Instructors Manual

for

Construction Surveying and Layout

Third Edition

Part Two - Officework and Calculations

Chapters 11-18

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Chapter 11 - Officework Practices

QUESTIONS AND PROBLEMS

1. Review a set of drawings and observe the line weights and types that are used.

Take any set of plans and observe the line weights that were used for the title block and order on the drawing. The will be the darkest lines on the page. Then look at the line weights on the main structure. They should be the darkest lines of the structure. Then look at the dimension lines and other lines, observing the thickness and darkness of the lines.

2. Draw horizontal and vertical guidelines on a sheet of paper and practice and improve your lettering.

3. List the basic information that should be shown on a site drawing.

North, Scale, graphical scale, legend of symbols, vicinity map, title block, existing contours, proposed contours, spot elevations, coordinates, direction and length of lines, description of monuments, road names, building outlines, building names, utilities, elevations, description of benchmarks,

4. State why a graphical scale should be used on all drawings.

The graphical scale shrinks or expands as a building is enlarged or reduced in size. Thus, it can always be used.

5. Review a site drawing and locate the dimensions needed to layout the building.

Any building or structure can be used here. A simple residential structure would be good for the inexperienced person. Identify the overall building dimensions that would be needed to set the outside corners of the building.

6. Develop a paper sheet size poster on how to care and maintain blueprints.

CARING FOR PRINTS HELPS THEM LAST LONGER

It isn't possible to keep blueprints in mint condition, but a few simple methods of caring for the prints will help them to last longer.

- Keep the prints clean by storing them inside the pickup and not in the pickup bed.
- Store the prints in a clean, dry place when not being use.
- Avoid using them in the rain if possible.
- If the project is large enough, build a print stand on the site to protect the prints from rain and dirt.
- While using prints, do not drink coffee or other drinks that could stain them.
- Only write on prints if permitted. Some jobs require prints to be turned in at the end of the job.
- Keep the prints out of the direct sunlight as they will fade over time.

7. Review a set of drawings for a small commercial project, looking at the C – Civil, S – Structural, A – Architectural, E – Electrical, M – Mechanical, and P – Plumbing drawings. Describe the similarities and differences in the drawings.

A small fast food building would be good for this exercise.

8. Review drawings from two different design firms, go through the drawings and prepare a sheet of the "Reading Guides" that are used on each set of drawings. Draw these guides on a sheet of paper and note the similarities and differences.

This is reader specific. Everyone has their own method.

9. Describe the process that you use to learn a set of drawings. Evaluate the effectiveness of your process and identify ways you could improve your blueprint reading ability.

This is reader specific. Everyone has their own method.

10. Describe why index contours are useful on topographic maps.

Index contours make it easy to determine the elevations of the ground. By only labeling index contours, the drawing is less cluttered.

11. List and describe the common characteristics of contours.

a. A contour on the ground closes on itself.

b. Contours are at right angles to the slope.

c. The ground is always higher on the same side of the contour.

d. Typically, contours won't cross each other.

e. Contours display flatness or steepness of the ground.

f. Contours point upstream when they cross the stream.

12. Describe why contours always point upstream when they approach and cross a river.

Water flows downhill. Therefore, as the contour crosses, the ground where the contour comes from is lower, causing the contour to come in from downstream, cross the water and then go towards the downstream again.

13. For the following grid, interpolate and draw the 5 foot contours.

74	77	80	94	92	97	102
77	80	99	110	99	90	91
76	78	92	97	94	92	96
78	88	100	102	100	93	85

14. On the following grid, draw the 2 foot contours.

76	78	92	97	94	92	96
74	77	80	94	92	97	102
77	80	99	110	99	90	91
78	88	100	102	100	93	85

15. State the purpose of lift drawings.

a) The purpose of lift drawings is to build the structure on paper before building it on the ground. It is easier to erase a mistake on paper than to erase it with a jackhammer.

Chapter 12 - Math Review and Conversions

QUESTIONS AND PROBLEMS

1. Convert to feet, tenths and hundredths

Problem	Given	Conversion
a	22 '-5"	22.4166'
b	45' – 4 ¼ "	45.3542'
c	127' – 8 ¾ "	127.6875'

2. Convert the following to feet and inches

Problem	Given	Conversion
a	4.32	4' – 3 13/16"
b	56.89	56' – 10"
c	123.42	123' – 5"

3. Convert the following from meters to feet

Problem	Given	Conversion
a	86.435m	282.295'
b	15.234m	49.980'
c	45.986	150.8727'

4. Convert the following from feet to meters

Problem	Given	Conversion
a	54.67'	16.6634'
b	23.45'	7.1476'
c	1229.89'	374.8705'

5. Convert the following from feet to meters

Problem	Given	Conversion
a	25'-3"	7.6962m
b	89'-7 ¼"	27.3114m
c	32'-2 ¼"	9.8107m

6. Convert the following from DMS to DD.

Problem	Given	Conversion
a	45° 23'15"	45.387500°
b	76° 45' 12"	76.753333°
c	44° 07	44.116667°

7. Convert the following from DD to DMS.

Problem	Given	Conversion
a	45.6789°	45° 40' 44"
b	156.34659°	156° 20' 48"
c	90.00121°	90° 00' 04"

8. Describe why mathematics is an important part of surveying

Questions 9 – 12. Calculate the unknowns for the right triangle information given.

Right Triangle

#	Angle A	Angle B	Angle C	Side a	Side b	Side c
9	40º	**50º**	90º	**35.41116**	**42.20138**	55.09
10	**62.53796**	**27.462030**	90º	45.12	23.45	**50.849940**
11	**80º**	10º	90º	**1325.321**	233.69	**1345.7671**
12	**31.538810**	**58.461180**	90º	**76.31157**	124.34	145.89

Questions 13to 17. Calculate the unknowns for the oblique triangle information given.

Oblique Triangle

#	Angle A	Angle B	Angle C	Side a	Side b	Side c
13	**23.860940**	**37.356850**	**118.78220**	30	45	65
14	**41.068670**	**18.931320**	120°	47.89	23.65	**63.129810**
15	23º 45’	45º 56’	**110.31660**	222.40	**396.77860**	**517.85410**
16	**34.675230**	78º 59’	**85.324770**	432.12	657.78	**757.01180**
17	20°	65°	95°	100	**264.98660**	**291.26780**

18. Calculate the area of the triangles in problems 9, 10, 11.

Ref. Problem	Side a	Side b	Side c	Area
9	35.41116	42.20138	55.09	747.1999
10	45.12	23.45	50.849940	529.032
11	1325.321	233.69	1345.7671	154857.132

19. Calculate the area of the triangles in problems 13, 14, 15.

Ref. Problem	Side a	Side b	Side c	Area
12	30	45	65	591.608
13	47.89	23.65	63.129810	490.4296
16	222.40	396.77860	517.85410	41226.946

20. Convert 455 cubic yards to cubic meters

347.87246 cubic meters

21. Convert 27 cubic meters to cubic yards

35.314667 cubic yards

22. If a tank holds 500 gallons, it has how many cubic yards?

2.475566 Cubic yards

23. How many square feet in 88.9 acres?

3872483.97 square feet

24. How many square yards in a square mile?

3097600.13 square Yards.

