Kevin Akin
LS Construction Review

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What to Study?

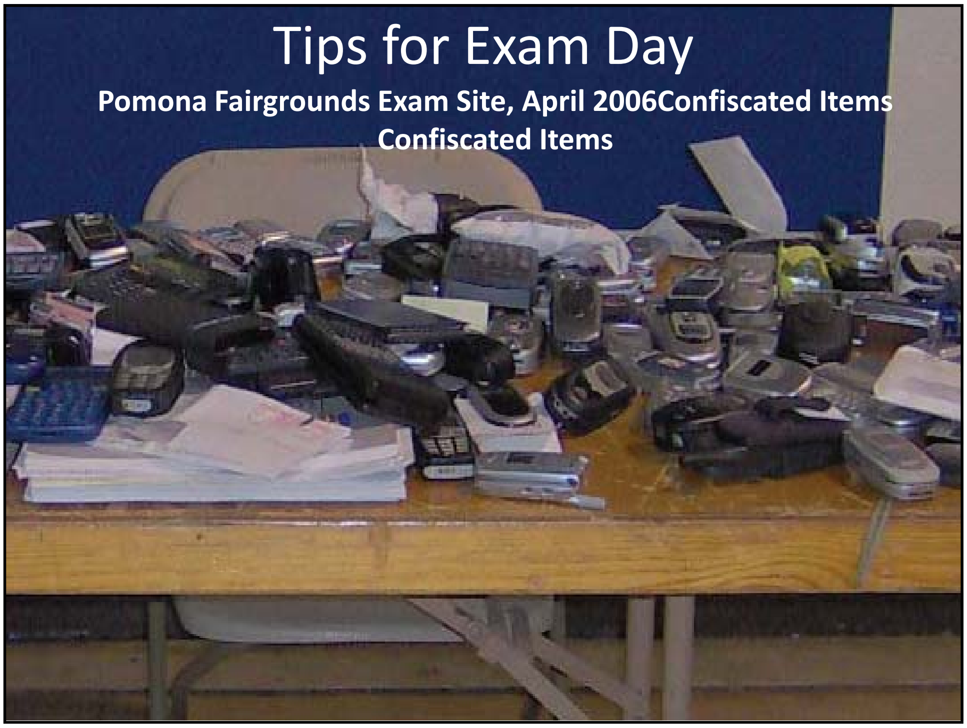
- http://www.pels.ca.gov/
  - Construction is a small part of the State Specific and NCEES exams
- Study and be familiar with
  - Route surveying
  - Circular curves
  - Vertical curves
  - Computing area of a cross-section
  - Staking
  - Stake Marking

Tips for Exam Day

- This is a Professional Licensure Exam
- Behave & **think** PROFESSIONALLY
- Follow all directions and instructions
- *Arrive early – before the doors open
- *Be ready for any weather conditions
- *Bring lunch and water packed in your car
- Bring your admittance notice
- Bring your valid government issued ID
- Bring appropriate reference materials
- Have a plan for the day made the day before
  - What to wear
  - What to have for breakfast, etc.

Tips for Exam Day

- Bring an appropriate calculator
- Bring a spare calculator or at least batteries
- Don’t stress
- Manage your time wisely
- Answer the questions that are asked of you
- **Do not bring an un-authorized calculator**
- **Do not bring any writing implements**
- **Do not bring cell phone, iPod, or loose paper or any other un-authorized items**
- **Do not look at anyone else’s exam**
- **Stop writing/erasing when time is called**
- **Do not discuss exam content**



Test Strategy

- Stay relaxed!!!
- Sketch out problems
- Skip construction problems you don’t know, understand, or are overly complicated
- Don’t get bogged down
- Work on large point value problems
- Return to unfinished problems as time permits
- Finish as much as you can

Calculator Strategy

- Know what calculators are allowed
- Have programs for
  - Calculating along alignment and station and outs
  - Circular curves
  - Vertical curves
  - Intersection
  - Area by coordinate
- Be fluent with the calculator and programs

Reference List

- **Caltrans Surveys Manual - Chapter 12,** 2006
- **Definitions of Surveying and Associated Terms,** 2005
  American Congress on Surveying and Mapping

A TEXT SIMILAR TO ONE OF THE FOLLOWING:

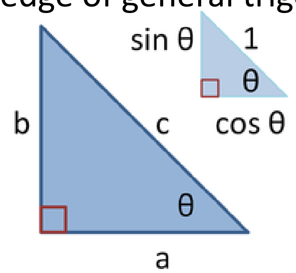
- **Elementary Surveying,** 13th Edition, 2007
  C. D. Ghilani and P. R. Wolf
- **Surveying,** 10th Edition, 1997
  F. H. Moffitt and J. Bossler
  Prentice Hall
- **Surveying: Theory and Practice,** 7th Edition, 1998
  Davis, Foote, Anderson and Mikhail
  McGraw-Hill, Inc., New York
- **Surveying with Construction Applications,** 6th Edition, 2006
  Barry F. Kavanagh
  Prentice-Hall, Inc., Upper Saddle River, N.J.

Construction Surveys

- Provide the reference points to guide the contractor to correctly place project items both horizontally and vertically
- Must be based on the same control system as the topographic survey and thus the design
- Items may be referenced to points or lines (horizontal alignments) in the plans
- Some items are more critical than others
- Some items are more critical horizontally
- Some items are more critical vertically

K31. Knowledge of general trigonometric formulas

- **Sin = o/h**
- **Cos = a/h**
- **Tan = o/a**



- **Law of Sines**

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C},$$ **and/or** $$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}.$$

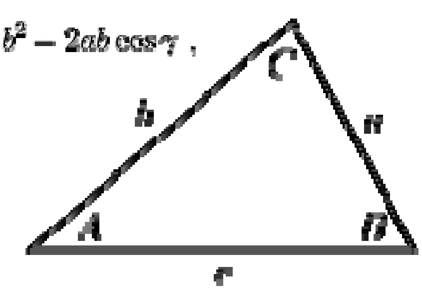
- **Law of Cosines**

$$c^2 = a^2 + b^2 - 2ab\cos\gamma\,,$$

$$c = \sqrt{a^2 + b^2 - 2ab\cos\gamma}\,;$$

$$\gamma = \arccos\frac{a^2 + b^2 - c^2}{2ab}\,;$$

$$a = b\cos\gamma \pm \sqrt{c^2 - b^2\sin^2\gamma}\,.$$



Construction Surveys

- Construction surveys provide:
  - Contractor guidance to build the project
  - Engineer reference points and stakes from which to inspect the contractor's work
- **SOAP BOX WARNING!**
  - **Construction surveys are the Engineer's last line of defense to identify design errors in the plans**
  - **If Surveys doesn't catch it – it may get built!**
  - **Try to find your own errors too**

Route Surveys

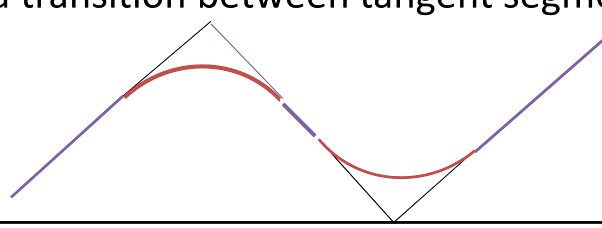
- Route surveys involve the development and control of linear public or private improvement projects such as:
- Highways
- Roads
- Power lines
- Pipelines
- Other linear features
- Have a Horizontal alignment
- Have a Vertical alignment or "profile"

Stationing

- If the beginning of an alignment is 0+00 how far is station 1+78.90 from the beginning?
- Does an alignment always have to start at 0+00?
- Is an alignment always on the centerline?
- What does A2+34.54 = B 3+78.11 mean?
- What does A2+34.54 = A 2+40.11 mean?
- Are Feet and Metric alignment stationed the same?
- How is Left and Right determined?

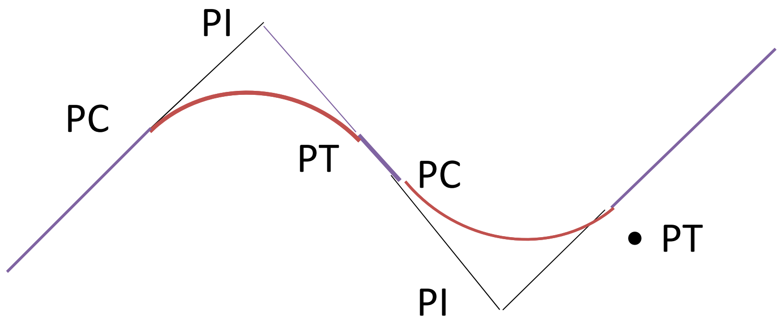
Route Alignments

- A Route Alignment is the horizontal path of a roadway, pipeline, or other linear feature
- Stationing is used to describe location or horizontal distance along the route alignment
- Roadway Alignments are typically a series of straight line segments called “tangents” with horizontal curve segments between them to provide a transition between tangent segments



