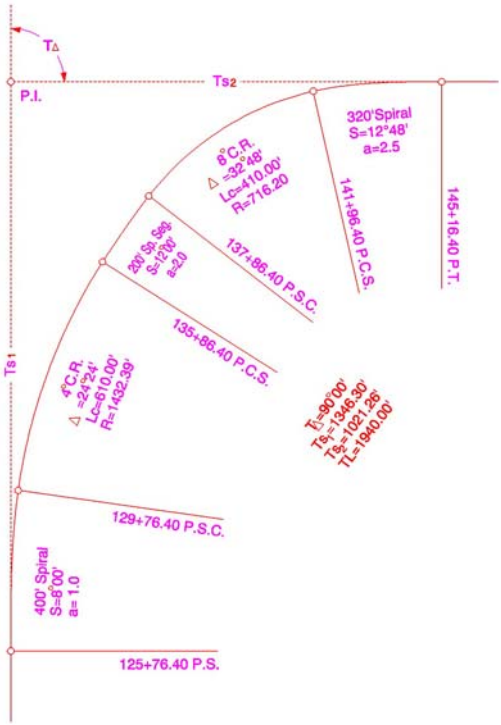
OREGON DEPARTMENT OF TRANSPORTATION

200 Hawthorne Avenue
Suite B250
Salem, OR 97310
(503) 986-3103

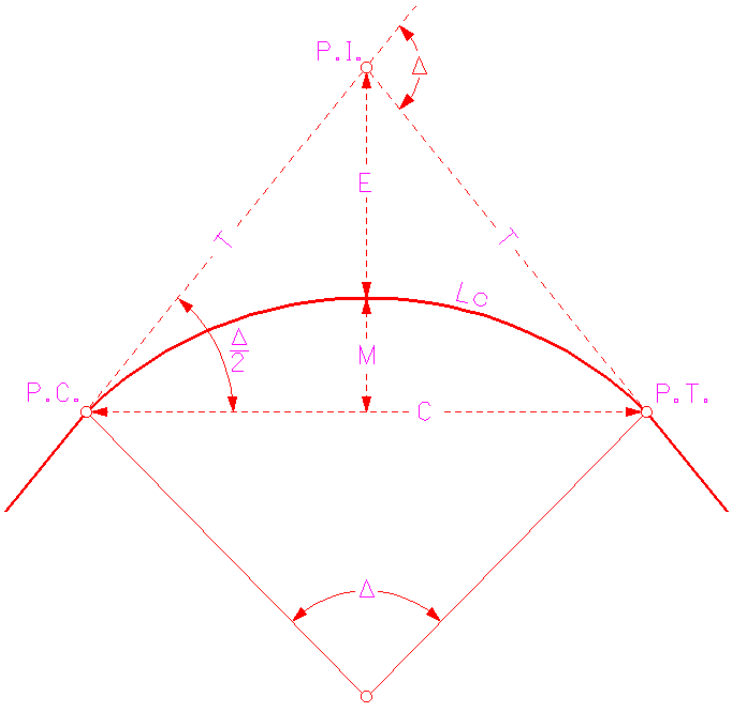
Ron Singh, PLS
Chief of Surveys
(503) 986-3033



Spirals Unraveled

Practice Exercises

ODOT Surveyors Conference
March, 2005



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

$$Lc = \frac{\pi R\Delta}{180}$$

$$E = \left(R \div \cos\frac{\Delta}{2}\right) - R$$

$$M = R - \left(R\cos\frac{\Delta}{2}\right)$$

$$C = 2R\sin deflection = 2R\sin\frac{\Delta}{2}$$

$$R = \frac{5729.578}{D}$$

Calculate the following Horizontal Curve Elements:

Chord Length	
Degree of Curve	4° Left
Delta	20°
External Distance	
Length of Curve	
Middle Ordinate	
P.C. Station	
P.I. Station	125+52.00
P.T. Station	
Radius	
Tangent Distance	