25. How many hectares in 90 acres?

36.421853 hectares

Chapter 13 - Chain Corrections

QUESTIONS AND PROBLEMS

1. A field engineer has measured the distance between column lines with a chain which is later discovered to be too short. In order to determine the actual distance between points, how should the correction be applied?

The correction should be subtracted from the recorded distance.

2. A field engineer used a chain which is too long to lay out a foundation of a large building. If she sets points at the prescribed distances from plans, how should the correction be applied?

The points will have to be moved closer together. In other words, subtract the correction to get the correct distance.

3. What is the distance between two building control points measured (recorded) to be 75 meters if the 30-meter chain was found to be too long by 0.015 meters?

Determine the number of chain lengths. 75/30 = 2.50 chain lengths.

The correction is 0.015 per chain length.

2.5 c.l. x 0.015 m per c.l. = 0.0375 m total correction.

This is a known to known measurement, therefore the recorded distance with a chain that is too long will shorter than it should be. To get the correct distance, Add the correction

75 + 0.0375 = **75.0375 meters**

4. A chain 100-feet long is laid on ground sloping 4%. What is the horizontal distance if the slope distance is 300.23 feet?

The chain is sloping 4%. This represents the hypotenuse of a triangle, therefore the horizontal length will be shorter.

This can be determined by several methods. One method is shown using the Pythagorean theorem. At 4% the ground changes 4 feet per 100 feet. In 300 feet the ground have a vertical change of 12 feet.

Therefore, one side of the equation is 12 feet and the other is 300.23.

$$c^2 = a^2 + b^2$$

$$\text{Horizontal} = \sqrt{12^2 + 300.23^2}$$

$$\text{Horizontal} = 299.99$$

5. A 100-foot steel chain (known to be 99.93 feet) was used to measure between two building points. A distance of 147.44 feet was recorded at a temperature of 43°F. What is the distance after correcting for temperature and chain length error?

- Situation: Known to Known
- Corrections: Length and Temperature

  Length of the chain is short resulting in more being recorded therefore the correction must be subtracted. C_l = -0.07

  Temperature was colder, resulting in the chain being shorter and more was recorded. Therefore, the correction must be subtracted.

  C_t = 0.00000645(43-68)100 = -0.016

  C_{total} = (-0.07) + (-0.016) = -0.086'/CL
- Total Correction = -0.086'/CL x 1.4744 CL = -0.127
- Corrected Distance = 147.44 – 0.127 = 147.313

6. The slope distance between the two points is 24.776 meters and the zenith angle is 81°17'. Compute the horizontal distance.

- Situation: Known to Known
- Corrections: Slope

  Hor Dist = Slope Dist (Sin Zenith Angle) = 24.776 (Sin 81° 17')
- Hor Dist = 24.490

7. The slope distance between two points is 42.71 feet, and the difference in elevation between them is 3.56 feet. Compute the horizontal distance.

- Situation: Known to Known
- Corrections: Slope

  Hor Dist = $c^2 – a^2 = 42.71^2 – 3.56^2$
- Horizontal Distance= 42.56'

8. A distance of 328 feet was measured along a 2% slope. Compute the horizontal distance.

- Situation: Known to Known
- Corrections: Slope

  $C_g = h^2/2L = 2^2/2(100)$ = 0.02'/CL
- Total Correction = 0.02'/CL x 3.28 CL = 0.066'
- Distance = 328' – 0.066 = 327.934'

9. It is required to lay out a rectangular building 25 meters wide by 40 meters long. If the 30-meter steel chain being used is 29.994 meters long, what distances should be laid out?

- Situation: Layout
- Corrections: Length

  C_l = +0.006'/CL
- Chain Lengths: 25/30 = 0.833CL, 40/30 = 1.33 CL
- Total Correction:

  +0.006m/CL x 0.833 CL = +0.005m

  0.006m/CL x 1.333 CL = +0.008m
- Distances to be Laid Out:

  25 + 0.005 = 25.005

  40 + 0.008 = 40.008

10. It is required to lay out a rectangular building 75 feet wide by 100 feet long. If the 100' steel chain being used is 99.97 feet long, what distances should be laid out?

- Situation: Layout
- Corrections: Length

  C_l = 0.03'/CL Short, therefore Add
- Chain Lengths: 0.75 CL and 1.00 CL
- Total Correction:

  +0.03'/CL x 0..75 CL = +0.023'

  +0.03'/CL x 1.000 CL = +0.03'
- Distances to be Laid Out:

  75 + 0.023 = 75.023

  100 + 0.03 = 100.03

11. A concrete slab measuring 10 feet by 85 feet is to be laid out by a chain known to be 100.03 feet long under standard conditions. What distances should be laid out?

- Situation: Layout
- Corrections: Length

  C_l = 0.03'/CL Long, Therefore Subtract
- Chain Lengths: 0.1 CL and 0.85 CL
- Total Correction:

  +0.03'/CL x 0.75 CL = +0.023'

  +0.03'/CL x 1.000 CL = +0.03'
- Distances to be Laid Out:

  75 + 0.023 = 75.023

  100 + 0.03 = 100.03

12. A 100' steel chain standardized at 99.98' was used to measure a distance between control points of 1275.36 feet when the field temperature was 87° F. The ground was sloping at 5%. What is this distance under standard conditions?

- Situation: Known to Known
- Corrections: Length, slope, and Temperature

  Length of the chain is short resulting in more being recorded therefore the correction must be subtracted. C_l = -0.02

  Temperature was warmer, resulting in the chain being longer and less was recorded. Therefore, the correction must be added.

  C_t = 0.00000645(87-68)100 = -0.012'/CL

  Slope results in a longer distance being recorded, therefore subtract. $C_g = h^2/2L = 5^2/2(100)$ = 0.125'/CL

  C_{total} = (-0.02) + (+0.012) + (-0.125')

  = -0.133'/CL
- Total Correction = -0.133'/CL x 12.7536 CL = -1.69
- Corrected Distance = 1275.36 – 1.69 = 1273.66

13. A steel chain known to be 100.03 feet is used to measure the distance between two building corners. If the distance between the corners is supposed to be 268.33 feet and the field temperature is 97° F, then what distance should be laid out?

- Situation: Layout
- Corrections: Length, and Temperature

  Length of the chain is long resulting in more being laid out therefore the correction must be subtracted. C_l = -0.03

  Temperature was warmer, resulting in the chain being longer and more being laid out. Therefore, the correction must be subtracted.

  C_t = 0.00000645(77-68)100 = -0.019'/CL

  C_{total} = (-0.03) + (-0.019) = -0.049'/CL
- Total Correction = -0.049'/CL x 2.6833 CL = -0.1315
- Corrected Distance = 268.33 – 0.1315 = 268.198

14. Two control points are known to be 487.63 feet apart. Using a 200' chain known to be 199.96 feet under standard conditions, what distance should be measured when the field temperature is 78° F?

- Situation: Known to Known
- Chain length = 487.63/200 = 2.43
- Corrections: Length, and Temperature

  Length of the chain is short resulting in more being recorded therefore the correction must be subtracted. C_l = -0.04

  Temperature was warmer, resulting in the chain being longer and less was recorded. Therefore, the correction must be added.

  C_t = 0.00000645(78-68)100 = +0.0129'/CL

  C_{total} = (-0.04) + (+0.012=) +

  = -0.0271'/CL
- Total Correction = -0.0271'/CL x 2.43 CL = —0.066
- Corrected Distance = 487.63 – 0.066 = 487.564

15. A distance was measured with a chain that was found to be 30.000m at a temperature of 20° C and a slope of 0° 00'. If the distance was recorded as 90.000 m, what was the actual length?