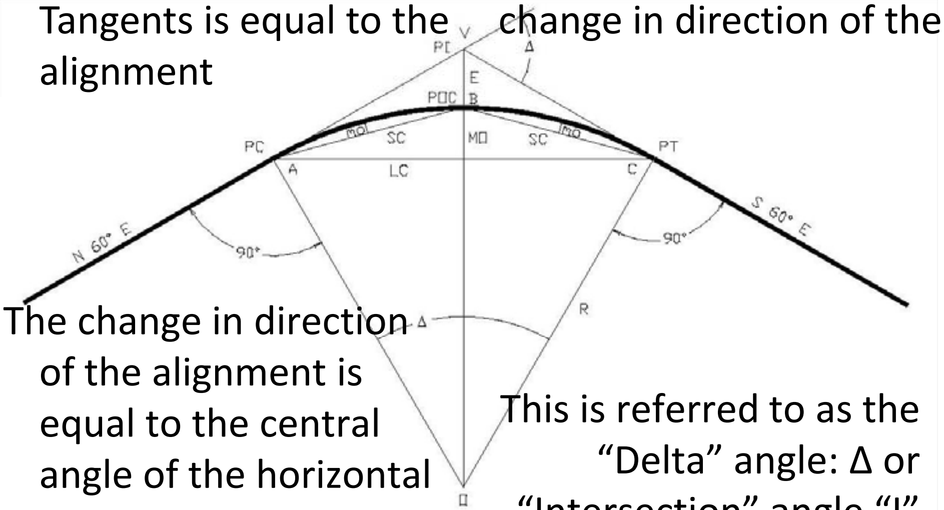
Properties of Alignments

- Tangent alignment segments are straight lines
- Tangents have a bearing & horizontal distance
- Tangents extend past a Point of Curvature (PC)
- Tangents intersect at a Point of Intersection (PI)
- Tangents to a horizontal curve are equal length



Properties of Alignments

- The “Intersection” angle at the PI between the Tangents is equal to the change in direction of the alignment

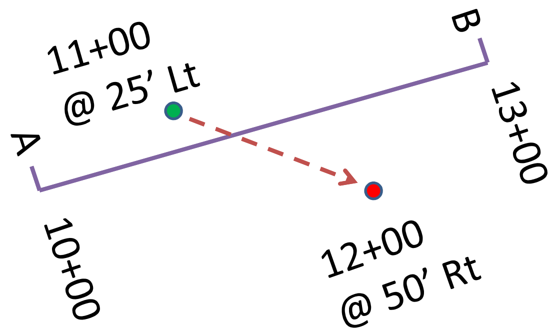


The change in direction of the alignment is equal to the central angle of the horizontal curve

This is referred to as the “Delta” angle: Δ or “Intersection” angle “I”

Station and Offset Exercise #1

- Calculate the direct distance from the green dot to the red dot?



Station and Offset Exercise #1

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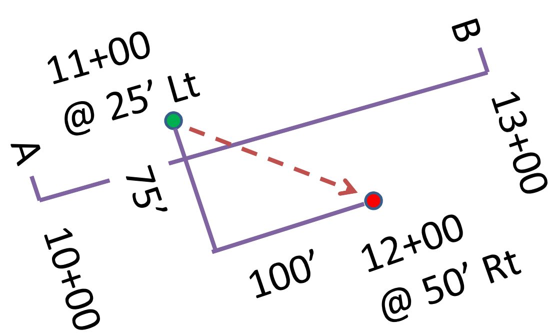
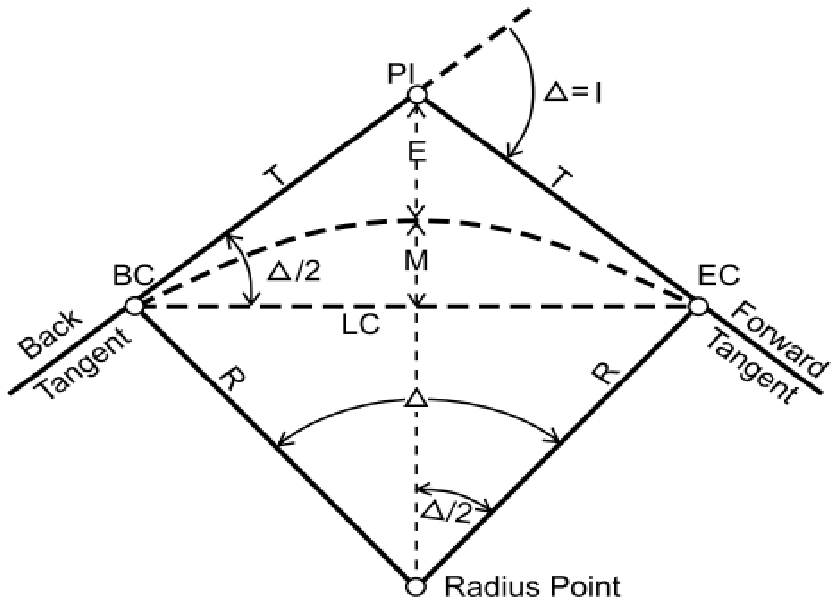


$c = \sqrt{(75')^2 + (100')^2}$

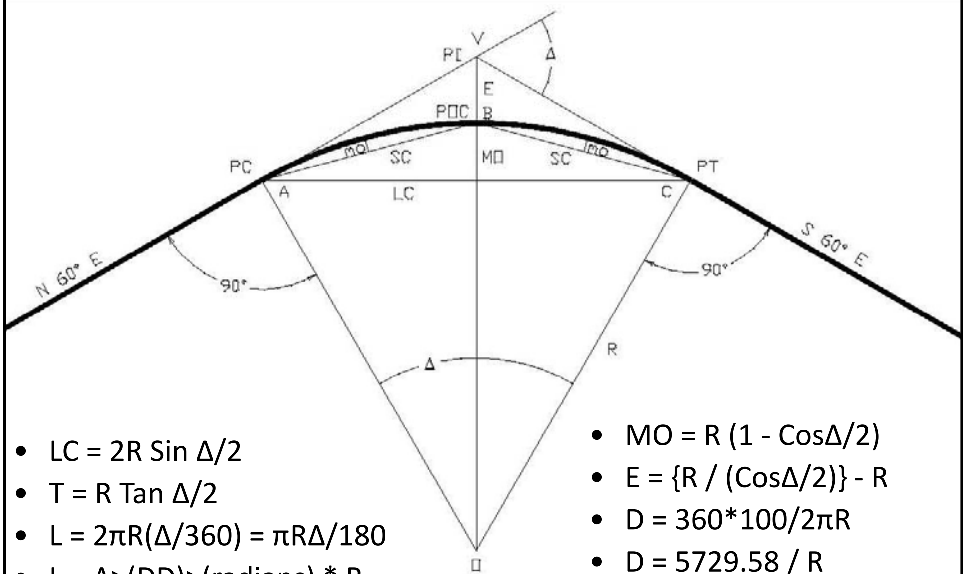
Components of Horizontal Circular Curves



Circular Curves

- Do you have the circular formulas memorized?
  - L length of curve
  - LC long chord
  - T Tangent
  - L Length of curve
  - M middle ordinate distance
  - E external distance
- Do you understand them?

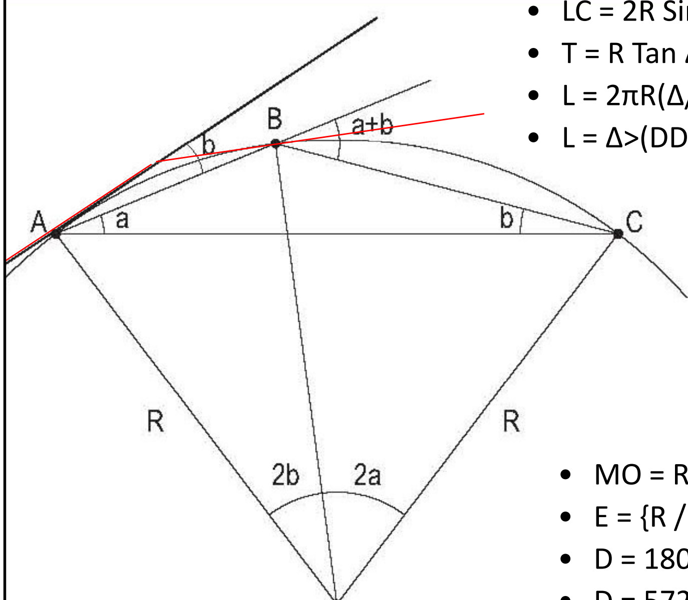
K34. Knowledge of the geometric properties and equations of a curve



- $LC = 2R \sin \Delta/2$
- $T = R \tan \Delta/2$
- $L = 2\pi R(\Delta/360) = \pi R\Delta/180$
- L = Δ>(DD)>(radians) * R

- $MO = R (1 - \cos\Delta/2)$
- $E = \{R / (\cos\Delta/2)\} - R$
- $D = 360*100/2\pi R$
- $D = 5729.58 / R$

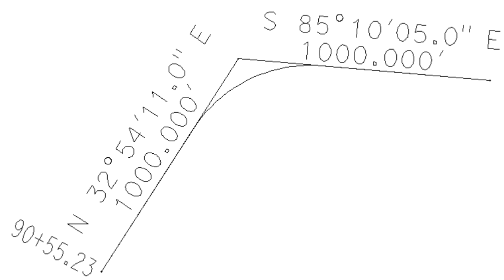
K35. Knowledge of curve deflections



- $LC = 2R \sin \Delta/2$
- $T = R \tan \Delta/2$
- $L = 2\pi R(\Delta/360) = \pi R\Delta/180$
- L = Δ>(DD)>(radians) * R

$$R = \frac{AC}{2 \sin (a+b)}$$

- $MO = R (1 - \cos\Delta/2)$
- $E = \{R / (\cos\Delta/2)\} - R$
- $D = 180/\pi / R$
- $D = 5729.58 / R$