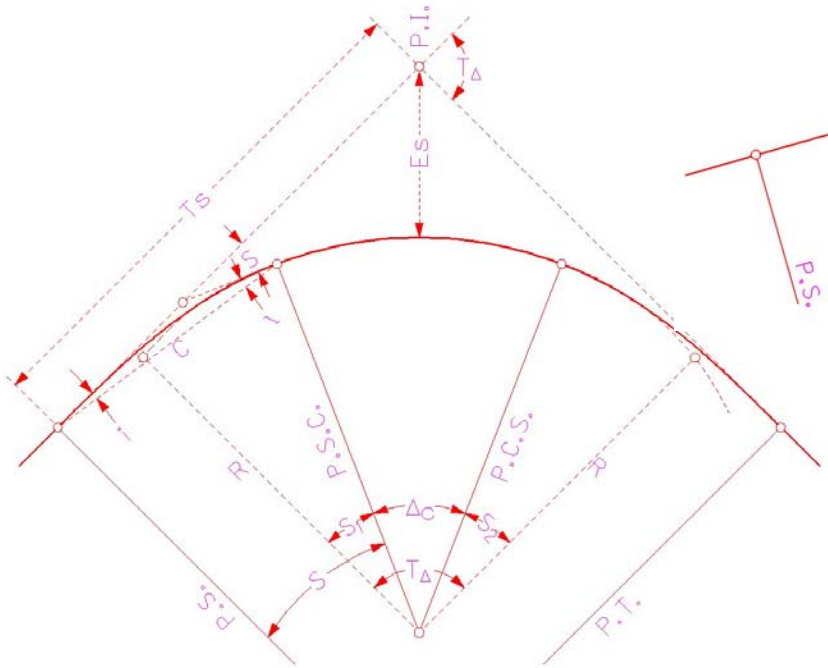
Calculate a 30’ right offset curve for the same curve as above:

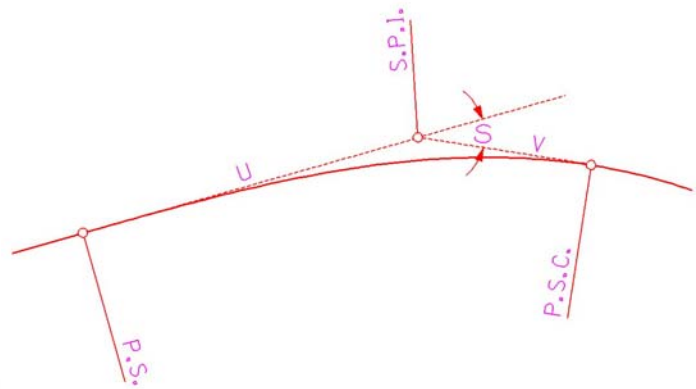
Chord Length	
Degree of Curve	
Delta	
Length of Curve	
P.C. Station	
P.T. Station	
Radius	

Answers to Page 1

Chord Length	497.47
Degree of Curve	4° Left
Delta	20°
External Distance	22.10
Length of Curve	500
Middle Ordinate	21.76
P.C. Station	122+99.43
P.I. Station	125+52.00
P.T. Station	127+99.43
Radius	1432.40
Tangent Distance	252.57

Chord Length	507.88
Degree of Curve	4°
Delta	20°
Length of Curve	510.47
P.C. Station	122+99.43
P.T. Station	127+99.43
Radius	1462.40





$$a = \frac{100D}{Ls} \qquad S = \frac{DLs}{200} = \frac{aLs^2}{20{,}000} = \frac{D^2}{2a}$$

Calculate "a" for the following spirals:

Degree of Curve	**Length of Spiral**	**"a" Value**
10°	200'	
7° 30'	250'	
4°	500'	
1° 30'	350'	