No corrections required.

Distance is 90.000m

Calculate the actual Horizontal Distance for the data in the table below.

#	Tape Length	Slope	Temp.	Recorded	Actual Distance
16	100.01 ft.	Zenith 92º 45’	44ºF	300.12 ft.	**299.76**
17	30.007 m	Elev diff 5.67 m	0º C	44.10 m	**43.734**
18	99.992 ft.	5%	98º F	200.34 ft.	**200.11**
19	29.994 m	0.00 m	28º C.	75.015 m	**75.007**
20	100.03 ft.	Vertical 2º 21’	12º F	345.43	**345.12**

Calculate the distances to be LAID OUT for the following data.

#	Tape Length	Slope	Temp.	Required Horizontal Distance	Distance to Lay Out
21	100.015 ft.	Zenith 87º 15’	64ºF	400 ft.	**408.10**
22	30.003 m	Elev diff 1.67 m	0º C	20 m	**20.072**
23	99.996 ft.	3%	98º F	150 ft.	**150.045**
24	29.995 m	Zenith 89º 15’	08º C	75 m	**76.10**
25	100.01 ft.	Vertical 2º 21’	32º F	350 ft.	**350.28**

Chapter 14 - Traverse Computations

QUESTIONS AND PROBLEMS

1. What is the angular closure for the following interior field angles of traverse ABCDEF, measured with equal precision?

A. 87° 54' 14" B. 90° 32' 45" C. 102° 43" 31"

D. 99° 24" 34" E. 156° 01' 55" F. 183° 23' 01"

Sum of the angles is 720° 00' 00". Therefore the closure is 0.

2. Using the angles in the previous problem, how much adjustment is needed for each angle?

None

3. Using adjusted angles from above, and a direction for line AB of 274° , what is the direction for each line?

AB = 274° 00' 00"

BC = 03° 27' 15"

CD = 80° 43'44"

DE = 161° 19' 10"

EF = 185° 17' 15"

FA = 181° 54' 14"

4. Provide the back azimuth for the following azimuths:

a) 232° 12' 07" Back azimuth = 412° 12' 07' or 52° 12' 07"

b) 156° 52' 17" Back Azimuth = 336° 52' 17"

c) 31° 32' 42" Back Azimuth = 211° 32' 42"

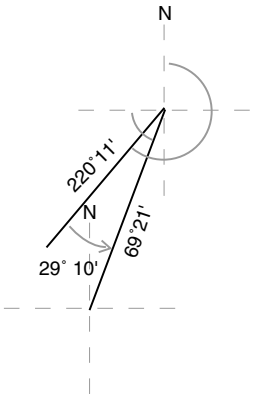
5. Convert the following azimuths into bearings:

a) 251° 43' 52" = (251° 43' 52" - 180°) Bearing = S 71° 43' 53" W

b) 111° 32' 59" = (180° - 111° 32' 59") Bearing = S 68° 27' 01" E

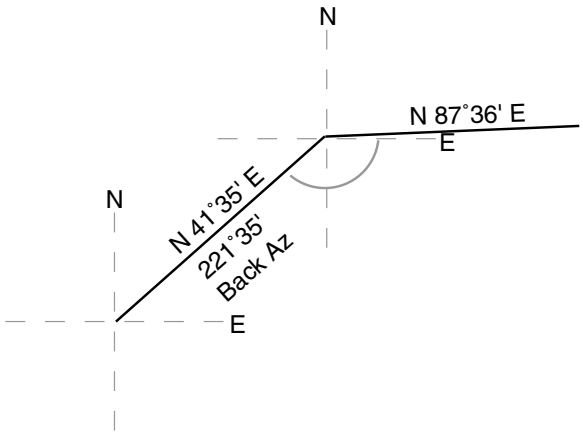
c) 336° 32' 52" = (360° - 336° 32' 52") Bearing = N 23° 27' 08" W

6. Given two successive azimuths of a traverse 69° 21' followed by 220° 11', what is the counterclockwise interior angle between them?



69° 21'
+ 180° 00'
249° 21'
- 220° 11'
29° 10'

7. Given two successive bearings of a traverse N 41° 35' E followed by N 87° 36' E, what is the interior angle between them?



41° 35'
+ 180° 00'
Back Az 221° 35'
- 87° 36'
133° 59'

8. A 4410' line bears N 68° 11' 07" E. What is the latitude and departure of the line?

Latitude = (Dist)(Cos Direction)
Latitude = (4410)(Cos 68° 11' 07")
Latitude = 1638.7842

Departure = (Dist)(Sin Direction)
Departure = (4410)(Sin 68° 11' 07")
Departure = 4094.2015

9. A 956' line bears S 32° 53' 42" W. What is the latitude and departure of the line?

Latitude = (Dist)(Cos Direction)
Latitude = (956)(Cos 32° 53' 42")
Latitude = 802.7219

Departure = (Dist)(Sin Direction)
Departure = (956)(Sin 32° 53' 42")
Departure = 519.2047

10. A 1436.32' line has an azimuth of 178° 52' 13". What is the latitude and departure of the line?

Latitude = (Dist)(Cos Direction)
Latitude = (1436.32)(Cos 178° 52' 13")
Latitude = -1436.0408

Departure = (Dist)(Sin Direction)
Departure = (1436.32)(Sin 178° 52' 13")
Departure = 28.3186

11. A 1233.45' line has an azimuth of 123° 24'. What is the latitude and departure of the line

Latitude = (Dist)(Cos Direction)

Latitude = (1233.45)(Cos 123° 24' 00")

Latitude = -678.9905

Departure = (Dist)(Sin Direction)

Departure = (1233.45)(Sin 123° 24' 00")

Departure = 1029.7431

12. The closure in latitudes of a loop traverse is N 0.0635 feet; the closure in departures is W 0.0512 feet. What is the linear error of closure?

$$LEOC = \sqrt{0.0635^2 + 0.0512^2}$$

LEOC =0.0816

13. A traverse was ran on a small jobsite. Assume angles were measured with equal precision. The Direction of AB is AzN 114°12'. Determine the linear error of closure and the precision. Adjust the traverse using the compass rule. Perform all calculations necessary to determine the coordinates of the points B and C. The coordinates of Point A are N5000 and East 10000.

Field Data

Pt.	*Field Angle*	*Adjustment*	*Adj. Angle*	*Distance*
A	26° 29’ 32”	-4”	26° 29’28”	
				444.05’
B	10° 00’ 04”	-4”	10° 00’00	
				333.10’
C	143° 30’ 36”	-4”	143° 30’32”	
				129.667’
Sum	180º 00’ 12”		180º 00’	

Continued on next page.

