

APPENDIX B

Contents

| Page | |
|-------------|--|
| B-1 | <u>Metric Conversions</u> |
| | <u>Additional Conversions</u> |
| | <u>Precision of Individual Measurements</u> |
| B-2 | <u>Inches, Decimal of Inches and Metric Conversions</u> |
| B-3 | <u>Minutes and Seconds to Decimal of Degree</u> |
| B-4 | <u>Triangle Formulae</u> |
| B-5 | <u>Right Triangle Formulae</u> |
| B-6 | <u>Horizontal Curve Formulae</u> |
| B-7 | <u>Compound Curve Formulae</u> |
| B-8 | <u>Vertical Curve Formulae</u> |
| B-9 | <u>Spiral Curve Formulae</u> |
| B-10 | <u>Transition (Spiral) Curve Formulae</u> |
| | |

For additional references and formulae, see [VDOT Construction Manual](#), Appendix D

METRIC CONVERSIONS

| | | | |
|---|------------------|---|---|
| * | 1 meter (m) | = | 39.37 inches (U. S. Survey Foot) |
| | 1 meter (m) | = | 39.37007874 inches (International Foot) |
| | 1 meter (m) | = | 3.280833333333 feet (U. S. Survey Foot) |
| | 1 meter (m) | = | 3.280839895 feet (International Foot) |
| | 1 kilometer (km) | = | 0.62136995 mile (per U. S. Survey Foot) |
| | 1 hectare (ha) | = | 2.471044 acres (per U. S. Survey Foot) |
| | 1 hectare (ha) | = | 2.471054 acres (per International Foot) |
| * | 1 meter (m) | = | 1,000 millimeters (mm) |
| * | 1 kilometer (km) | = | 1,000 meters (m) |
| * | 1 hectare (ha) | = | 10,000 sq. meters (m ²) |

ADDITIONAL CONVERSIONS

| | | | |
|---|---------------------|---|--|
| | 1 U. S. Survey Foot | = | 1.000002 International Foot |
| | 1 U.S. Survey acre | = | 1.000004 acre (per International Foot) |
| * | 1 rod, pole, perch | = | 16½ feet (U. S. Survey Foot) |
| * | 1 chain (Gunter's) | = | 66 feet (U. S. Survey Foot) |
| * | 1 chain (Gunter's) | = | 4 rods or 100 links |
| * | 1 link | = | 7.92 inches (U. S. Survey Foot) |
| * | 1 furlong | = | 660 U.S. Survey Feet or 10 chains |
| * | 1 mile | = | 5,280 feet (U. S. Survey Foot) |
| * | 1 mile | = | 8 furlongs or 80 chains or 320 rods |
| * | 1 acre | = | 43,560 feet ² (per U. S. Survey Foot) |
| * | 1 station | = | 100 feet (ft) or 100 meters (m) |
| * | 1 staking interval | = | 50 feet (ft) or 20 meters (m) |

*** Denotes exact conversion values. All others correct to figures shown.**

PRECISION OF INDIVIDUAL MEASUREMENTS

| | | |
|-------------------------|---|--|
| Horizontal Measurements | - | <u>nearest 0.005 feet with EDM/Total Station</u> <u>nearest 0.01 feet with steel chain</u> <u>nearest 0.02 feet with cloth/fiberglass tape</u> |
| Vertical Measurements | - | <u>nearest 0.01 feet on bridges</u> <u>nearest 0.01 feet on existing pavement</u> <u>nearest 0.05 feet on natural ground</u> |
| Trig Leveling/DTM | - | <u>nearest 0.01 feet for H.I and target height</u> |

NOTE: All surveying measurements will be made in feet and decimals of a foot.