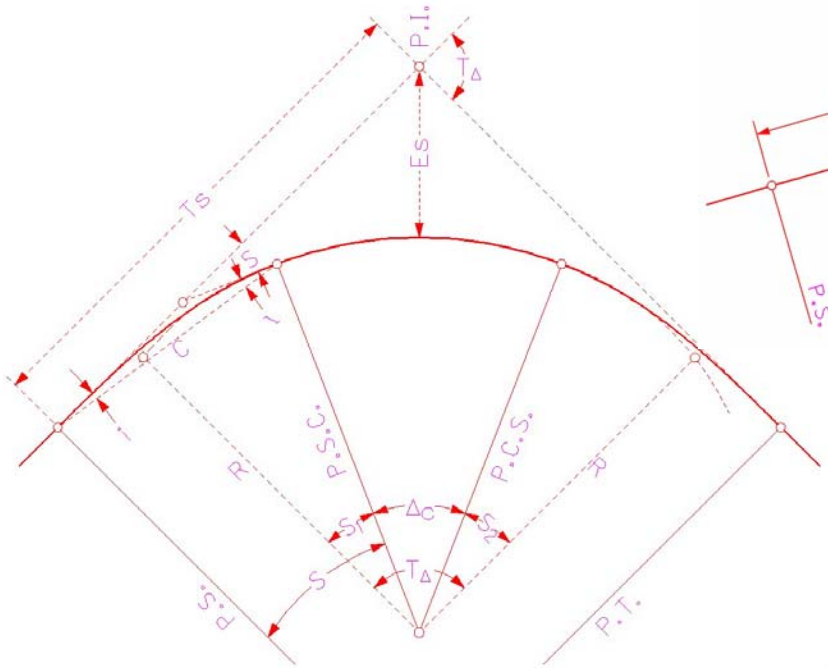
Calculate S°for the following spirals:

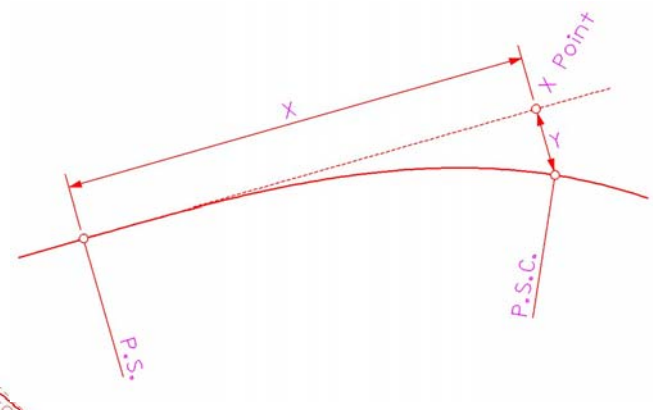
Given Information	S°
200' spiral into a 4° curve	
400' spiral into an "a" value of 1	
Spiral with an "a" value of 2 into a 5° curve	
500' spiral into a 6° 15' curve	

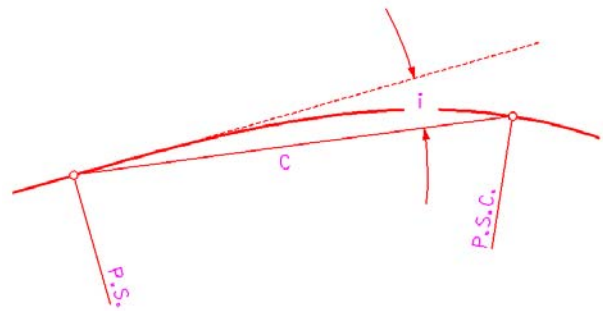
Answers to Page 3

Degree of Curve	Length of Spiral	"a" Value
10°	200'	5
7° 30'	250'	3
4°	500'	0.8
1° 30'	350'	0.4