Line	Dir.	Dist.	Cos	Sin	Lat. N	Lat. S	Dep. E	Dep. W
AB	114°12’	444.05’	-0.4099	0.9121		-182.0263	405.0269 **+0.0193**	
BC	284°12’	333.10’	0.2453	-0.9694	81.7119 **-0.0053**			-322.9222 **-0.0145**
CA	320°41’28”	129.667’	0.7737	-0.6335	100.3288 **-0.0021**			-82.1442 **-0.0056**
	Σ	**906.8170**		Σ	**182.0407**	**182.0263**	**405.0269**	**405.0664**
					0.0144		**0.0395**	

LEOC = 0.0420 Precision Ratio = 1/21568

LINE	Adj. Lat	Adj Dep	Point	North	East
			A	5000.00	10,000.00
AB	-182.0334	+405.0462			
			B	4817.9666	10405.0462
BC	+81.7066	-322.9077			
			C	4899.6732	10082.1385
CA	+100.3267	82.1386			

14. A traverse was ran on a large jobsite. Assume angles were measured with equal precision. The Direction of WX is AzN 224°56'. Determine the linear error of closure and the precision. Adjust the traverse using the compass rule. Perform all calculations necessary to determine the coordinates of points X, Y, and Z. The coordinates of Point A are N1000 and East 5000.

Field Data

Pt.	Field Angle	Adjustment	Adj. Angle	Direction	Distance
W	121° 17’41”	+02”	121°17’43”		
				224° 56’	107.865’
X	78° 23’06”	+02”	78° 23’08”		
				326° 32’ 56”	172.849’
Y	79° 50’27”	+02”	79° 50’29”		
				66° 42’ 23”	152.471’
Z	80° 28’38”	+02”	80° 28’40”		
				166° 13’ 43”	131.948’
Sum	359° 59’ 52”		360º 00’		

Line	Dir.	Dist.	Cos	Sin	Lat. N	Lat. S	Dep. E	Dep. W
WX	224° 56'	107.865	-0.7079	-0.7063		76.3608 **-0.0008**		76.1833 **-0.0017**
XY	326° 32' 56"	172.849'	0.8344		144.2177 **+0.0013**			95.2787 **-0.0027**
YZ	66° 42' 23"	152.471	0.3954	0.9185	60.2936 **+0.0012**		140.0432 **+0.0024**	
ZW	166° 13' 43"	131.948	-0.9713	0.2380		128.1549 **-0.0010**	31.4100 **+0.0021**	
	∑	**565.133**		∑	**204.5113**	**204.5157**	**171.4532**	**171.4620**
						0.0044		**0.0088**

LEOC = 0.0098 Precision Ratio = 1/57440

LINE	Adj. Lat	Adj Dep	Point	North	East
			W	1000.00	5000.00
WX	76.3600	76.1816			
			X	923.6400	4923.8184
XY	144.2190	95.2760			
			Y	1067.8590	4828.5424
YZ	60.2948	140.0456			
			Z	1128.1538	4968.5880
ZW	128.1539	31.4121			
			W	999.9999	5000.0001

15. A four-sided closed traverse ABCD has the following angles and distances.

A = 88° 30' AB= 262.56

B = 90° 22' BC = 955.63

C = 87° 00' CD = 244.10

D = 94° 08' DA = 944.73'

The direction of AB is an azimuth of 88° .

a) Perform a check for angular closure. Measured with equal precision.

b) Compute the direction for all sides. (Azimuths)

c) Compute the latitudes and departures.

d) Compute the linear error of closure and the precision ratio.

e) Using the compass rule, compute the adjustments for latitudes and departures and apply the adjustments.

f) Assuming coordinates of North 1000 and East 5000 for point A, compute the coordinates of B, C, and D.

Field Data

Pt.	*Field Angle*	*Adjustment*	*Adj. Angle*	*Direction*	*Distance*
A	88° 30'	0	88° 30'		
				88°	262.56
B	90° 22'	0	90° 22'		
				177° 38'	955.63
C	87° 00'	0	87° 00'		
				270° 38'	244.10
D	94° 08'	0	94° 08'		
				356° 30'	944.73
A	360° 00' 00"				

Line	*Dir.*	*Dist.*	*Cos*	*Sin*	*Lat. N*	*Lat. S*	*Dep. E*	*Dep. W*
AB	88°	262.56	.0349	0.9994	9.162 **-0.0014**		262.40 **-0.0112**	
BC	177° 38'	955.63	-0.9991	0.0413		954.8149 **+0.0052**	39.4621 **-0.0407**	
CD	270° 38'	244.10	0.0111	-0.9999	2.6982 **-0.0013**			244.0851 **0.0104**
DA	356° 30'	944.73	0.9981	-0.0610	942.9679 **-0.0052**			57.6744 **0.0402**
	∑	**2407.02**		∑	**954.8281**	**954.8149**	**301.8620**	**301.7595**
						0.0132		**0.1025**

LEOC = 0.1033 Precision Ratio = 1/23290

LINE	Adj. Lat	Adj Dep	Point	North	East
			A	1000	5000
AB	9.1606	262.3888			
			B	1009.1606	5262.3888
BC	954.8201	39.4213			
			C	54.3405	5301.8101
CD	2.6969	244.0955			
			D	57.0374	5057.7146
DA	942.9627	57.7146			
			A	1000.0001	5000.0000

16. For the closed traverse ABCD, answer the following questions

a) What are the corrected departures?

b) What are the corrected latitudes?

c) What is the error of closure?

d) What is the approximate precision?

Assuming starting coordinates of North 10000 and E 5000 for point A, what are the coordinates of the other traverse points?

Course	Direction	Distance
MN	N 0º 00’ 00” E	664.150’
NO	N 79º 51’ 58.0” E	315.200’
OP	S 37º 59’ 04.0” E	592.47’
PQ	S 58º 08’ 44.0” W	456.165’
QM	S 87º 37’ 02.0” W	287.635’

Line	Dir.	Dist.	Cos	Sin	Lat. N	Lat. S	Dep. E	Dep. W
MN	N0º 00' 00"E	664.150'	1.0000	0.0000	664.150 **+0.0196**		0.0000 **-0.0195**	
NO	N79º 51'58"E	315.200'	0.1759	0.9844	55.4591 **+0.0093**		310.2827 **-0.0092**	
OP	S37º59' 04"E	592.47'	0.7882	0.6154		466.9717 **-0.0174**	364.6342 **-0.0174**	
PQ	S58º08'44"W	456.165'	0.5278	0.8494		240.7471 **-0.0134**		387.4627 **+0.0134**
QM	S87º37'02"W	287.635'	0.0416	0.9991		11.9585 **-0.0085**		287.3863 **+0.0084**
	Σ	**2315.62**		Σ	**719.6091**	**719.6773**	**674.9169**	**674.8490**
					0.0682		**0.0679**	

LINE	Adj. Lat	Adj Dep	Point	North	East
			M	1000	5000
MN	664.1696	-0.0195			
			N	1664.1696	4999.9805
NO	55.4684	310.2735			
			O	1719.6380	5310.2540
OP	-466.9543	364.6168			
			P	1252.6837	5674.8708
PQ	-240.7337	-387.4761			
			Q	1011.9500	5287.3947
QM	-11.9500	-287.3947			
			M	1000.0000	5000.0000

17. Using the data from problem 13, calculate the adjusted distances and directions from the adjusted latitudes and departures.

Point	North	East	Line	Adj. Direction	Adj. Distance
A	5000.00	10000.00			
			AB	114º 11' 59"	444.0705
B	4817.9666	10405.0462			
			BC	284º 11' 59"	333.0847
C	4899.6732	10082.1385			
			CA	320º 41' 33"	129.6619
A	4999.9999	9999.9999			

18. Using the data from problem 14, calculate the adjusted distances and directions from the adjusted latitudes and departures.