CONVERSION CHART (International Foot)

| <u>decimal</u> <u>inches</u> | <u>(in)</u> <u>inches</u> | <u>(cm)</u> <u>centimete</u> <u>rs</u> | | <u>(ft)</u> <u>feet</u> | <u>(cm)</u> <u>centimete</u> <u>rs</u> | <u>(m)</u> <u>meters</u> | <u>(km)</u> <u>kilometer</u> |
|---------------------------------|------------------------------|--|--|----------------------------|--|-----------------------------|---------------------------------|
| <u>0.0313</u> | <u>1/32</u> | <u>0.079</u> | | <u>1</u> | <u>30.48</u> | <u>0.3048</u> | <u>0.000304</u> |
| <u>0.0625</u> | <u>1/16</u> | <u>0.159</u> | | <u>2</u> | <u>60.96</u> | <u>0.6096</u> | <u>0.000609</u> |
| <u>0.0938</u> | <u>3/32</u> | <u>0.238</u> | | <u>3</u> | <u>91.44</u> | <u>0.9144</u> | <u>0.000914</u> |
| <u>0.1250</u> | <u>1/8</u> | <u>0.318</u> | | <u>4</u> | <u>121.92</u> | <u>1.2192</u> | <u>0.001219</u> |
| <u>0.1563</u> | <u>5/32</u> | <u>0.397</u> | | <u>5</u> | <u>152.40</u> | <u>1.5240</u> | <u>0.001524</u> |
| <u>0.1875</u> | <u>3/16</u> | <u>0.476</u> | | <u>6</u> | <u>182.88</u> | <u>1.8288</u> | <u>0.001829</u> |
| <u>0.2188</u> | <u>7/32</u> | <u>0.556</u> | | <u>7</u> | <u>213.36</u> | <u>2.1336</u> | <u>0.002134</u> |
| <u>0.2500</u> | <u>1/4</u> | <u>0.635</u> | | <u>8</u> | <u>243.84</u> | <u>2.4384</u> | <u>0.002438</u> |
| <u>0.2813</u> | <u>9/32</u> | <u>0.714</u> | | <u>9</u> | <u>274.32</u> | <u>2.7432</u> | <u>0.002743</u> |
| <u>0.3125</u> | <u>5/16</u> | <u>0.794</u> | | <u>10</u> | <u>304.80</u> | <u>3.0480</u> | <u>0.003048</u> |
| <u>0.3438</u> | <u>11/32</u> | <u>0.873</u> | | <u>20</u> | <u>609.60</u> | <u>6.0960</u> | <u>0.006096</u> |
| <u>0.3750</u> | <u>3/8</u> | <u>0.953</u> | | <u>30</u> | <u>914.40</u> | <u>9.1440</u> | <u>0.009144</u> |
| <u>0.4063</u> | <u>13/32</u> | <u>1.032</u> | | <u>40</u> | <u>1219.20</u> | <u>12.1920</u> | <u>0.012192</u> |
| <u>0.4375</u> | <u>7/16</u> | <u>1.111</u> | | <u>50</u> | <u>1524.00</u> | <u>15.2400</u> | <u>0.015240</u> |
| <u>0.4688</u> | <u>15/32</u> | <u>1.191</u> | | <u>60</u> | <u>1828.80</u> | <u>18.2880</u> | <u>0.018288</u> |
| <u>0.5000</u> | <u>1/2</u> | <u>1.270</u> | | <u>70</u> | <u>2133.60</u> | <u>21.3360</u> | <u>0.021336</u> |
| <u>0.5313</u> | <u>17/32</u> | <u>1.349</u> | | <u>80</u> | <u>2438.40</u> | <u>24.3840</u> | <u>0.024384</u> |
| <u>0.5625</u> | <u>9/16</u> | <u>1.429</u> | | <u>90</u> | <u>2743.20</u> | <u>27.4320</u> | <u>0.027432</u> |