A. Two street centerlines intersect as shown above. A curve with a radius of 550.00 ft. will connect the streets. Compute the following:

1) BC Station : __________________

2) EC Station: __________________

3) Tangent Length: __________________

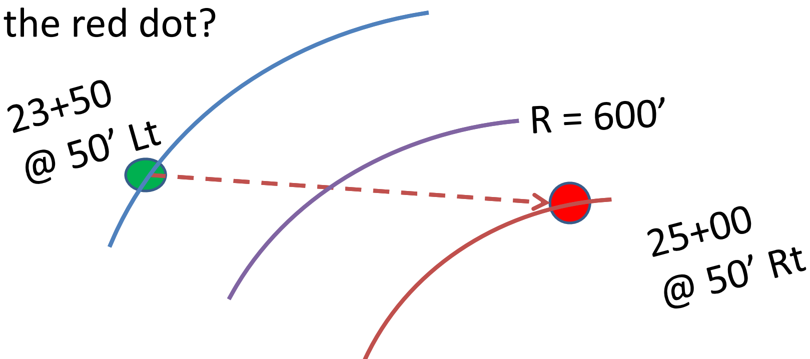
4) Length of Curve: __________________

5) Delta: __________________

6) A total station is set up on the PC backsighting the PI. Compute the angle and distance to station 101+05.60.

Station and Offset Exercise #2

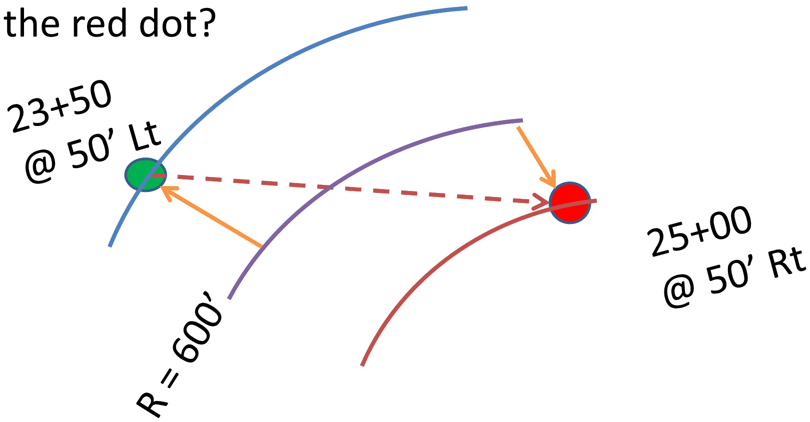
- Calculate the direct distance from the green dot to the red dot?



- What do we know?
- Do we have circles?
- Do we have triangles?

Station and Offset Exercise #2

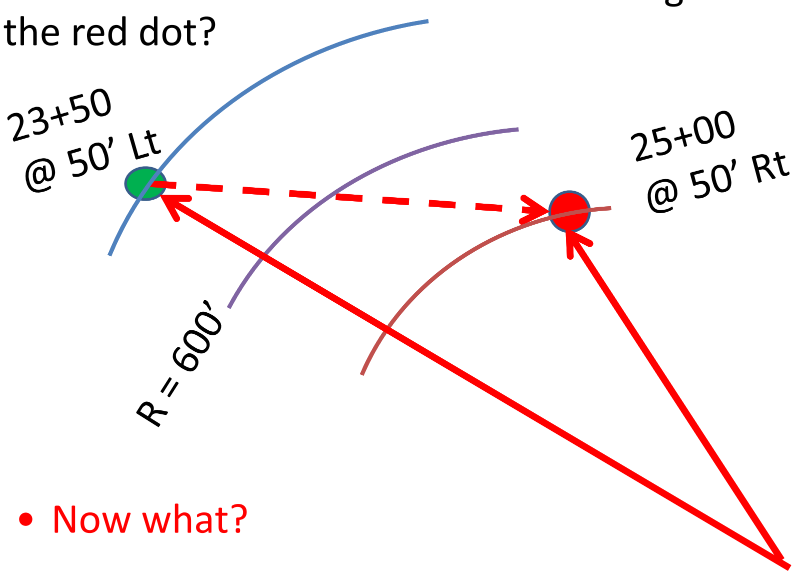
- Calculate the direct distance from the green dot to the red dot?



- Where is the triangle?

Station and Offset Exercise #2

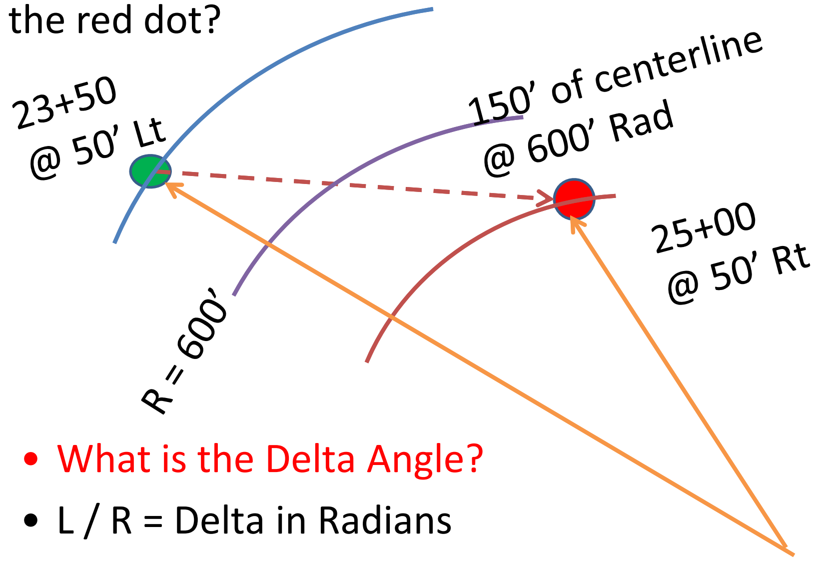
- Calculate the direct distance from the green dot to the red dot?



- Now what?

Station and Offset Exercise #2

- Calculate the direct distance from the green dot to the red dot?

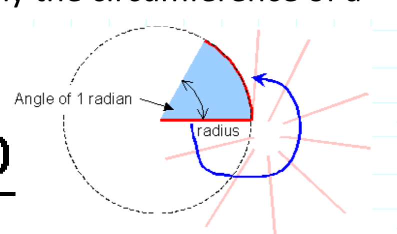


- What is the Delta Angle?
- L / R = Delta in Radians

What are 'radians' ?

- One radian is the angle of an arc created by wrapping the radius of a circle around its circumference.
- In this diagram, the radius has been wrapped around the circumference to create an angle of 1 radian. The pink lines show the radius being moved from the inside of the circle to the outside:
- The radius 'r' fits around the circumference of a circle exactly 2pi times. That is why the circumference of a circle is given by:
- circumference = 2(pi)r

$$\text{degrees} = \text{radians} \times \frac{180}{\pi}$$



Station and Offset Exercise #2

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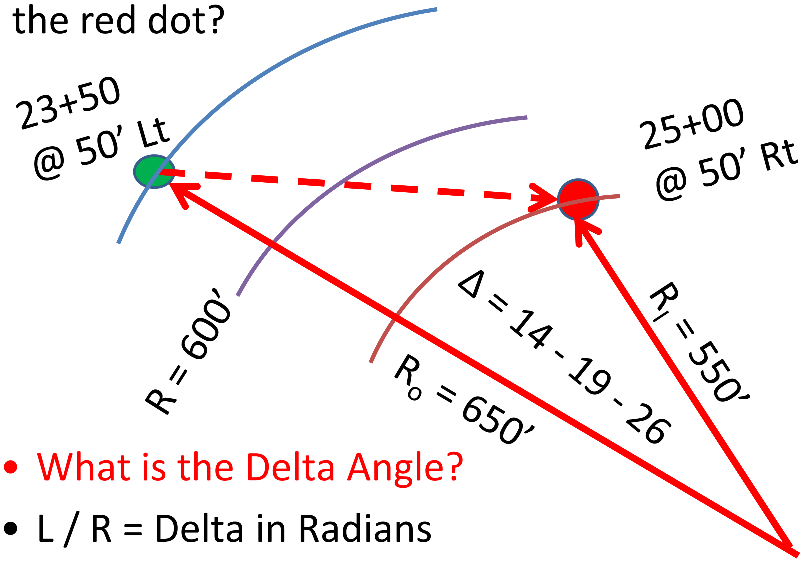

- What is the Delta Angle?
- L / R = Delta in Radians

Station and Offset Exercise #2

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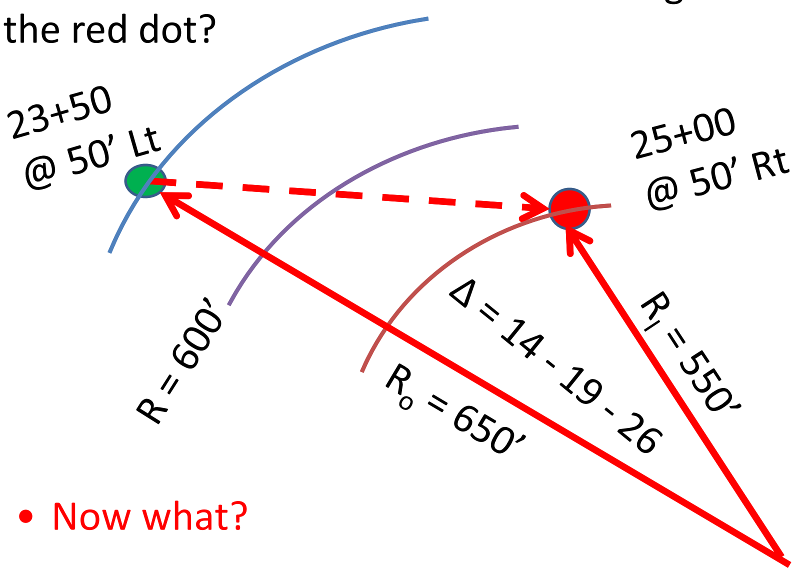

- Now what?