Given Information	S°
200' spiral into a 4°curve	4° 00'
400' spiral into an "a" value of 1	8° 00'
Spiral with an "a" value of 2 into a 5°curve	6° 15'
500' spiral into a 6°15' curve	15° 37' 30"







$$X = Ls\left(1 - \frac{\theta^2}{10} + \frac{\theta^4}{216} - \frac{\theta^6}{9{,}360} + \frac{\theta^8}{685{,}440} - \frac{\theta^{10}}{76{,}204{,}800} + \frac{\theta^{12}}{11{,}975{,}040{,}000} - \frac{\theta^{14}}{2{,}528{,}170{,}444{,}800}\right)$$

$$Y = Ls\left(\frac{\theta}{3} - \frac{\theta^3}{42} + \frac{\theta^5}{1{,}320} - \frac{\theta^7}{75{,}600} + \frac{\theta^9}{6{,}894{,}720} - \frac{\theta^{11}}{918{,}086{,}400} + \frac{\theta^{13}}{168{,}129{,}561{,}600} - \frac{\theta^{15}}{40{,}537{,}905{,}408{,}000}\right)$$

Calculate the following spiral elements:

Degree of Curve “D”	6°
Total Delta	45°
Length of Spiral “Ls”	400’
“a” value	
S°	
Deflection from the Tangent to PSC “i”	
Spiral Chord “C”	
X	
Y	
Semi-Tangent “Ts”	