Point	North	East	Line	Adj. Direction	Adj. Distance
W	1000.00	5000.00			
			WX	224°55'58.8"	107.863
X	923.6400	4923.8184			
			XY	326º 33’	172.849
Y	1067.8590	4828.5424			
			YZ	66°42'22.8"	152.474
Z	1128.1538	4968.5880			
			ZA	166º 13’ 40”	131.947
W	999.9999	5000.000			

19. For the closed traverse ABCD answer the following questions:

Course	Bearing	Length	Latitude	Departure
AB	S 77º 48’ E	76	16.06	74.3
BC	S 68º 14’ W	135	50.1	125.4
CD	N 10º 26’ W	42	41.3	7.6
DA	N 67º 03’ E	63.71	24.8	58.67

a) What are the corrected departures?

b) What are the corrected latitudes?

c) What is the error of closure?

d) What is the approximate precision?

Assuming starting coordinates of North 1000 and E 1000 for point A, what are the coordinates of the other traverse points?

Line	Dir.	Dist.	Cos	Sin	Lat. N	Lat. S	Dep. E	Dep. W
AB	S 77º 48' E	76				16.06 **-0.014**	74.3 **+0.007**	
BC	S 68º 14' W	135				50.1 **-0.026**		125.4 **-0.013**
CD	N 10º 26' W	42			41.3 **+0.008**			7.6 **-0.004**
DA	N 67º 03' E	63.71			24.8 **+0.012**		58.67 **+0.006**	
	∑	**316.71**		∑	**66.10**	**66.16**	**132.97**	**133.0**
					0.06		**0.03**	

LINE	Adj. Lat	Adj Dep	Point	North	East
			A	1000	5000
AB	-16.046	+74.307			
			B	983.954	5074.307
BC	-50.074	-125.387			
			C	933.886	4948.920
CD	+41.308	-7.596			
			D	975.188	4941.324
DA	+24.812	+58.676			
			A	1000.0000	5000.0000

20. For the adjusted latitudes and departures given below and with coordinates of Point A being North 10000 East 20000, calculate the coordinates of Point C:

Course	Latitude	Departure	Point	North	East
			A	10000	20000
AB	S 350	E 160			
			B	9650	20160
BC	N 310	E 120			
			C	9960	20280
CA	N40	W 280			
				10000	20000

Chapter 15 - Coordinate Geometry

QUESTIONS AND PROBLEMS

Chapter 16 - Horizontal Curves

QUESTIONS AND PROBLEMS

Problems 1-10: Calculate the missing curve parts in the following table.

Curve Problem#	I	R	Degree of Curve	T	L	E	M.O.	LC
1	18°54'	357.25	16º02'17"	59.463	117.312	4.915	4.848	117.312
2	10º51'23"	2291.83	2º30'	217.777	434.25	10.324	10.277	433.601
3	51º16'55"	250.00	22º55'06"	120.00	223.760	27.308	24.619	216.366
4	7º17'12"	2020.477	2º50'09"	128.65	256.953	4.32	3.90	256.78
5	23°16'	607.013	9º26'20"	124.97	246.496	12.731	12.469	244.806
6	36º27'09"	441.01	12º59'31"	145.221	280.578	23.295	22.126	275.87
7	68º38'46"	286.479	20º	195.591	343.23	60.402	49.884	323.067
8	59º41'32"	754.86	7º35'25"	433.12	786.493	115.431	100.121	751.346
9	55º34'19"	1037.66	5º31'18"	546.77	1006.438	135.241	119.647	967.45
10	45°44'	780.810	7º20'35"	329.292	623.24	66.596	61.363	606.826

11. Given PI @ 19 + 87, "I" angle = 42°14', R = 900; compute tangent (T), the length of arc (L), and compute the stationing of the PC and PT

I Angle	42°14'00.0"
Radius	900.000
Arc Length	663.400
Tangent Length	347.582
P.C	16+39.418
P.T.	23+02.818

12. Given PI @32 +43, "I" angle = 7° 29', Da = 9° , compute tangent (T). length of arc (L) and compute the stationing of the PC and PT.

Central Angle	7°29'00.0"
Degree of Curve	9°00'00.0"
Radius	636.620
Arc Length	83.148
Tangent Length	41.633
P.C.	32+01.367
P.T	32+84.515

13. Given: PI @ 5+555, "I" angle of 22° , R= 770 meters, Computer the parts of the curve. T, L, LC, Da, E, MO, Stationing of the PC and PT.

Central Angle	22°00'00.0"
Degree of Curve	7°26'27.6"
Radius	770.000
Arc Length	295.659
Chord Length	293.846
Tangent Length	149.673
External	14.412
MO	14.147
P.C.	4+05.827
P.T.	7+01.486

14. Given PI @35+ 24.776, "I" angle = 33°54' , and R = 800 feet, compute the deflection at every half-station.

Central Angle	33°54'00.0"
Degree of Curve	7°09'43.1"
Radius	800.000
Arc Length	473.333
Chord Length	466.459
Tangent Length	243.821
Offset	0.000

P C 32+80. 955	0ø00'00	0	0
33+00	0º40'55	19. 045	19.045
33+50	2º28'21	49. 992	69. 024
34+00	4º15'46	49. 992	118. 936
34+50	6º03'12	49. 992	168. 731
35+00	7º50'38	49. 992	218. 362
35+50	9º38'04	49. 992	267. 779
36+00	11º25'29	49. 992	316. 935
36+50	13º12'55	49. 992	365. 782
37+00	15º00'21	49. 992	414. 271
37+50	16º47'47	49. 992	462. 356
P T 37+54.288	16º57'00	4. 288	466. 459

15. Given PI @ 17 +59.424, "I" angle = 15° 52'12", R = 288 meters, compute the deflection at every 20 meter station.

Central Angle	15°52'12.0"
Degree of Curve	19°53'39.7"
Radius	288.000
Arc Length	79.771
Chord Length	79.517
Tangent Length	40.143
Offset	0.000

Station	*Deflection*	*Short Chord*	*Long Chord*
P.C. 17+19.281	0º00'00.0"	0.000	0.000
17+20.000	0º04'17"	0.719	0.719
17+40.000	2º03'39	19.996	20.714
17+60.000	4º03'01	19.996	40.685
17+80.000	6º02'23"	19.996	60.606
P.T.17+99.053	7º56'06	19.049	79.517

16. Given Da = 3.22 degrees, L = 632.62', and PC = 19 + 73.42, find the remaining components of the curve.

Central Angle	21°17'54"'00.0"
Degree of Curve -	3°22'00
Radius	1701.855
Arc Length	632.62
Chord Length	628.984
Tangent Length	320.003
External	29.824
MO	29.310
P.I.	16+53.42
P.C.	19+73.42
P.T.	26+06.04

17. Two highway tangents intersect with a right deflection I angle of 21°35' 00" at PI sta. 12 + 12. A 04° 30' 00" horizontal curve (Da) is to be used to connect the tangents. Compute R, T, L, E, LC, and MO for the curve. Compute in tabular form the deflection angles to layout the curve at half stations. Compute the short and long chords.