| <u>0.5938</u> | <u>19/32</u> | <u>1.508</u> | | <u>100</u> | <u>3048.00</u> | <u>30.4800</u> | <u>0.030480</u> |
| <u>0.6250</u> | <u>5/8</u> | <u>1.588</u> | | <u>200</u> | <u>6096.00</u> | <u>60.9600</u> | <u>0.060960</u> |
| <u>0.6563</u> | <u>21/32</u> | <u>1.667</u> | | <u>300</u> | <u>9144.00</u> | <u>91.4400</u> | <u>0.091440</u> |
| <u>0.6875</u> | <u>11/16</u> | <u>1.746</u> | | <u>400</u> | <u>12192.00</u> | <u>121.9200</u> | <u>0.121920</u> |
| <u>0.7188</u> | <u>23/32</u> | <u>1.826</u> | | <u>500</u> | <u>15240.00</u> | <u>152.4000</u> | <u>0.152400</u> |
| <u>0.7500</u> | <u>3/4</u> | <u>1.905</u> | | <u>600</u> | <u>18288.00</u> | <u>182.8800</u> | <u>0.182880</u> |
| <u>0.7813</u> | <u>25/32</u> | <u>1.984</u> | | <u>700</u> | <u>21336.00</u> | <u>213.3600</u> | <u>0.213360</u> |
| <u>0.8125</u> | <u>13/16</u> | <u>2.064</u> | | <u>800</u> | <u>24384.00</u> | <u>243.8400</u> | <u>0.243840</u> |
| <u>0.8438</u> | <u>27/32</u> | <u>2.143</u> | | <u>900</u> | <u>27432.00</u> | <u>274.3200</u> | <u>0.274320</u> |
| <u>0.8750</u> | <u>7/8</u> | <u>2.223</u> | | <u>1000</u> | <u>30480.00</u> | <u>304.80</u> | <u>0.3048</u> |
| <u>0.9063</u> | <u>29/32</u> | <u>2.302</u> | | <u>2000</u> | <u>60960.00</u> | <u>609.60</u> | <u>0.6096</u> |
| <u>0.9375</u> | <u>15/16</u> | <u>2.381</u> | | <u>3000</u> | <u>91440.00</u> | <u>914.40</u> | <u>0.9144</u> |
| <u>0.9688</u> | <u>31/32</u> | <u>2.461</u> | | <u>4000</u> | <u>121920.00</u> | <u>1219.20</u> | <u>1.2192</u> |
| <u>1.0000</u> | <u>1</u> | <u>2.540</u> | | <u>5000</u> | <u>152400.00</u> | <u>1524.00</u> | <u>1.5240</u> |
| <u>2.0000</u> | <u>2</u> | <u>5.080</u> | | <u>6000</u> | <u>182880.00</u> | <u>1828.80</u> | <u>1.8288</u> |
| <u>3.0000</u> | <u>3</u> | <u>7.620</u> | | <u>7000</u> | <u>213360.00</u> | <u>2133.60</u> | <u>2.1336</u> |
| <u>4.0000</u> | <u>4</u> | <u>10.160</u> | | <u>8000</u> | <u>243840.00</u> | <u>2438.40</u> | <u>2.4384</u> |
| <u>5.0000</u> | <u>5</u> | <u>12.700</u> | | <u>9000</u> | <u>274320.00</u> | <u>2743.20</u> | <u>2.7432</u> |
| <u>6.0000</u> | <u>6</u> | <u>15.240</u> | | <u>10000</u> | <u>304800.00</u> | <u>3048.00</u> | <u>3.0480</u> |
| <u>7.0000</u> | <u>7</u> | <u>17.780</u> | | | | | |
| <u>8.0000</u> | <u>8</u> | <u>20.320</u> | | | | | |
| <u>9.0000</u> | <u>9</u> | <u>22.860</u> | | | | | |
| <u>10.0000</u> | <u>10</u> | <u>25.400</u> | | | | | |
| <u>11.0000</u> | <u>11</u> | <u>27.940</u> | | | | | |
| <u>12.0000</u> | <u>12</u> | <u>30.480</u> | | | | | |