Station and Offset Exercise #2

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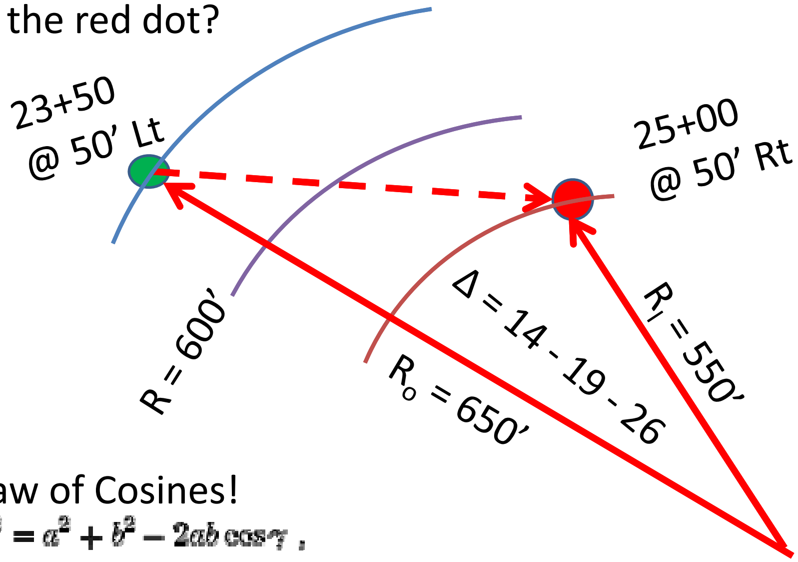
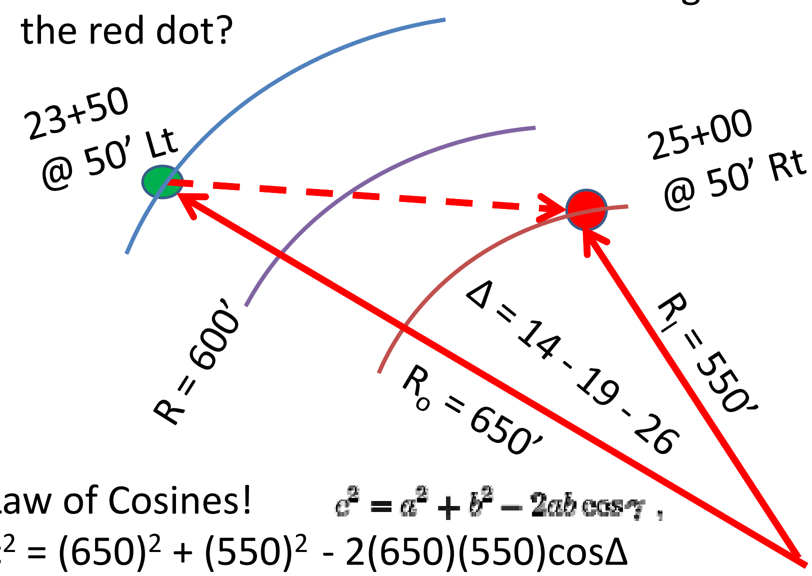


Law of Cosines!

$c^2 = a^2 + b^2 - 2ab\cos\gamma$,

Station and Offset Exercise #2

- Calculate the direct distance from the green dot to the red dot?

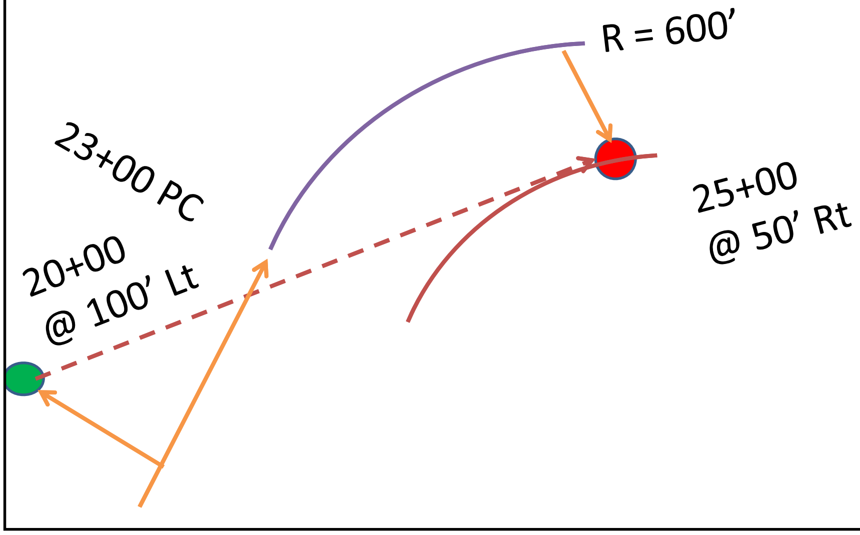


Law of Cosines! $c^2 = a^2 + b^2 - 2ab\cos\gamma$,

$c^2 = (650)^2 + (550)^2 - 2(650)(550)\cos\Delta$

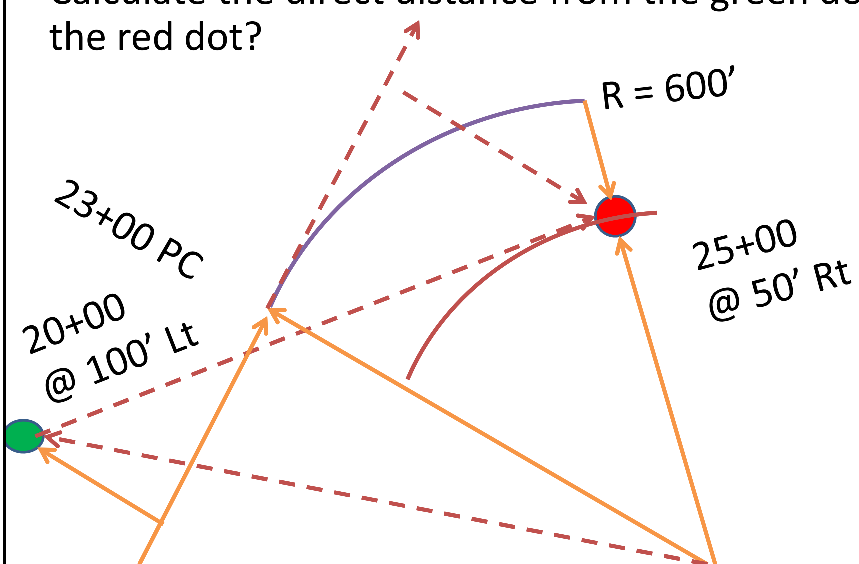
Station and Offset Exercise #3

- Calculate the direct distance from the green dot to the red dot?



Station and Offset Exercise #3

- Calculate the direct distance from the green dot to the red dot?