$$i = \arctan\left(\frac{Y}{X}\right)$$

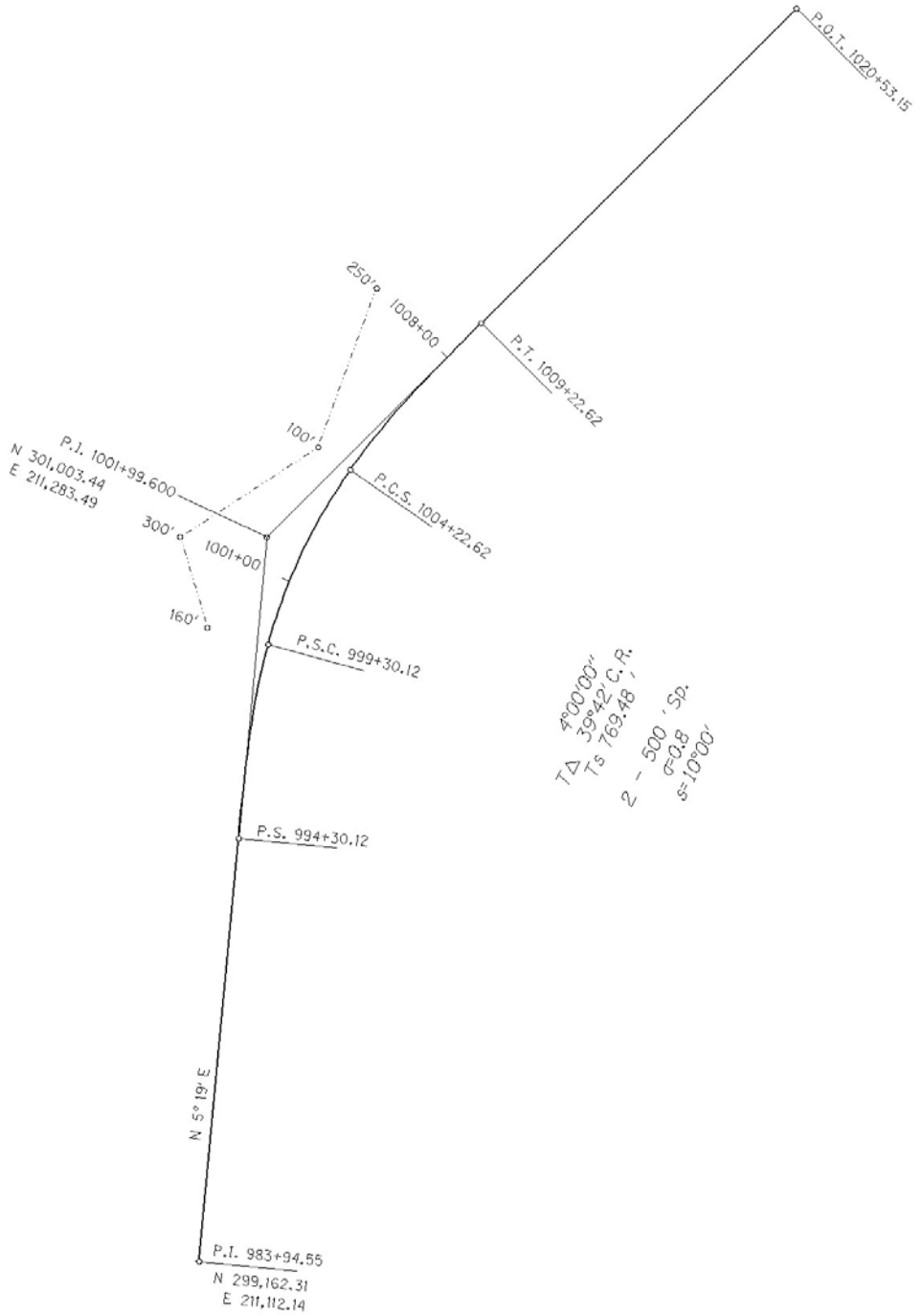
$$C = \sqrt{X^2 + Y^2}$$

Answers to Page 5

Degree of Curve “D”	6°
Total Delta	45°
Length of Spiral “Ls”	400’
“a” value	1.5
S°	12°
Deflection from the Tangent to PSC “i”	3°59’55”
Spiral Chord “C”	399.22’
X	398.25’
Y	27.84’
Ts	598.14’

Problem 1

- ► From R/W Map 8B-29-15
- ► Centerline Monuments 994+30.12 PS, 1009+22.62 PT, and the PI at 1001+99.60 are found in the field.
- ► Client needs R/W staked at 999+30.12 (160' Lt), 1001+00 (300' Lt), 1004+22.62 (100' Lt), and 1008+00 (250' Lt).



Centerline Station	Northing	Easting	Offset	Northing	Easting
994+30.12 PS					
999+30.12 PSC			160’ Lt		
1001+00 POC			300’ Lt		
1004+22.62 PCS			100’ Lt		
1008+00 POS			250’ Lt		
1009+22.62 PT					

Steps

1. Calculate PS coordinates (using PI, back bearing, and semi-tangent distance)
2. Calculate PT coordinates (using PI, ahead bearing, and semi-tangent distance)
3. Calculate X and Y values for spirals (or refer to table 5)
4. Calculate i and I values for spirals
5. Calculate C for spirals (or refer to table 5)
6. Calculate U and V values for spirals (or refer to table 5)
7. Calculate PSC coordinates (using X and Y values)
8. Calculate PCS coordinates (using X and Y values)
9. Calculate local tangent bearing for PSC (using S angle)
10. Calculate local tangent bearing for PCS (using S angle)
11. Calculate PSC, 160’ Lt coordinates (using local tangent bearing+90° to establish bearing)
12. Calculate arc distance from PSC to 1001+00
13. Calculate deflection angle from PS-PSC to 1001+00
14. Calculate coordinates for 1001+00
15. Calculate local tangent bearing at 1001+00
16. Calculate coordinates for 1001+00, 300’ Lt (using local tangent bearing+90° to establish bearing)
17. Calculate PCS, 100’ Lt coordinates (using local tangent bearing+90° to establish bearing)
18. Interpolate U, V, and S values to 1008+00 POS (from Table 5)
19. Calculate coordinates for 1008+00 (through SPI using U, S, and V)
20. Calculate 1008+00, 250’ Lt coordinates (using local tangent bearing+90° to establish bearing)