MINUTES & SECONDS to DECIMALS of a DEGREE

| | <u>Minutes</u> | <u>Seconds</u> | | <u>Minutes</u> | <u>Seconds</u> | |
|-----------|-----------------|-----------------|--|----------------|-----------------|-----------------|
| <u>1</u> | <u>0.016667</u> | <u>0.000278</u> | | <u>31</u> | <u>0.516667</u> | <u>0.008611</u> |
| <u>2</u> | <u>0.033333</u> | <u>0.000556</u> | | <u>32</u> | <u>0.533333</u> | <u>0.008889</u> |
| <u>3</u> | <u>0.050000</u> | <u>0.000833</u> | | <u>33</u> | <u>0.550000</u> | <u>0.009167</u> |
| <u>4</u> | <u>0.066667</u> | <u>0.001111</u> | | <u>34</u> | <u>0.566667</u> | <u>0.009444</u> |
| <u>5</u> | <u>0.083333</u> | <u>0.001389</u> | | <u>35</u> | <u>0.583333</u> | <u>0.009722</u> |
| <u>6</u> | <u>0.100000</u> | <u>0.001667</u> | | <u>36</u> | <u>0.600000</u> | <u>0.010000</u> |
| <u>7</u> | <u>0.116667</u> | <u>0.001944</u> | | <u>37</u> | <u>0.616667</u> | <u>0.010278</u> |
| <u>8</u> | <u>0.133333</u> | <u>0.002222</u> | | <u>38</u> | <u>0.633333</u> | <u>0.010556</u> |
| <u>9</u> | <u>0.150000</u> | <u>0.002500</u> | | <u>39</u> | <u>0.650000</u> | <u>0.010833</u> |
| <u>10</u> | <u>0.166667</u> | <u>0.002778</u> | | <u>40</u> | <u>0.666667</u> | <u>0.011111</u> |
| <u>11</u> | <u>0.183333</u> | <u>0.003056</u> | | <u>41</u> | <u>0.683333</u> | <u>0.011389</u> |
| <u>12</u> | <u>0.200000</u> | <u>0.003333</u> | | <u>42</u> | <u>0.700000</u> | <u>0.011667</u> |
| <u>13</u> | <u>0.216667</u> | <u>0.003611</u> | | <u>43</u> | <u>0.716667</u> | <u>0.011944</u> |
| <u>14</u> | <u>0.233333</u> | <u>0.003889</u> | | <u>44</u> | <u>0.733333</u> | <u>0.012222</u> |
| <u>15</u> | <u>0.250000</u> | <u>0.004167</u> | | <u>45</u> | <u>0.750000</u> | <u>0.012500</u> |
| <u>16</u> | <u>0.266667</u> | <u>0.004444</u> | | <u>46</u> | <u>0.766667</u> | <u>0.012778</u> |
| <u>17</u> | <u>0.283333</u> | <u>0.004722</u> | | <u>47</u> | <u>0.783333</u> | <u>0.013056</u> |
| <u>18</u> | <u>0.300000</u> | <u>0.005000</u> | | <u>48</u> | <u>0.800000</u> | <u>0.013333</u> |
| <u>19</u> | <u>0.316667</u> | <u>0.005278</u> | | <u>49</u> | <u>0.816667</u> | <u>0.013611</u> |
| <u>20</u> | <u>0.333333</u> | <u>0.005556</u> | | <u>50</u> | <u>0.833333</u> | <u>0.013889</u> |
| <u>21</u> | <u>0.350000</u> | <u>0.005833</u> | | <u>51</u> | <u>0.850000</u> | <u>0.014167</u> |
| <u>22</u> | <u>0.366667</u> | <u>0.006111</u> | | <u>52</u> | <u>0.866667</u> | <u>0.014444</u> |
| <u>23</u> | <u>0.383333</u> | <u>0.006389</u> | | <u>53</u> | <u>0.883333</u> | <u>0.014722</u> |
| <u>24</u> | <u>0.400000</u> | <u>0.006667</u> | | <u>54</u> | <u>0.900000</u> | <u>0.015000</u> |
| <u>25</u> | <u>0.416667</u> | <u>0.006944</u> | | <u>55</u> | <u>0.916667</u> | <u>0.015278</u> |
| <u>26</u> | <u>0.433333</u> | <u>0.007222</u> | | <u>56</u> | <u>0.933333</u> | <u>0.015556</u> |
| <u>27</u> | <u>0.450000</u> | <u>0.007500</u> | | <u>57</u> | <u>0.950000</u> | <u>0.015833</u> |
| <u>28</u> | <u>0.466667</u> | <u>0.007778</u> | | <u>58</u> | <u>0.966667</u> | <u>0.016111</u> |
| <u>29</u> | <u>0.483333</u> | <u>0.008056</u> | | <u>59</u> | <u>0.983333</u> | <u>0.016389</u> |
| <u>30</u> | <u>0.500000</u> | <u>0.008333</u> | | | | |

Example: To convert $8^{\circ} 49' 27''$ to decimal of a degree.