Station and Offset Exercise #3

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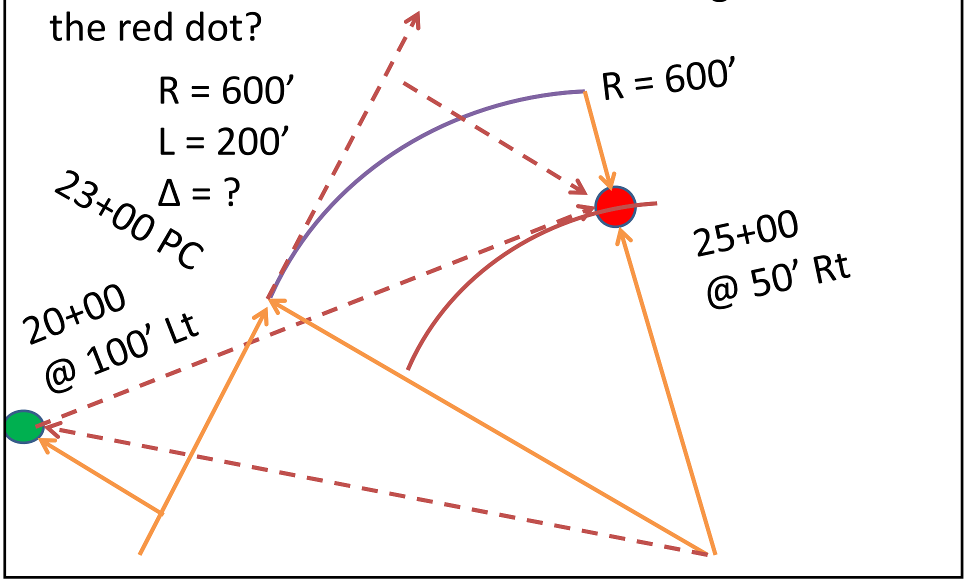

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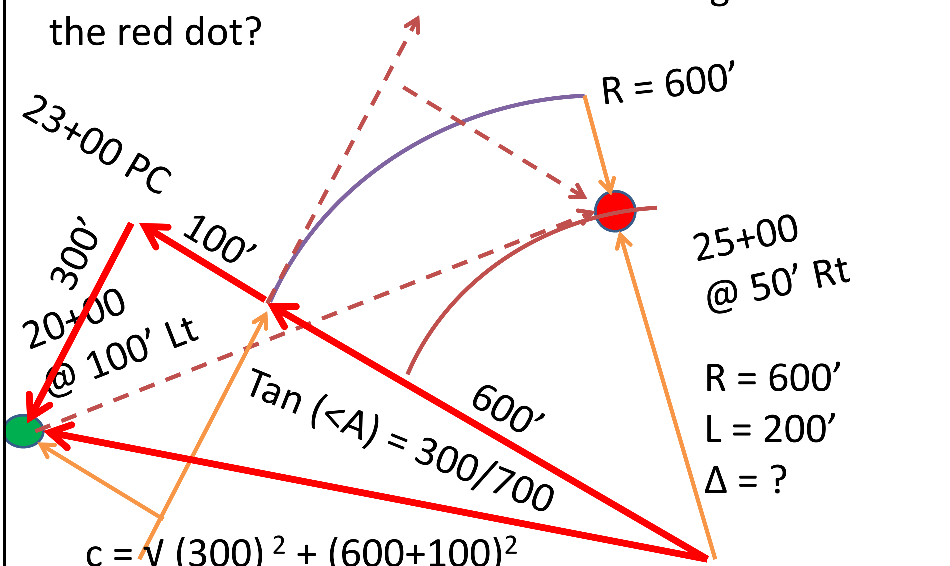
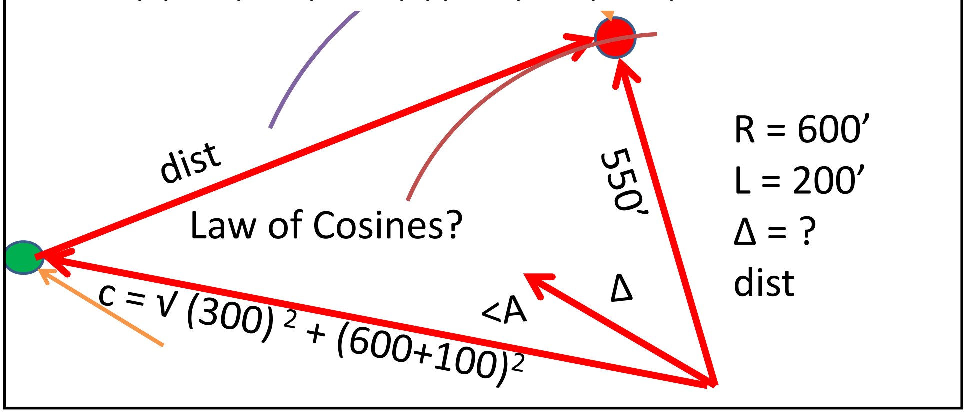


Station and Offset Exercise #3

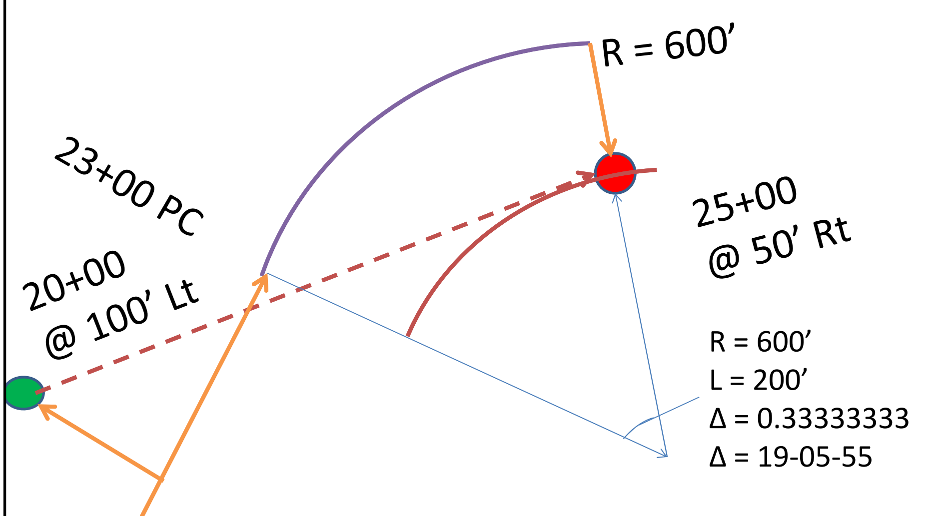
- Calculate the direct distance from the green dot to the red dot?

Law of Cosines!
$dist^2 = (c)^2 + (550)^2 - 2(c)(550)\cos(\Delta+A)$



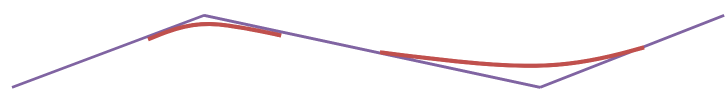
Station and Offset Exercise #3

- Alternate method of calculating this distance?



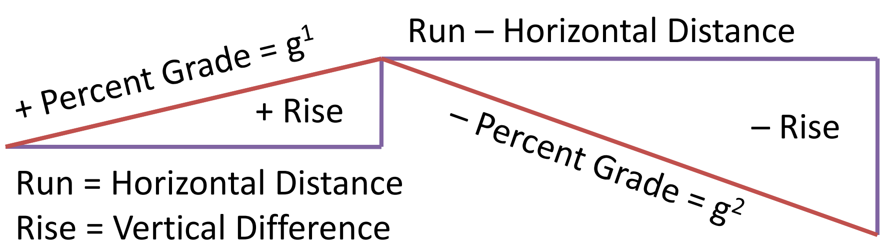
Route Profiles

- A Profile is the vertical alignment of a route
- Profiles include straight grade lines and vertical curves grade lines
- Straight grade lines are lines of constant grade
- Straight grade lines have a point of intersection
- Vertical curves grade lines provide smooth transitions between straight grade lines



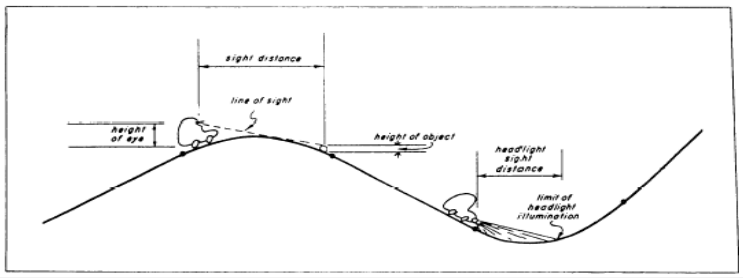
Straight Grade Lines

- Straight grade lines are lines of constant grade
- How steep is the road? Percent Grade?
- Rise over Run
- Straight grade lines have a point of intersection
- Vertical curves provide smooth transitions between adjacent straight grade lines

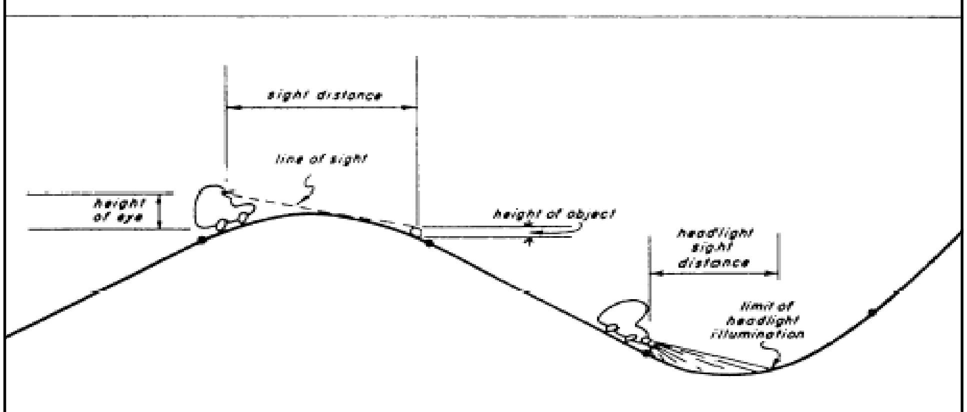


Vertical Curve Lines

- Vertical curves are curves in the vertical plane
- Vertical curves are tangent parabolic curves
- Vertical curves provide smooth transitions between straight grade lines
- Vertical curves have a point of intersection of the straight grade lines
- Vertical curves are either CREST or SAG



