

FORMULAS FOR ARC DEFINITION

$$\Delta = \frac{DL}{100}$$

$$D = \frac{5729.58}{R}$$

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

$$L = \frac{100\Delta}{D}$$

$$R = \frac{5729.58}{D}$$

$$E = T \tan \frac{\Delta}{4} = R \sec \frac{\Delta}{2} - R = R \operatorname{exsec} \frac{\Delta}{2}$$

$$M = R \operatorname{Vers} \frac{\Delta}{2}$$

$$L.C. = 2R \sin \frac{\Delta}{2}$$

Locating the P.C. and P.T.

$$\text{Sta. P.C.} = \text{Sta. P.I.} - T$$

$$\text{Sta. P.T.} = \text{Sta. P.C.} + L$$

LEGEND

P.I. - Point of Intersection

P.C. - Point of Curvature

P.T. - Point of Tangency

Δ - Deflection Angle Between the Tangents

T - Tangent Distance

E - External Distance

R - Radius of the Circular Arc

M - Middle Ordinate

L.C. - Long Chord (Distance Between P.C. and P.T.)

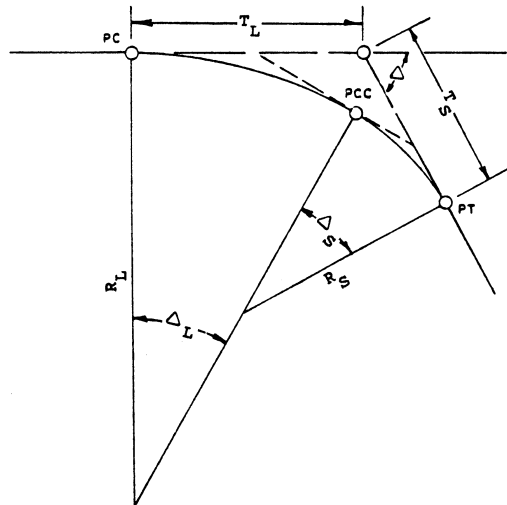
C - Midpoint of Long Chord

D - Degree of Curvature

L - Length of Curve

**FIGURE E-1
SIMPLE CURVE COMPUTATIONS**

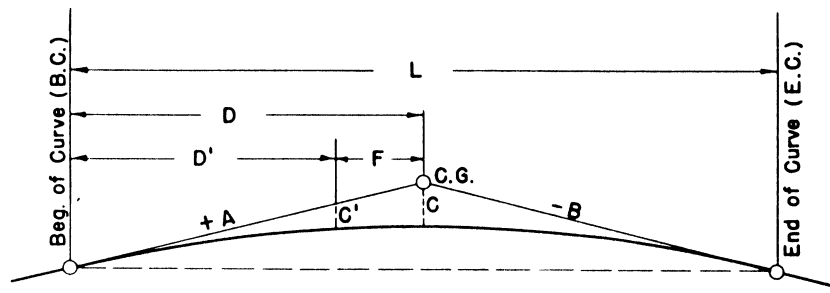
(Arc Definition)