Using the chart above:

$$\begin{aligned} 8^{\circ} &= 8.000000 \\ 49' &= 0.816667 \\ 27'' &= 0.007500 \end{aligned}$$

Add the three numbers to get the result..... 8.824167°

Example: To convert 8.824167° to degrees, minutes and seconds.

First, we know $8.00000 = 8^{\circ}$ and 0.824167 degree

Next multiply: $(0.824167 \text{ degree}) * (60 \text{ minutes/degree}) = 49.45020 \text{ minutes.}$

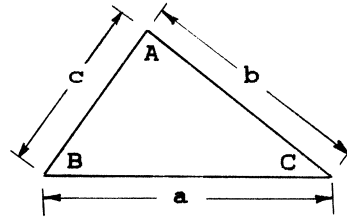
Now, we know we have 49 minutes and 0.450020 minute.

Next multiply: $(0.450020 \text{ minute}) * (60 \text{ seconds/minute}) = 27.0012 \text{ seconds}$

For the result: $8^{\circ} 49' 27''$

TRIANGLE FORMULAE

| | |
|-----------------|--|
| 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 | $\frac{a-b}{a+b} = \frac{\tan \frac{1}{2}(A-B)}{\tan \frac{1}{2}(A+B)}$ |

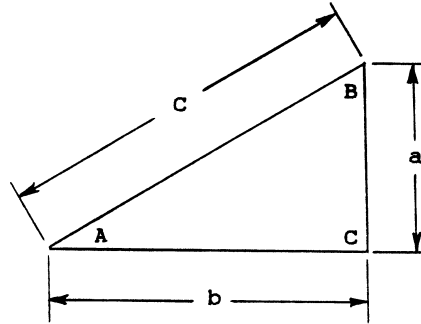


| Find | Given | Formula |
|-------|-------|---|
| A | BC | $180^\circ - (B+C)$ |
| sin A | acC | $\frac{a \times \sin C}{c}$ |
| sin A | abB | $\frac{a \times \sin B}{b}$ |
| cos A | abc | $\frac{b^2 + c^2 - a^2}{2bc}$ |
| tan A | acB | $\frac{a \times \sin B}{c - (a \times \cos B)}$ |
| tan A | abC | $\frac{a \times \sin C}{b - (a \times \cos C)}$ |
| 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 | $\sqrt{a^2 + b^2 - (2ab \times \cos C)}$ |

RIGHT TRIANGLE FORMULAE

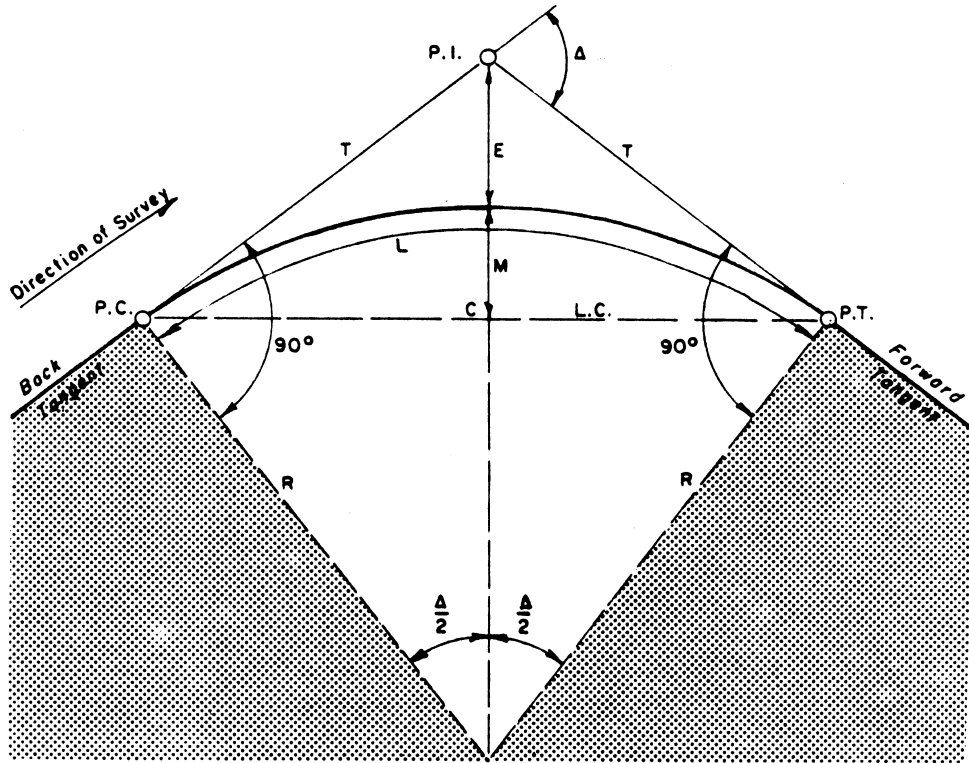
| | | |
|---|--|---|
| $\text{SIN} = \frac{\text{Opposite Side}}{\text{Hypotenuse}}$ | $\text{TAN} = \frac{\text{Opposite Side}}{\text{Adjacent Side}}$ | $\text{SEC} = \frac{\text{Hypotenuse}}{\text{Adjacent Side}}$ |
| $\text{COS} = \frac{\text{Adjacent Side}}{\text{Hypotenuse}}$ | $\text{COT} = \frac{\text{Adjacent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