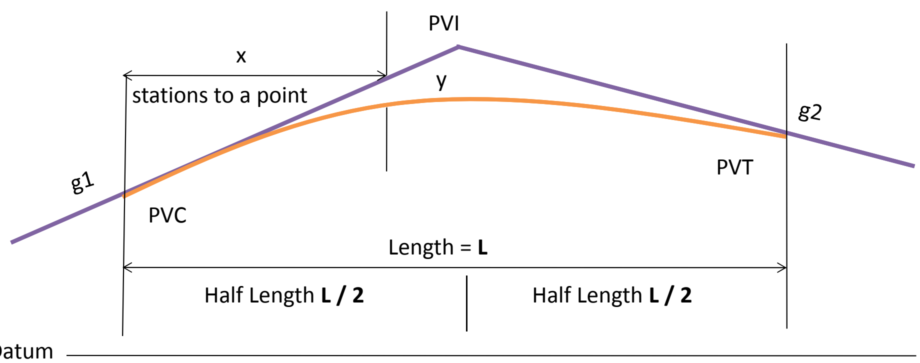
Crest and Sag vertical curves



Equal Length Vertical Curve

- Vertical Curve length is determined horizontally
- Vertical Curves are tangent to Straight Grades
- Grade change is gradual throughout
- Grade change is continuous throughout
- PVI is equal distance from the PVC and PVT

Equal Length Vertical Curve



PVC Elevation (above datum) = Y_{PVC}

Length in Stations = L $y = ax^2$ $a = [(g^2 - g^1) / (2L)]$ $e = a (L / 2)^2$

Tangent elevation = $Y_{PVC} + g^1x$ $r = (g^2 - g^1) / L$

Curve elevation $= Y_{PVC} + g^1x + ax^2$

$= Y_{PVC} + g^1x + [(g^2 - g^1) / (2L)]\, x^2$

Procedures for vertical curve calcs

Store the value for the PVC elevation: $\mathbf{Y_{PVC}}$

Calculate and store the value for **a** $= [(g^2 - g^1) / (2L)]$

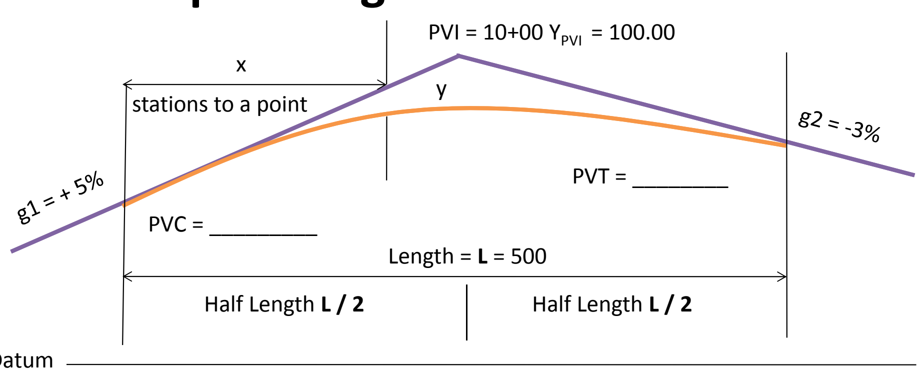
Calculate intermediate point elevations

Calculate the high or low point elevation

Point on Curve elevation = $Y_{PVC} + g^1x + ax^2$

Station	x	x^2	ax^2	g^1x	PVC Elev	Elev Curve
PVC	0	0				
	1	1				
	2	4				
	3	9				
	4	16				
	5	25				
EVC	6	36				

Equal Length Vertical Curve



PVC Elevation (above datum) = Y_{PVC}

Length in Stations = L $y = ax^2$ $a = [(-3 - 5) / 2(5)] = -0.8$ $e = a (L / 2)^2$

Tangent elevation = $Y_{PVC} + g^1x$ $r = (g^2 - g^1) / L$

Curve elevation $= Y_{PVC} + g^1x + ax^2$

$= Y_{PVC} + g^1x + [(g^2 - g^1) / (2L)]\, x^2$

Horizontal Distance to Maximum or Minimum in Stations $x_m = -g^1 / 2a = g^1 L / (g^1 - g^2)$

Procedures for vertical curve calcs

Calculate and store PVC station: ____________
Calculate and store PVC elevation: $\mathbf{Y_{PVC}}$ ________Calc $\mathbf{Y_{PVT}}$______
Calculate and store **a** = $[(g^2 - g^1)/(2L)] = [(-3 - 5)/2(5)]$ = **- 0.8**
Calculate intermediate point elevations
Calculate the high or low point station $x_m = -g^1 / 2a = g^1 L / (g^1 - g^2)$
Calculate the high or low point elevation from the station
Point on Curve elevation = $\mathbf{ax^2 + g^1x + Y_{PVC}}$

Station	x	x^2	ax^2 +	g^1x +	$Y_{PVC\ (Elev)}$	Elev
PVC 7+50	0	0	0	0	87.50	87.50
8+00	0.5				87.50	
9+00	1.5				87.50	
10+00	2.5				87.50	
10+62.5 (max)	3.125				87.50	
11+00	3.5				87.50	
12+00	4.5				87.50	
EVC 12+50	5				87.50	

Procedures for vertical curve calcs

Calculate and store PVC station: ____________
Calculate and store PVC elevation: $\mathbf{Y_{PVC}}$ _______ Calc $\mathbf{Y_{PVT}}$______
Calculate and store **a** = $[(g^2 - g^1)/(2L)] = [(-3 - 5)/2(5)]$ = **- 0.8**
Calculate intermediate point elevations
Calculate the high or low point station $x_m = -g^1 / 2a = g^1 L / (g^1 - g^2)$
Calculate the high or low point elevation from the station
Point on Curve elevation = $\mathbf{ax^2 + g^1x + Y_{PVC}}$

Station	x	x^2	ax^2 +	g^1x +	$Y_{PVC\ (Elev)}$	Elev
PVC 7+50	0	0	0	0	87.50	87.50
8+00	0.5	0.25	-0.20	2.5	87.50	89.80
9+00	1.5				87.50	93.20
10+00	2.5				87.50	95.00
10+62.5 (max)	3.125				87.50	95.31
11+00	3.5				87.50	95.20
12+00	4.5				87.50	93.80
EVC 12+50	5				87.50	92.50

Procedures for vertical curve calcs

Calculate and store PVC station: ___________
Calculate and store PVC elevation: $\mathbf{Y_{PVC}}$ ______ Calc $\mathbf{Y_{PVT}}$ _____
Calculate and store **a** = $[(g^2 - g^1)/(2L)] = [(-3 - 5)/2(5)] = \mathbf{-0.8}$
Calculate intermediate point elevations
Calculate the high or low point station $x_m = -g^1 / 2a = g^1 L / (g^1 - g^2)$
Calculate the high or low point elevation from the station
Point on Curve elevation = $\mathbf{ax^2 + g^1x + Y_{PVC}}$

Station	x	x^2	ax^2 +	g^1x +	$Y_{PVC\,(Elev)}$	Elev
PVC 7+50	0	0	0	0	87.50	87.50
8+00	0.5	0.25	-0.20	2.5	87.50	89.80
9+00	1.5	2.25	-1.80	7.50	87.50	93.20
10+00	2.5				87.50	
10+62.5 (max)	3.125				87.50	
11+00	3.5				87.50	
12+00	4.5				87.50	
EVC 12+50	5				87.50	

Procedures for vertical curve calcs

Calculate and store PVC station: ___________
Calculate and store PVC elevation: $\mathbf{Y_{PVC}}$ ______ Calc $\mathbf{Y_{PVT}}$ _____
Calculate and store **a** = $[(g^2 - g^1)/(2L)] = [(-3 - 5)/2(5)] = \mathbf{-0.8}$
Calculate intermediate point elevations
Calculate the high or low point station $x_m = -g^1 / 2a = g^1 L / (g^1 - g^2)$
Calculate the high or low point elevation from the station
Point on Curve elevation = $\mathbf{ax^2 + g^1x + Y_{PVC}}$

Station	x	x^2	ax^2 +	g^1x +	$Y_{PVC\,(Elev)}$	Elev
PVC 7+50	0	0	0	0	87.50	87.50
8+00	0.5	0.25	-0.20	2.5	87.50	89.80
9+00	1.5	2.25	-1.80	7.50	87.50	93.20
10+00	2.5	6.25	-5.00	12.50	87.50	95.00
10+62.5 (max)	3.125				87.50	
11+00	3.5				87.50	
12+00	4.5				87.50	
EVC 12+50	5				87.50	

Procedures for vertical curve calcs

Calculate and store PVC station: ___________

Calculate and store PVC elevation: $\mathbf{Y_{PVC}}$ ______ Calc $\mathbf{Y_{PVT}}$______

Calculate and store **a** = $[(g^2 - g^1)/(2L)] = [(-3 - 5)/2(5)] = \mathbf{-0.8}$

Calculate intermediate point elevations

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9+00	1.5	2.25	-1.80	7.50	87.50	93.20
10+00	2.5	6.25	-5.00	12.50	87.50	95.00
10+62.5 (max)	3.125	9.7656	-7.8125	15.625	87.50	95.31
11+00	3.5				87.50	
12+00	4.5				87.50	
EVC 12+50	5				87.50	