<u>GIVEN</u>	<u>SOLUTION</u>	<u>LEGEND</u>
$\Delta_L, \Delta_S, T_S, R_S$	$R_L = \frac{T_S \sin \Delta - R_S \text{Vers} \Delta + R_S}{\text{Vers} \Delta_L}$	P.C. - Point of Curvature
$\Delta_L, \Delta_S, T_L, R_L$	$R_S = \frac{T_L \sin \Delta - R_L \text{Vers} \Delta + R_L}{\text{Vers} \Delta_S}$	P.C.C. - Point of Compound Curvature
$\Delta_L, \Delta_S, R_L, R_S$	$T_L = \frac{R_L \text{Vers} \Delta - (R_L - R_S) \text{Vers} \Delta_S}{\sin \Delta}$	P.T. - Point of Tangency
$\Delta_L, \Delta_S, T_S, R_L$	$R_S = \frac{T_S \sin \Delta - R_L \text{Vers} \Delta_L}{\text{Vers} \Delta - \text{Vers} \Delta_L}$	R_L - Radius of Major Curve
$\Delta_L, \Delta_S, T_L, R_S$	$R_L = \frac{R_S \text{Vers} \Delta_S - T_L \sin \Delta}{\text{Vers} \Delta_S - \text{Vers} \Delta}$	R_S - Radius of Minor Curve
$\Delta_L, \Delta_S, T_L, T_S$	$R_S = \frac{T_S \sin \Delta - \tan 1/2 \Delta_L (T_L + T_S \cos \Delta)}{\text{Vers} \Delta - \sin \Delta \tan 1/2 \Delta_L}$	T_L - Long Tangent
Δ, T_L, T_S, R_S	$\tan 1/2 \Delta_L = \frac{T_S \sin \Delta - R_S \text{Vers} \Delta}{T_L + T_S \cos \Delta - R_S \sin \Delta}$	T_S - Short Tangent
Δ, T_L, T_S, R_L	$\tan 1/2 \Delta_S = \frac{R_L \text{Vers} \Delta - T_L \sin \Delta}{R_L \sin \Delta - T_L \cos \Delta - T_S}$	Δ - Total Deflection Angle of the Compound Curve = $\Delta_L + \Delta_S$
Δ, T_S, R_L, R_S	$\cos \Delta_L = \frac{R_L - T_S \sin \Delta - R_S \cos \Delta}{R_L - R_S}$	Δ_L - Deflection Angle of Major Curve
Δ, T_L, R_L, R_S	$\text{Vers} \Delta_S = \frac{R_L \text{Vers} \Delta - T_L \sin \Delta}{R_L - R_S}$	Δ_S - Deflection Angle of Minor Curve

**FIGURE E-2
COMPOUND CURVE COMPUTATIONS**

PARABOLIC VERTICAL CURVE



C.G. = Point of change of gradient.

C = Center correction.

C' = Correction at any given point on curve.

D = $L/2$ = Half length of vertical curve.

D' = Distance to point where correction is required from beginning or end of curve.

$$C = \frac{\text{Alg. diff.} \times \text{length of curve in stations}}{8}$$

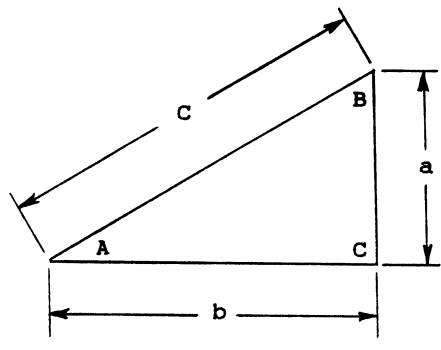
$$C' = C \left(\frac{D'}{D} \right)^2$$

FIGURE E-3
PARABOLIC VERTICAL CURVE
COMPUTATIONS

Inches	0	1	2	3	4	5	6	7	8	9	10	11
0	.0000	.0833	.1667	.2500	.3333	.4167	.5000	.5833	.6667	.7500	.8333	.9167
1/16	.0052	.0885	.1719	.2552	.3385	.4219	.5052	.5885	.6719	.7552	.8385	.9219
1/8	.0104	.0938	.1771	.2604	.3438	.4271	.5104	.5938	.6771	.7604	.8438	.9271
3/16	.0156	.0990	.1823	.2656	.3490	.4323	.5156	.5990	.6823	.7656	.8490	.9323
1/4	.0208	.1042	.1875	.2708	.3542	.4375	.5208	.6042	.6875	.7708	.8542	.9375
5/16	.0260	.1094	.1927	.2760	.3594	.4427	.5260	.6094	.6927	.7760	.8594	.9427
3/8	.0313	.1146	.1979	.2813	.3646	.4479	.5313	.6146	.6979	.7813	.8646	.9479
7/16	.0365	.1198	.2031	.2865	.3698	.4531	.5365	.6198	.7031	.7865	.8698	.9531
1/2	.0417	.1250	.2083	.2917	.3750	.4583	.5417	.6250	.7083	.7917	.8750	.9583
9/16	.0469	.1302	.2135	.2969	.3803	.4635	.5469	.6302	.7135	.7969	.8802	.9635
5/8	.0521	.1354	.2188	.3021	.3854	.4688	.5521	.6354	.7188	.8021	.8854	.9688
11/16	.0573	.1406	.2240	.3073	.3906	.4740	.5573	.6406	.7240	.8073	.8906	.9740
3/4	.0625	.1458	.2292	.3125	.3958	.4792	.5625	.6458	.7292	.8125	.8958	.9792
13/16	.0677	.1510	.2344	.3177	.4010	.4844	.5677	.6510	.7344	.8177	.9010	.9844
7/8	.0729	.1563	.2396	.3229	.4063	.4896	.5729	.6563	.7396	.8229	.9063	.9896
15/16	.0781	.1615	.2448	.3281	.4115	.4948	.5781	.6615	.7448	.8281	.9115	.9948