| Find | Given | Formula | Find | Given | Formula |
|--------|---------------|-------------------------------------|---------|---------------|-------------------------------------|
| 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**

HORIZONTAL CURVE FORMULAE



FORMULAS FOR ARC DEFINITION

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

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

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

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

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

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

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

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

Locating the P.C. and P.T.

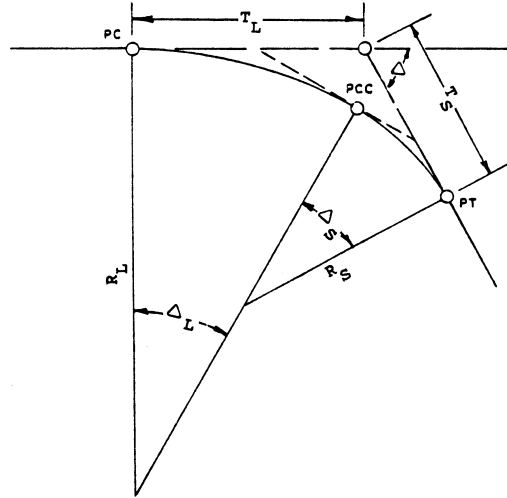
Sta. P.C. = Sta. P.I. - T

Sta. P.T. = 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

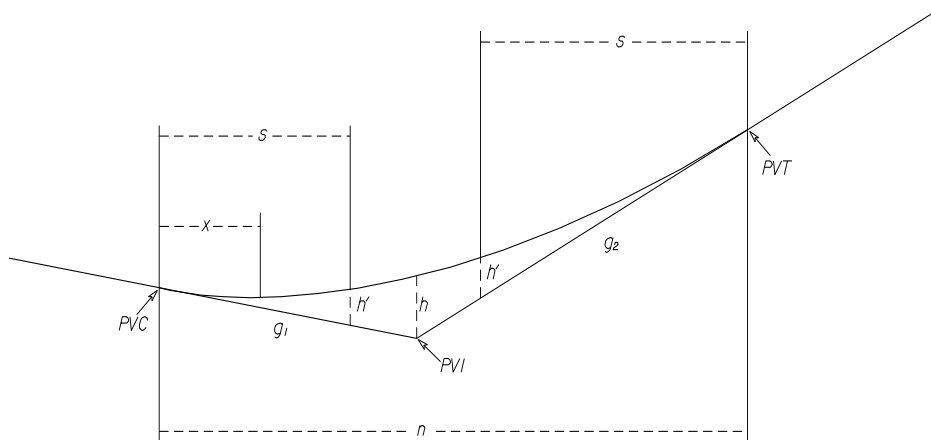
COMPOUND CURVE FORMULAE



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

VERTICAL CURVE FORMULAE

VERTICAL CURVE FORMULAE



h = center orientation
 h' = correction at any point on curve
 n = length of vertical curve in feet
 g_1 = grade in expressed as feet per foot. For example, 2% would be expressed as 0.02.
 g_2 = grade out expressed the same as grade in.
 s = horizontal distance, on curve measured from nearest end of curve, in feet.
 x = horizontal distance, in feet, measured from PVC to point on curve
 y = elevation of any point on vertical curve in feet
 y' = elevation at PVC, in feet