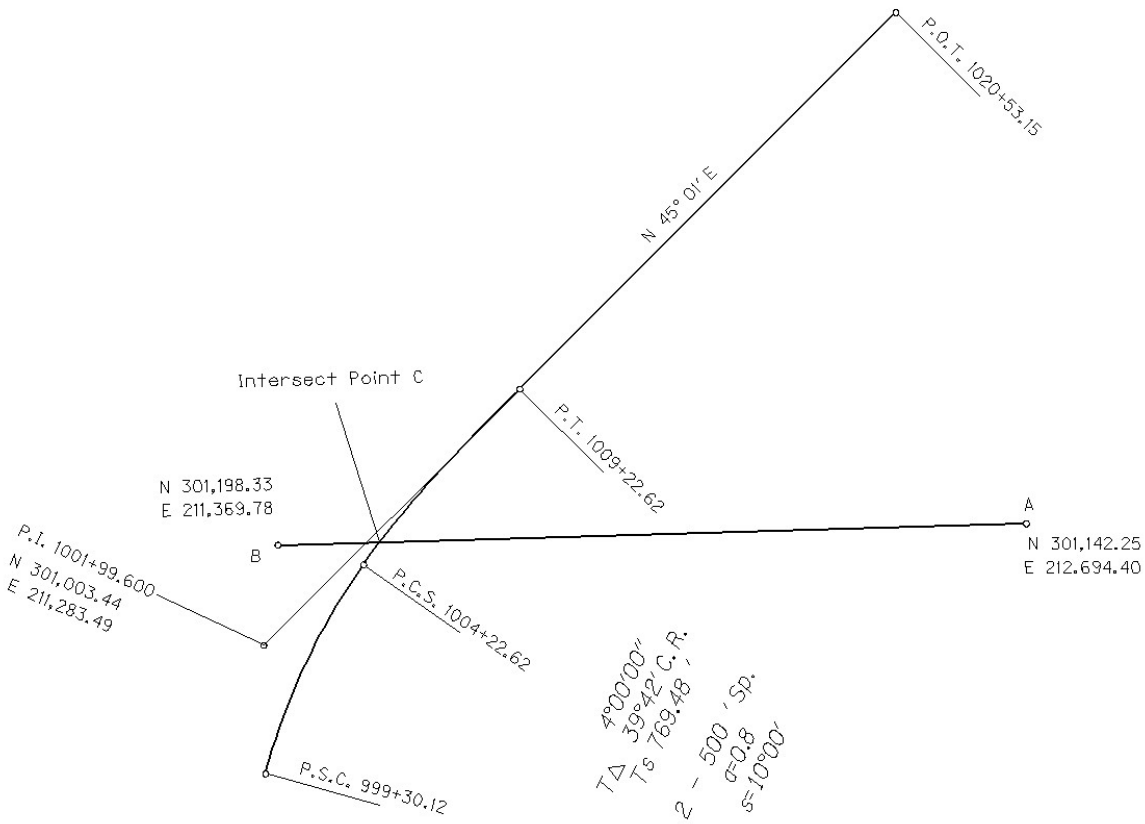
Workspace for Solving Problem 1

Answers to Page 7

Centerline Station	Northing	Easting	Offset	Northing	Easting
994+30.12 PS	300,237.28	211,212.19			
999+30.12 PSC	300,730.93	211,287.28	160’ Lt	300,773.18	211,132.96
1001+00 POC	300,891.72	211,341.75	300’ Lt	301,004.64	211,063.81
1004+22.62 PCS	301,174.47	211,495.68	100’ Lt	301,231.85	211,413.78
1008+00 POS	301,460.40	211,741.32	250’ Lt	301,635.36	211,562.75
1009+22.62 PT	301,547.38	211,827.75			

Problem 2

- ► From R/W Map 8B-29-15
- ► Calculate the Centerline and Property Line Intersection Coordinates of Landowner X near Station 1005.



Intersect Point "C" Station	Northing	Easting

Steps

1. Validate Givens
2. Calculate PT coordinates
3. Guess spiral lengths to a point on either side of intersection (LG1 and LG2)
4. Calculate coordinates for C1 and C2 (points on either side of intersection)
5. Calculate angle BAC1 and BAC2 (or linear offset)
6. Proportion angles to determine an additive spiral length for LG1
7. Calculate C3 coordinates (using new spiral length)
8. Calculate angle BAC2 and BAC3 (or linear offset)
9. Repeat steps 6, 7, and 8 until you converge on a solution within the required precision.

Workspace for Solving Problem 2

Answers to Page 11

Intersect Point "C" Station	Northing	Easting
1004+44.70	301,192.46	211,508.49