Procedures for vertical curve calcs

Calculate and store PVC station: ___________

Calculate and store PVC elevation: $\mathbf{Y_{PVC}}$ ______ Calc $\mathbf{Y_{PVT}}$______

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Calculate intermediate point elevations

Calculate the high or low point station $x_m = -g^1 / 2a = g^1 L / (g^1 - g^2)$

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10+00	2.5	6.25	-5.00	12.50	87.50	95.00
10+62.5 (max)	3.125	9.7656	-7.8125	15.625	87.50	95.31
11+00	3.5	12.25	-9.80	17.5	87.50	95.20
12+00	4.5				87.50	
EVC 12+50	5				87.50	

Procedures for vertical curve calcs

Calculate and store PVC station: ___________

Calculate and store PVC elevation: $\mathbf{Y_{PVC}}$ ______ Calc $\mathbf{Y_{PVT}}$______

Calculate and store **a** = $[(g^2 - g^1)/(2L)] = [(-3 - 5)/2(5)] = \mathbf{-0.8}$

Calculate intermediate point elevations

Calculate the high or low point station $x_m = -g^1 / 2a = g^1 L / (g^1 - g^2)$

Calculate the high or low point elevation from the station

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10+00	2.5	6.25	-5.00	12.50	87.50	95.00
10+62.5 (max)	3.125	9.7656	-7.8125	15.625	87.50	95.31
11+00	3.5	12.25	-9.80	17.5	87.50	95.20
12+00	4.5	20.25	-16.20	22.5	87.50	93.80
EVC 12+50	5					

Procedures for vertical curve calcs

Calculate and store PVC station: ___________

Calculate and store PVC elevation: $\mathbf{Y_{PVC}}$ ______ Calc $\mathbf{Y_{PVT}}$______

Calculate and store **a** = $[(g^2 - g^1)/(2L)] = [(-3 - 5)/2(5)] = \mathbf{-0.8}$

Calculate intermediate point elevations

Calculate the high or low point station $x_m = -g^1 / 2a = g^1 L / (g^1 - g^2)$

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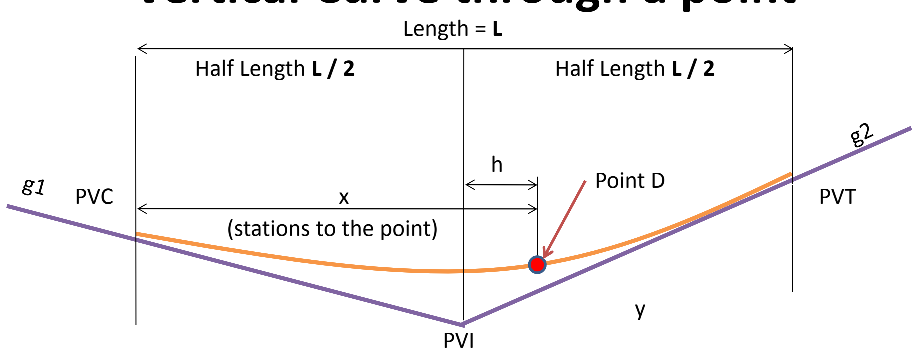
10+00	2.5	6.25	-5.00	12.50	87.50	95.00
10+62.5 (max)	3.125	9.7656	-7.8125	15.625	87.50	95.31
11+00	3.5	12.25	-9.80	17.5	87.50	95.20
12+00	4.5	20.25	-16.20	22.5	87.50	93.80
EVC 12+50	5	25	-20.00	25	87.50	92.50

Vertical Curve through a point

- Determine the length of vertical curve required
- To Intersect a certain elevation
- To Provide required clearance to an object

- Substitute given values into Vertical Curve elevation formula: $y = Y^{PVC} + g^1 x + ax^2$
- Determine PVC station & elevation if not given
- Enter Y^{PVC} value into formula
- Substitute Point D elevation for y
- Substitute Point D distance from PVC for x

Vertical Curve through a point



Datum

PVC Elevation (above datum) = Y_{PVC} Length in Stations = L $h = PVI_{station} - D_{station}$

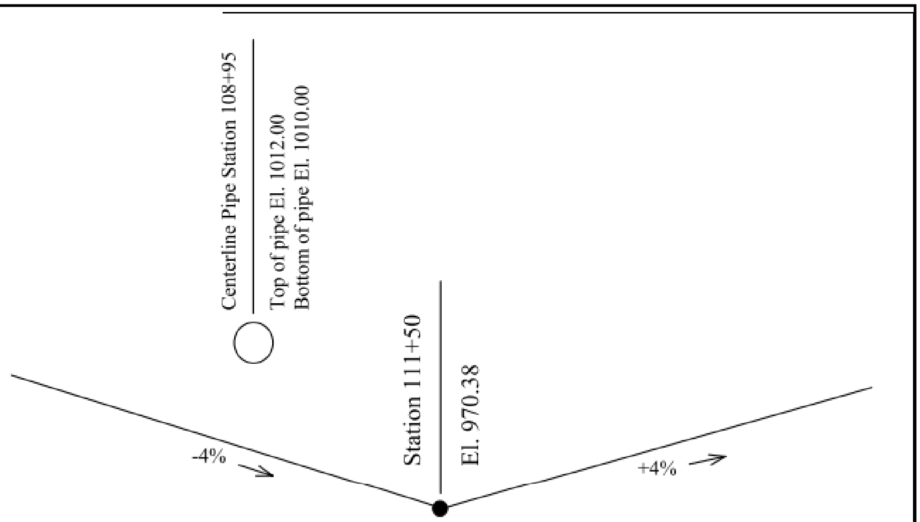
Tangent elevation = $Y_{PVC} + g^1x$ Curve elevation $y = Y_{PVC} + g^1x + ax^2$

$y = ax^2$ $a = [(g^2 - g^1) / (2L)]$ $e = a (L / 2)^2$ $r = (g^2 - g^1) / L$ $Y_{PVC} = Y_{PVI} - g^1 (L/2)$

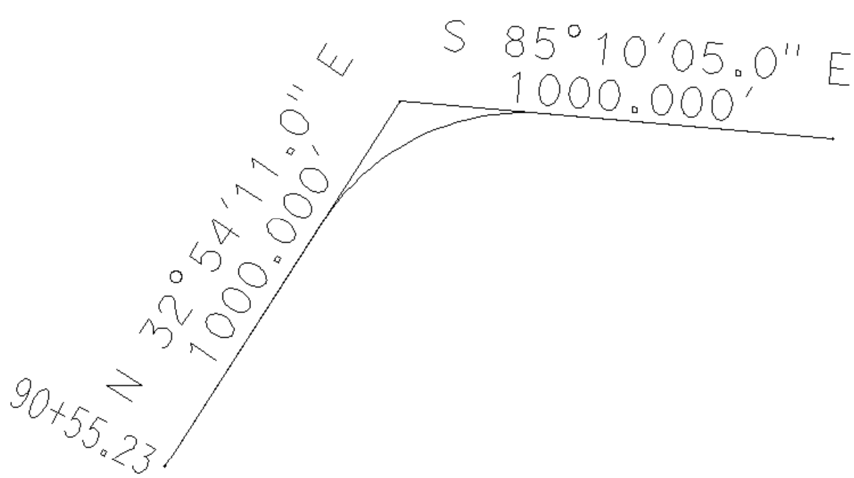
Elevation of Point D = $Y_{PVC} + g^1x + [(g^2 - g^1) / (2L)]\, x^2$

Horizontal Distance to Maximum or Minimum in Stations

$\mathbf{x_m = - g^1 / 2a = g^1 / r}$



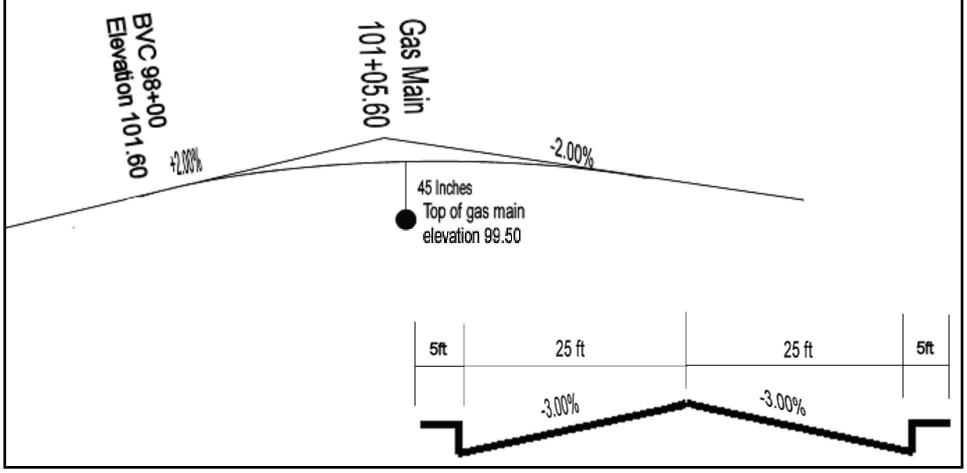
- Calculate length of VC to be 5' above top of pipe