TABLE E-1
INCHES AND FRACTIONS OF AN INCH
IN DECIMALS OF A FOOT

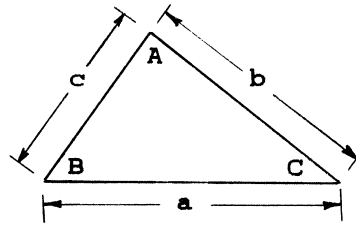
$\text{SIN} = \frac{\text{Opposite Side}}{\text{Hypotenuse}}$	$\text{TAN} = \frac{\text{Opposite Side}}{\text{Adjacent Side}}$	$\text{SEC} = \frac{\text{Hypotenuse}}{\text{Adjacent Side}}$
$\text{COS} = \frac{\text{Adjacent Side}}{\text{Hypotenuse}}$	$\text{COT} = \frac{\text{Adjacent Side}}{\text{Opposite Side}}$	$\text{CSC} = \frac{\text{Hypotenuse}}{\text{Opposite Side}}$



<u>Find</u>	<u>Given</u>	<u>Formula</u>	<u>Find</u>	<u>Given</u>	<u>Formula</u>
SIN A	Sides a, c	$\frac{a}{c}$	SIDE b	Side a, Tan A	$\frac{a}{\text{Tan A}}$
SIN A	Cos A, Tan A	Cos A Tan A	SIDE c	Sides a, b	$\sqrt{a^2 + b^2}$
SIN A	Cos A	$\sqrt{1 - \text{Cos}^2 A}$	SIDE c	Side a, Sin A	$\frac{a}{\text{Sin A}}$
COS A	Sides b, c	$\frac{b}{c}$	SIDE c	Side b, Cos A	$\frac{b}{\text{Cos A}}$
COS A	Sin A, Tan A	$\frac{\text{Sin A}}{\text{Tan A}}$	TAN A	Sin A, Cos A	$\frac{\text{Sin A}}{\text{Cos A}}$
COS A	Sin A	$\sqrt{1 - \text{Sin}^2 A}$	TAN A	Sides a, b	$\frac{a}{b}$
SIDE a	Sides b, c	$\sqrt{c^2 - b^2}$	ANGLE A	Angles B, C	$C - B$
SIDE a	Side c, Sin A	$c \text{ Sin A}$	ANGLE B	Angles A, C	$C - A$
SIDE a	Side b, Tan A	$b \text{ Tan A}$	ANGLE C	Angles A, B	$A + B$
SIDE b	Sides a, c	$\sqrt{c^2 - a^2}$			
SIDE b	Side c, Cos A	$c \text{ Cos A}$			

**FIGURE E-4
REFERENCE FORMULAS-90° TRIANGLE**

Law of sines	$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$
Law of cosines	$a^2 = b^2 + c^2 - 2bc \cos A$ $b^2 = a^2 + c^2 - 2ac \cos B$ $c^2 = a^2 + b^2 - 2ab \cos C$
Law of tangents	$\frac{a-b}{a+b} = \frac{\tan \frac{1}{2}(A-B)}{\tan \frac{1}{2}(A+B)}$























Find	Given	Formula
A	BC	$180^\circ - (B+C)$
sin A	acC	$\frac{a \times \sin C}{c}$
sin A	abB	$\frac{a \times \sin B}{b}$
cos A	abc	$\frac{b^2 + c^2 - a^2}{2bc}$
tan A	acB	$\frac{a \times \sin B}{c - (a \times \cos B)}$
tan A	abC	$\frac{a \times \sin C}{b - (a \times \cos C)}$
B	AC	$180^\circ - (A + C)$
sin B	abA	$\frac{b \times \sin A}{a}$
sin B	bcC	$\frac{b \times \sin C}{c}$
cos B	abc	$\frac{c^2 + a^2 - b^2}{2ac}$
tan B	bcA	$\frac{b \times \sin A}{c - (b \times \cos A)}$
C	AB	$180^\circ - (A + B)$
sin C	acA	$\frac{c \times \sin A}{a}$