Central Angle	21°35'00.0"
Degree of Curve	4°30'00.0"
Radius	1273.240
Arc Length	479.630
Chord Length	476.799
Tangent Length	242.692
Offset	0.000

Station	*Deflection*	*Short Chord*	*Long Chord*
P.C. 9+69.308	0º00'00.0"	0.000	0.000
10+00.000	0º41'26.0"	30.691	30.691
10+50.000	1º48'56.0"	49.997	80.678
11+00.000	2º56'26.0"	49.997	130.634
11+50.000	4º03'56.0"	49.997	180.540
12+00.000	5º11'26.0"	49.997	230.376
12+50.000	6º18'56.0"	49.997	280.123
13+00.000	7º26'26.0"	49.997	329.763
13+50.000	8º33'56.0"	49.997	379.275
14+00.000	9º41'26.0"	49.997	428.641
P.T14+48.938	10º47'30.0”	48.935	476.799

18. If a simple circular curve has a length of curve 410', and the degree of curvature (Da) is known to be 21.000°, and the station of the PI is 155 + 75.42, what is the central angle of this curve?

I = 86°06'00"

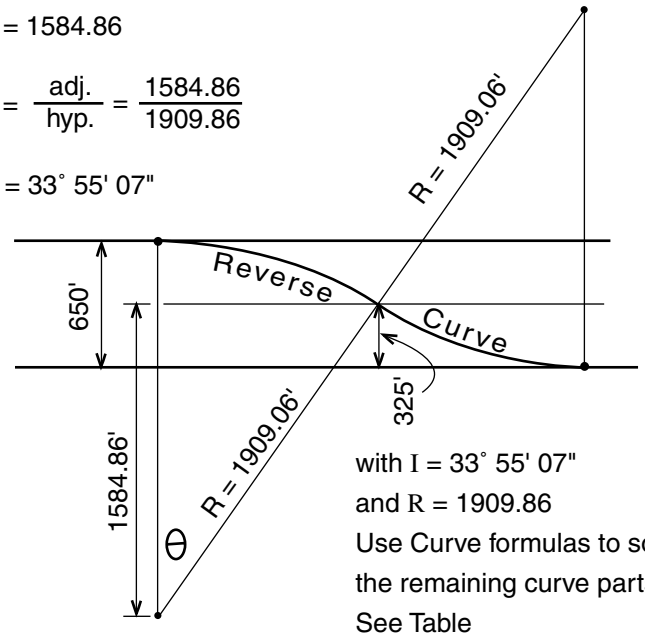
19. Two parallel highways 650' apart are to be joined by a reverse curve made up of two circular curves of equal radius. These curves are to have a (Da) of 3°. Determine all parts of these curves.

$$R = \frac{5729.58}{DA} = \frac{5729.58}{3} = 1908.86$$

1908.86 - 325 = 1584.86

$$\text{Cos } \theta = \frac{\text{adj.}}{\text{hyp.}} = \frac{1584.86}{1909.86}$$

θ = 33° 55' 07"



with I = 33° 55' 07"
and R = 1909.86
Use Curve formulas to solve for
the remaining curve parts
See Table

3° = 1909.86'

I = Cos (adj/hyp) = 3169.72/3819.72 = 33°55'07"

R = 1909.86

LC = 1114.18

T = 582.42

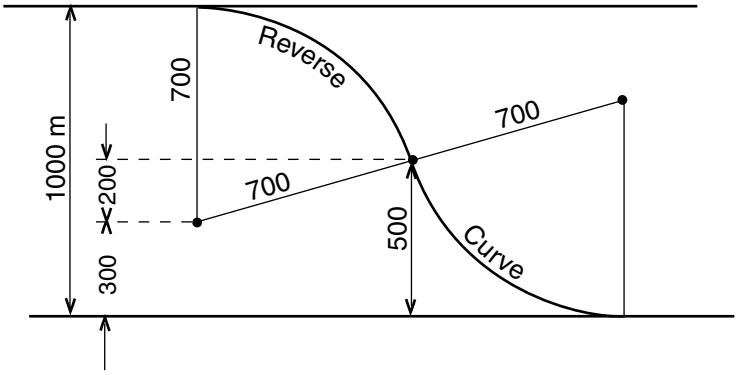
L = 1130.62

20. Two parallel highways 1000 meters apart are to be joined by a reverse curve made up of two circular curves of equal radius. These curves are to have a radius of 700 meters. Determine all parts of the curves.

R = 700

$\text{Cos}\,\theta = \frac{200}{700} = 73^\circ\ 23'\ 54''$

with I and R known, use curve formulas to solve for the remaining curve parts. See Table.



I = Cos = Adj/hyp = 400/1400 = 73°23'54"

R = 700

T = 519.30

L = 893.58

LC = 834.13

21. A 30 foot wide street is to be laid out in a subdivision and staked 2 feet back of the curbs on both sides of the street. A curve to the right with a PI of 15+78.45 has an I angle of 22°44' with a radius of 525'. Calculate the curve with offset data for both sides of the street.

Central Angle	22°44'00.0"
Degree of Curve-Arc	10°54'48.5"
Radius	525.000
Arc Length	208.305
Chord Length	206.941
Tangent Length	105.541
Deflection/Foot in Minutes	3.274

Station	*Deflection*	*Short Chord Center line*	*Long Chord Center line*	*S.C. Offset + 17'*	*L.C. Offset + 17'*	*S.C. Offset -17*	*L.C. Offset - 17'*
P.T 16+81.214	11°22'00.0	206.941	31.210	213.642	32.220	30.199	200.240
16+50.000	9°39'48.2"	176.252	49.981	181.960	51.600	48.363	170.545
16+00.000	6°56'06.0"	126.781	49.981	130.886	51.600	48.363	122.675
15+50.000	4°12'23.9"	77.022	49.981	79.516	51.600	48.363	74.527
15+00.000	1°28'41.8"	27.088	27.088	27.965	27.965	26.211	26.211
P.C 14+72.909	0°00'00.0	0.000	0.000	0.000	0.000	0.000	0.000

22. Given the following coordinates for a curve in a subdivision.

PI=N1609.70306, E1602.29975 @Station 21+46.95

PC =N 1500, E 1500

PT = N 1614.93798, E 1752.20838

RP = N 1253.02658, E 1764.84659

a) Calculate the parts of the curve. I, R, Da, LC, L, T, PC & PT Station.

Central Angle	45°00'00.0"
Degree of Curve	15°49'18.5"
Radius	362.132
Arc Length	284.418
Chord Length	277.164
Tangent Length	150.000
P.C	19+96.950
P.T	22+81.368

b) Calculate the layout data (Deflections and long chords for 50 foot stations) for this curve?

Station	*Deflection*	*Short Chord Centerline*	*Long Chord Centerline*
P.T 22+81.368	22º30'00"	31.358	277.164
22+50.00	20º01'07"	49.960	247.933
22+00.00	16º03'47"	49.960	200.401
21+50.00	12º06'27"	49.960	151.913
21+00.00	8º09'08	49.960	102.703
20+50.00	4º11'48"	49.960	53.003
20+00.00	0º14'28"	3.050	3.050
P.C 19+96.950	0º00'00	0.000	0.000

c) The +40 foot offset layout data for the curve.

Station	*Deflection*	*S.C. Offset + 40'*	*L.C. Offset + 40'*
P.T 22+81.368	22º30'00.0"	34.822	307.779
22+50.000	20º01'06.7"	55.479	275.319
22+00.000	16º03'47.1"	55.479	222.536
21+50.000	12º06'27.5"	55.479	168.693
21+00.000	8º09'07.8	55.479	114.047
20+50.000	4º11'48.2"	55.479	58.857
20+00.000	0º14'28.6"	3.387	3.387
P.C 19+96.950	0°00'00.0	0.000	0.000

d) The –30 foot offset layout data for the curve.