B. During construction a buried gas main was discovered at station 101+05.60 crossing the road perpendicularly. Use the typical street section, elevations, and grade information shown below to design a vertical curve. The minimum distance from the top of the AC to the top of the gas main must be 45 inches. Compute:

The length of the vertical curve: ____________________

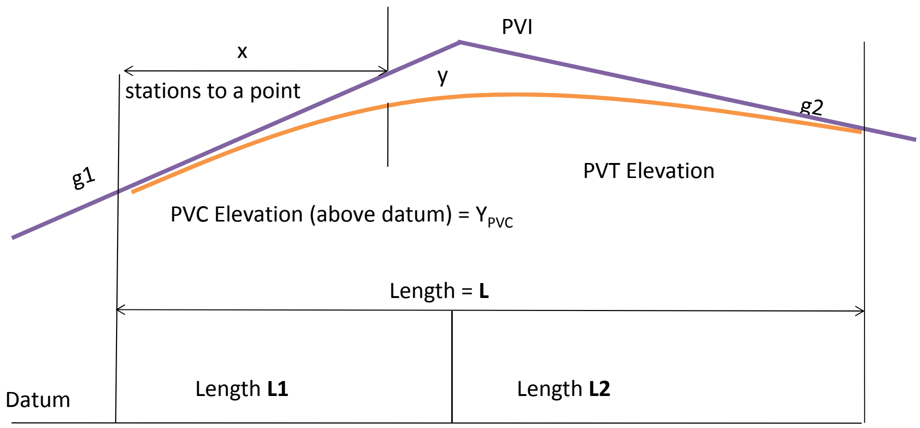
The Station and elevation of the EVC: ____________________



Un-Equal Tangent Vertical Curve

- Made of 2 Equal length Vertical Curves which meet at the PVI station
- Tangent lengths are Un-Equal T_1 and T_2
- Vertical Curve length is determined horizontally

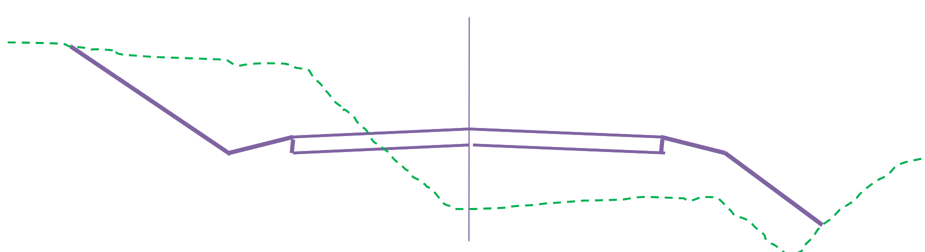
Un-Equal Tangent Vertical Curve



See handout for formulas

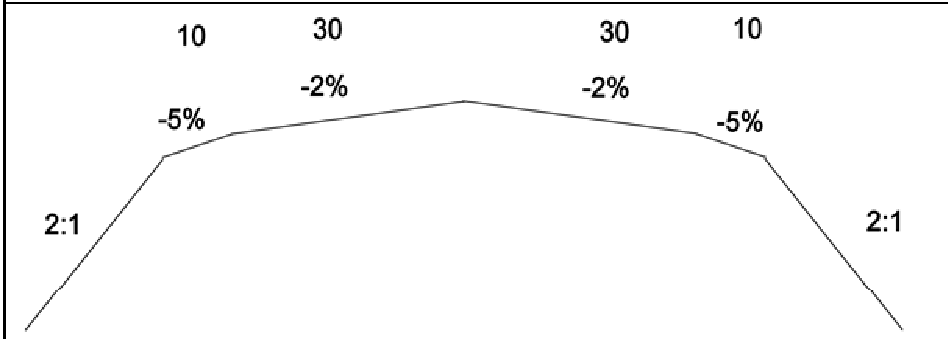
Route Cross Sections

- A Route Cross Section is the shape of the planned feature as viewed looking up-station
- The Cross Section is a cutaway view at a right angle to the horizontal path of a roadway, pipeline, channel, or other linear feature

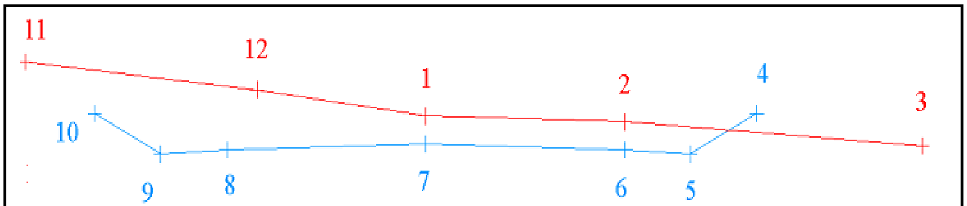


Area by Cross-section (End Area)

- Typical design cross section 20+00.00 CL EL = 45.4



- OG cross Section @ 20+00.00
- 55.6 52.2 49.0 48.1 45.2
- -60.4 -25.4 0 30.6 75.1

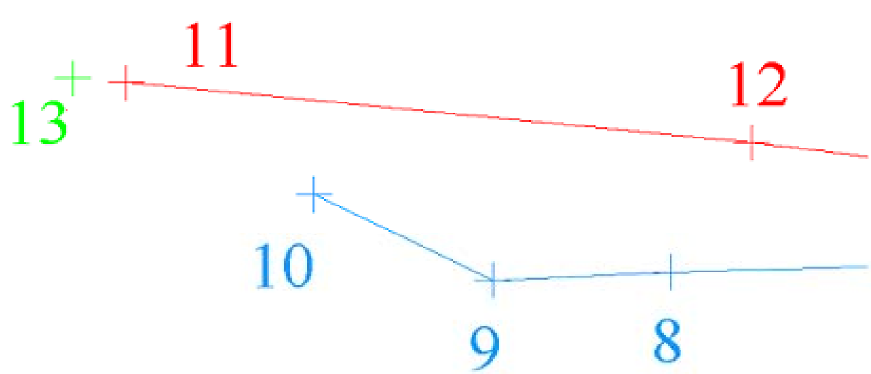


- 55.6 52.2 49.0 48.1 45.2
- -60.4 -25.4 0 30.6 75.1
- 49.3 44.3 44.8 45.4 44.8 44.3 49.3
- -50.0 -40.0 -30.0 0 30.0 40.0 50.0

Calculate

- Left and Right Catch points (Intersection of design slope with OG)
- Area of cross-section

Left Catch Point



Calculated Catch Points

- **Right Catch Point**
- Elev. 47.1 45.6 Rt.

- **Left Catch Point**
- Elev 55.9 63.1 LT

- **Area**
- 511.6 sq. ft.

Slope Stakes

- Where would you set the slope stake?
- How would the stake be marked?

In laying out a highway for construction, slope stakes are needed. A fill is required at station 14+40; centerline elevation 48.75. The full width of the road from top of slope to top of slope is 36 ft and is level. The road design specifies side slopes of 2.5/1. A trial shot is taken 40.0 ft from the centerline at elevation 42.3. Assuming natural ground is fairly level, how far and in which direction from the trial shot should the "catch point" be located and staked?

A. 19.4 ft toward centerline
B. 5.9 ft away from centerline
C. 5.9 ft toward centerline
D. 19.4 ft away from centerline

Volume

- What is a common way of calculating volumes from end areas?
- Where does this common method not work well?
- What are the typical English and Metric earthwork volumes?

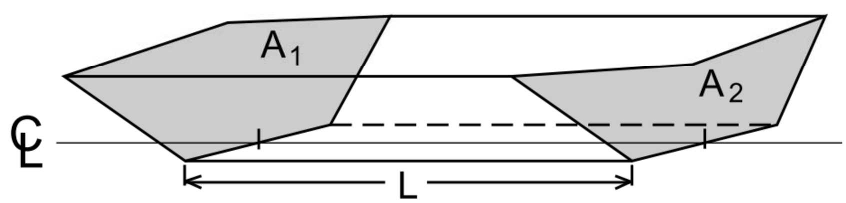
Volume in cu yd

$$2V = \frac{L\,(A_1 + A_2)}{27}$$

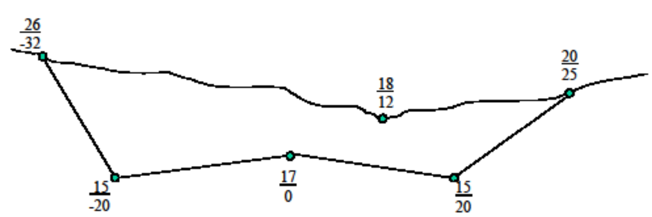
Where:

L = Distance between end areas, A_1 and A_2, in ft

A_1 A_2 = end areas



Area by Coordinates



1. List the y and x coordinates for each vertex counterclockwise, back to the first point to close.
2. Multiply x of each vertex by the y of the next vertex. Add them up.
3. Multiply the y of each vertex by the x of the next vertex. Add them up.
4. Subtract the sum of the products in step 3 from the sum of the products in step 2.
5. Divide by 2 for the area.

Area By Coordinates

y	x	+	-	sum
17	0			
15	20	0	340	-340
20	25	400	375	25
18	12	450	240	210
26	-32	312	-576	888
15	-20	-480	-520	40
17	0	-340	0	-340
		342	- (-141) =	483 ÷ 2 = 241.5sq.ft