Find	Given	Formula
sin C	bcB	$\frac{c \times \sin B}{b}$
cos C	abc	$\frac{a^2 + b^2 - c^2}{2ab}$
tan C	bca	$\frac{c \times \sin A}{b - (c \times \cos A)}$
tan C	acB	$\frac{c \times \sin B}{a - (c \times \cos B)}$
a	cAC	$\frac{c \times \sin A}{\sin C}$
a	bAB	$\frac{b \times \sin A}{\sin B}$
a	bcA	$\sqrt{b^2 + c^2 - (2bc \times \cos A)}$
b	aAB	$\frac{a \times \sin B}{\sin A}$
b	cBC	$\frac{c \times \sin B}{\sin C}$
b	acB	$\sqrt{a^2 + c^2 - (2ac \times \cos B)}$
c	aAC	$\frac{a \times \sin C}{\sin A}$
c	bBC	$\frac{b \times \sin C}{\sin B}$
c	abc	$\sqrt{a^2 + b^2 - (2ab \times \cos C)}$

FIGURE E-5
REFERENCE FORMULAS -
OBLIQUE TRIANGLE

TABLE E-2
METRIC CONVERSION FACTORS

To Convert From	To	Multiply By	To Convert From	To	Multiply By
<u>LENGTH</u>			<u>VELOCITY</u>		
inch (in)	metre (m)	.0254	foot/second	metre/second (m/s)	.3048
foot (ft)	metre (m)	.3048	mile/hour (U.S. statute)	metre/second (m/s)	.4470
yard (yd)	metre (m)	.9144	mile/hour (U.S. statute)	kilometre/hour	1.6093
mile (U.S. statute)	metre (m)	1609.344			
<u>AREA</u>			<u>TEMPERATURE</u>		
inch ² (in ²)	metre ² (m ²)	.0006	degree Fahrenheit	degree celsius	$t^{\circ}\text{C} = (t^{\circ}\text{F} - 32)/1.8$
foot ² (ft ²)	metre ² (m ²)	.0929			
yard ²	metre ² (m ²)	.8361			
mile ² (U.S. statute)	metre ² (m ²)	2589988.			
acres	metre ² (m ²)	4046.8560			
<u>MASS</u>			<u>Other Commonly Used Units</u>		
ton (short, 2000 lbs.)	kilogram (kg)	907.1847	Millimetre:	0.001 metre	
			Centimetre:	0.01 metre	
			Kilometre:	1000 metre	
			Kilogram:	1000 grams	
			Millilitre:	0.001 litre	
<u>VOLUME</u>					
foot ³ (ft ³)	metre ³ (m ³)	.0283			
yard ³ (yd ³)	metre ³ (m ³)	.7645			
acre-foot	metre ³ (m ³)	1233.482			
ounce (U.S. fluid)	litre (l)	0.0296			
pint (U.S. liquid)	litre (l)	0.4732			
quart (U.S. liquid)	litre (l)	0.9463			
gallon (U.S. liquid)	litre (l)	3.7853			

BAR SIZES		WEIGHT POUNDS PER FOOT	NOMINAL DIMENSIONS - ROUND SECTIONS		
DIAMETER	DESIGNATION		DIAMETER INCHES	CROSS SECTIONAL AREA - SQ. INCHES	PERIMETER INCHES
		.167	.250	.05	.786
		.376	.375	.11	1.178
		.668	.500	.20	1.571
		1.043	.625	.31	1.963
		1.502	.750	.44	2.356
		2.044	.875	.60	2.749
		2.670	1.000	.79	3.142
		3.400	1.128	1.00	3.544
		4.303	1.270	1.27	3.990
		5.313	1.410	1.56	4.430

Bar numbers are based on the number of $\frac{1}{8}$ inches included in the nominal diameter of the bar.
Bar no. 2 in plain rounds only.

**TABLE E-3
STANDARD REINFORCING BARS**