitude+Correction for Latitude = 23.511+0.171 = 23.682 m.

f) Adjusted E = Adjusted E of Previous Point+Adjusted Departure = -84.000+32.358= -51.642 m.
Adjusted N = Adjusted N of Previous Point+Adjusted Latitude = 120+23.682 = 143.682 m.

Pnt	Side	Length (m)	Fore sight (gon)	Back sight (gon)	Inter. angle (gon)	Adj. Inter. angle (gon)	Adjust. Azimuth (gon)	COMPUTED				ADJUSTED			
								Depar-ture (m)	Latitude (m)	Easting (m)	Northing (m)	Depar-ture (m)	Latitude (m)	Easting (m)	Northing (m)
A			362	65	103	102				-84,000	120,000			-84,000	120,000
	AB	40					60	32,361	23,511			32,358	23,682		
B			218	327	109	108				-51,639	143,511			-51,642	143,682
	BC	90					152	61,609	-65,607			61,603	-65,222		
C			103	151	48	47				9,970	77,904			9,961	78,460
	CD	70					305	-69,784	5,492			-69,789	5,792		
D			372	116	144	143				-59,814	83,396			-59,828	84,252
	DA	43					362	-24,170	35,564			-24,172	35,748		
A										-83,984	118,961			-84,000	120,000
SUM		243			404	400		0.016	-1.039			0.000	0.000		