Station	*Deflection*	*S.C. Offset -30*	*L.C. Offset - 30'*
P.T 22+81.368	22º30'00.0"	28.760	254.203
22+50.000	20º01'06.7"	45.821	227.393
22+00.000	16º03'47.1"	45.821	183.799
21+50.000	12º06'27.5"	45.821	139.329
21+00.000	8º09'07.8	45.821	94.194
20+50.000	4º11'48.2"	45.821	48.612
20+00.000	0º14'28.6"	2.797	2.797
P.C 19+96.950	0º00'00.0	0.000	0.000

e) What are the coordinates of the stations on the centerline of the curve?

Station Centerline	*Direction from PC to Point*	*Long Chord Distance from PC to Point*	*North*	*East*
P.T 22+81.368	65°30'	277.164	1614.93798	1752.20838
22+50.000	63°01'07	247.933	1612.49	1720.94
22+00.000	59°03'47"	200.401	1603.02	1671.89
21+50.000	55°06'27"	151.913	1586.90	1624.60
21+00.000	51°09'08"	102.703	1564..42	1579.99
20+50.000	47°11'48"	53.003	1536.01	1538.89
20+00.000	43°14'28"	3.050	1502.22	1538.89
P.C 19+96.950	0°	0.000	N 1500	E 1500

f) What are the coordinates of the +40 Offset points on the curve?

Station +40	*North*	*East*
P.T 22+81.368	1654.91	1750.81
22+50.000	1652.19	1716.10
22+00.000	1641.68	1661.62
21+50.000	1623.78	1609.11
21+00.000	1598.82	1559.57
20+50.000	1567.27	1513.93
20+00.000	1529.75	1473.07
P.C 19+96.950	1527.28	1470.75

g) What are the coordinates of the -30 Offset points on the curve?

Station -30	*North*	*East*
P.T 22+81.368	1584.96	1753.26
22+50.000	1582.71	1724.58
22+00.000	1574.03	1679.59
21+50.000	1559.24	1636.22
21+00.000	1538.62	1595.30
20+50.000	1512.57	1557.61
20+00.000	1481.58	1523.86
P.C 19+96.950	1479.54	1521.94

23. Given the following coordinates for a curve in a subdivision:

PI = N 1502.69181, E 5148.33000 @ Station 67+89.76

PC = N 1224.23000, E 4987.56000

PT = N 1617.92144, E 5448.51345

RP = N 770.23041, E 5773.91155

a) Calculate the parts of the curve. I, R, Da, LC, L, T, PC & PT Station.

Central Angle	39°00'00"
Degree of Curve	6°18'36"
Radius	908.00
Arc Length	618.056
Chord Length	606.193
Tangent Length	321.540
P.C	64+68.220
P.T	70+86.276

b) Calculate the layout data (Deflections and long chords for 50 foot stations) for this curve?

Station	*Deflection*	*Short Chord Centerline*	*Long Chord Centerline*
PT 70+86.276	19°30'00.0"	36.274	606.193
70+50.000	18°21'19.7"	49.994	571.879
70+00.000	16°46'40.6"	49.994	524.212
69+50.000	15°12'01.5"	49.994	476.148
69+00.000	13°37'22.4"	49.994	427.723
68+50.000	12°02'43.3"	49.994	378.974
68+00.000	10°28'04.2"	49.994	329.937
67+50.000	8°53'25.1"	49.994	280.650
67+00.000	7°18'46.0"	49.994	231.151
66+50.000	5°44'06.9"	49.994	181.476
66+00.000	4°09'27.8"	49.994	131.664
65+50.000	2°34'48.7"	49.994	81.752
65+00.000	1°00'09.6"	31.778	31.778
PC 64+68.220	0°00'00.0"	0.000	0.000

c) The +40 foot offset lavout data for the curve.

Station	Deflection	S.C. Offset + 40'	L.C. Offset + 40'
PT 70+86.276	19°30'00.0"	37.872	632.898
70+50.000	18°21'19.7"	52.196	597.072
70+00.000	16°46'40.6"	52.196	547.305
69+50.000	15°12'01.5"	52.196	497.124
69+00.000	13°37'22.4"	52.196	446.565
68+50.000	12°02'43.3"	52.196	395.668
68+00.000	10°28'04.2"	52.196	344.472
67+50.000	8°53'25.1"	52.196	293.014
67+00.000	7°18'46.0"	52.196	241.334
66+50.000	5°44'06.9"	52.196	189.471
66+00.000	4°09'27.8"	52.196	137.464
65+50.000	2°34'48.7"	52.196	85.353
65+00.000	1°00'09.6"	33.178	33.178
PC 64+68.220	0°00'00.0"	0	0

d) The –30 foot offset layout data for the curve.

Station	Deflection	S.C. Offset -30	L.C. Offset - 30'
PT 70+86.276	19°30'00.0"	35.07	586.16
70+50.000	18°21'19.7"	48.34	552.98
70+00.000	16°46'40.6"	48.34	506.89
69+50.000	15°12'01.5"	48.34	460.42
69+00.000	13°37'22.4"	48.34	413.59
68+50.000	12°02'43.3"	48.34	366.45
68+00.000	10°28'04.2"	48.34	319304
67+50.000	8°53'25.1"	48.34	271.38
67+00.000	7°18'46.0"	48.34	223.51
66+50.000	5°44'06.9"	48.34	175.48
66+00.000	4°09'27.8"	48.34	127.31
65+50.000	2°34'48.7"	48.34	79.05
65+00.000	1°00'09.6"	30.73	30.73
PC 64+68.220	0°00'00.0"	0	0

e) What are the coordinates of the stations on the centerline of the curve?

Station Centerline	*Direction from PC to Point*	*Long Chord Distance from PC to Point*	*North*	*East*
PT 70+86.276	49°30’	606.193	1617.92	5448.51
70+50.000	48°21’20”	571.879	1604.25	5414.92
70+00.000	46°46’41”	524.212	1583.22	5369.56
69+50.000	45°12’02”	476.148	1559.74	5325.42
69+00.000	43°37’22”	427.723	1533.86	5282.65
68+50.000	42°02’43”	378.974	1505.66	5241.37
68+00.000	40°28’04”	329.937	1475.24	5201.70
67+50.000	38°53’25”	280.650	1442.67	5163.76
67+00.000	37°18’46”	231.151	1408.07	5127.68
66+50.000	35°44’07”	181.476	1371.54	5093.55
66+00.000	34°09’28”	131.664	1333.10	5061.48
65+50.000	32°34’49”	81.752	1293.12	5031.58
65+00.000	31°00’10”	31.778	1251.47	5003.93
PC 64+68.220	000°00’00”	0.000	1224.23	4987.56

f) What are the coordinates of the +40 Offset points on the curve?

Station +40	*North*	*East*
PT 70+86.276	1655.26	5434.18
70+50.000	1640.99	5399.10
70+00.000	1619.04	5351.74
69+50.000	1594.52	5305.67
69+00.000	1567.50	5261.01
68+50.000	1538.06	5217.91
68+00.000	1506.29	5176.49
67+50.000	1472.30	5136.88
67+00.000	1436.17	5099.21
66+50.000	1398.03	5063.58
66+00.000	1357.98	5030.10
65+50.000	1316.15	4998.88
65+00.000	1272.67	4970.01
PC 64+68.220	1244.23	4952.92

g) What are the coordinates of the -30 Offset points on the curve?

Station -30	*North*	*East*
PT 70+86.276	1589.91047	5459.26032
70+50.000	1576.68857	5426.77324
70+00.000	1556.36158	5382.91474
69+50.000	1533.65452	5340.24447
69+00.000	1508.62683	5298.87956
68+50.000	1481.36157	5258.95880
68+00.000	1451.94641	5220.60420
67+50.000	1420.45854	5183.92154
67+00.000	1386.99607	5149.02488
66+50.000	1351.67134	5116.02830
66+00.000	1314.57833	5085.02198
65+50.000	1275.84052	5056.10767
65+00.000	1235.56998	5029.36916
PC 64+68.220	1209.23000	5013.54076

24. The azimuth along the tangent from the PC of a curve to the PI is 123°37'. The coordinates of the PC are N2332.34, E6909.87. If the curve has an I angle of 41° 22', R = 475' and the station of the PI is 56+89.44. Data Shown for a CURVE LEFT.

a. Calculate the curve parts Da, LC, L, T, PC & PT Station.

Central Angle	41°22'00"
Degree of Curve	12°03'44"
Radius	475.000
Arc Length	342.943
Chord Length	335.543
Tangent	179.330
PC	55+10.11
PT	58+53.05

b. Calculate the deflections, and long chords for 50' stations.

Station	Deflection	Short Chord	Long Chord
PC 55+10.11	0°00'00.0	0.000	0.000
55+50.000	2°24'21"	39.878	39.878
56+00.000	5°25'17"	49.977	89.756
56+50.000	8°26'13"	49.977	139.385
57+00.000	11°27'09"	49.977	188.628
57+50.000	14°28'05"	49.977	237.348
58+00.000	17°29'01"	49.977	285.412
58+50.000	20°29'57"	49.977	332.685
P.T. 58+53.05	20°41'00.0"	3.053	335.543

c. Calculate the coordinates of these curve points. CURVE LEFT

Station Ctrline	Direction from PC to Point	Long Chord Distance from PC to Point	North	East
PC 55+10.11	To PI 123° 37’	0.000	N2332.34,	E6909.87.
55+50.000	121°12’39”	39.878	2311.68	6943.98
56+00.000	118°11’43”	89.756	2289.93	6988.98
56+50.000	115°10’47”	139.385	2273.04	7036.01
57+00.000	112°09’51”	188.628	2261.18	7084.56
57+50.000	109°08’55”	237.348	2254.49	7134.09
58+00.000	106°07’59”	285.412	2253.03	7184.04
58+50.000	103°07’03”	332.685	2256.84	7233.87
P.T. 58+53.05	102°46’	335.543	2257.24	7236.90

25. On a large highway project, curve #12 has a PI at 160+34.58 and PI coordinates of N 1476.89, E 6749.56. Curve #13 on the route is at PI station 174+25.89 and PI coordinates of N 1867.36, E 7335.90. Curve #13 has an I angle of 21°23' and a radius of 350. Shown for a CURVE RIGHT.

a. Calculate the curve parts I, R, Da, LC, L, T, PC & PT Station.

Central Angle	21°23'
Degree of Curve – Arc	16°22'13"
Radius	350'
Arc Length	130.623
Chord Length	129.867
Tangent Length	66.080
PC Station	173+59.810
PT Station	174+90.433

b. Calculate the deflections, and long chords for 50' stations.

Station	*Deflection*	*Long Chord*
PC 173+59.81	0°	0
174+00	3° 17’ 23”	40.168
174+50	7° 22’ 56”	89.941
PT 174+90.43	10° 41’ 30”	129.867

c. Calculate the coordinates of these curve points.

Station Centerline	*Direction from PC to Point*	*Long Chord Distance from PC to Point*	*North*	*East*
PC 173+59.81	To PI 56° 20’ 19”	0.000	1830.73	7280.90
174+00	59° 37’ 42”	40.168	1851.04	7315.56
174+50	63° 43’ 15”	89.941	1870.55	7361.54
PT 174+90.43	67° 01’ 49”	129.867	1881.41	7400.47

d. Calculate the radial layout data if an instrument is set on project control point number CP25 (N1800, E7700, with a backsight onto the PI of Curve 13.

Instrument at	*Backsight on*	*Point*	*Angles turned to the Right off of the Backsight*	*Distance*
CP 25	PI of Curve #13 with 0°00'00"	PC	353° 42' 44"	420.225
		174+00	357° 04' 52"	387.813
		174+50	1° 17' 35"	345.735
		PT	4° 43' 26"	310.396

26. The layout data for curve #4 on the highway has been calculated and shown in the table below. Arriving at the PC of the curve, it is seen that the area hasn't been cleared yet and it will be impossible to establish the curve entirely from the PC. Layout will require "moving up on the curve" frequently. The PC was occupied and points 19+00 and 19+50 were located before obstacles were encountered.

Station	*Arc*	*Deflection Increment*	*Total Deflection*	*Short Chord*	*Long Chord*
PT 20+64.15	14.15	02° 15' 07"	30° 45' 15"	14.15	184.088
20 + 50	50	07° 57' 28"	28° 30' 05"	49.839	171.785
20 + 00	50	07° 57' 28"	20° 32' 37"	49.839	126.332
19 + 50	50	07° 57' 28"	12° 35' 09"	49.839	78.446
19 + 00	29.08	04° 37' 41"	4° 37' 41"	29.048	29.048
PC 18 +70.92	0	0	000° 00' 00"	0.000	0.000

a) If the instrument is moved to 19+50, what angle will you set on the circle if you BS the PC?

You would set the deflection of the point you are SIGHTING on which is 000°00'00" for the PC.

b) If you are set at 19+50, what angle will you turn to set 20+00?

You will continue your original notes and will turn to 20°32'37"

c) If the instrument is moved to 20+00 and and the BS is on 19+50, what will you set on the circle before turning to the deflection for 20+00?

You will set the deflection of the point you are sighting on. The deflection for 19+50 is 12° 35' 37". That is what you would set on the instrument

d) If you are at 20+00 and you turn to a line that is tangent to the circle, what angle will you read on the circle?

You will turn the deflection of 20+00 to get a line that is tangent to the curve. The deflection for 20+00 is 20°32'37".

e) If you want a line radial to the curve at 20+00, what angle will you turn to on the circle?

You would turn the deflection of point 20+00 plus the 90°. This would total 110°32'37".

f) If a line radial to the curve is needed at station 19+75.23, what deflection angle and long chord will be needed to set that point, and what angle will be turned from a setup at that point to establish the radial line?

Assuming you are set up at the PC. The deflection angle to 19+75.23 will be 16°36'05" an the long chord will be 101.40.

The angle that would be turned at that point to establish a radial line would be 16°36'05" + 90° or 106°36'05".

g) Finally you have a clear line of sight to the PT and prepare to shoot it in. What long chord will need to be measured from your setup at 20+00 to the PT

The chord distance would be 63.81.

h) What is the chord length for an arc of 100 feet on this curve?

The chord for an arc of 100 feet is 98.72.