$$1) h = \frac{n}{8} (g_1 - g_2)$$

$$2) h' = h \left(\frac{2s}{n} \right)^2$$

Elevation Equation for any point on curve: $y = y' + g(x) + \left(\frac{g_2 - g_1}{2n} \right) (x)^2$

Equation for Low or High Point of Curve: $x = \left(\frac{-gn}{g_2 - g_1} \right)$

SPIRAL CURVE FORMULAE

In order to approximate the path a vehicle makes when entering or leaving a circular horizontal curve, a spiral transition curve will be provided for horizontal curves with a radius less than or equal to 850 meters, except for interchange ramps and loops.

The spiral to be used is known as the Talbot Transition Spiral and has the following characteristics:

1. - The radius of the spiral at any point is inversely proportional to its length. The radius at the TS (beginning of the spiral) is infinite and at the SC (end of the spiral) is equal to the radius of the circular curve R.

$$\begin{array}{l} R \quad \text{radius of the circular curve} \\ r \quad \text{radius at the distance } L_x \text{ from TS} \\ LS \quad \text{length of spiral} \end{array}$$

$$R \div r = L_x \div LS$$

2. - The central angle of a spiral curve is exactly 1/2 of a circular curve with the same radius and length.

$$DE = \text{central angle of spiral}$$

$$DE = (28.6479 \times LS) \div R$$

3. - Spiral angles are directly proportional to the squares of their lengths from the TS.

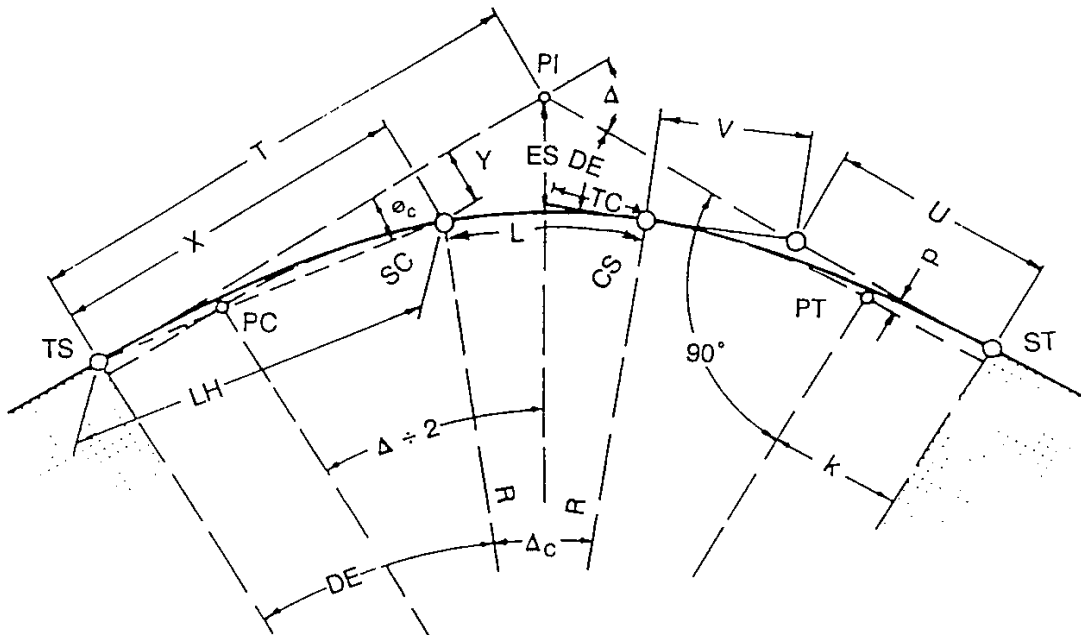
$$\Delta L \quad \text{central angle for spiral for a length}$$

$$L_x \text{ from TS}$$

$$\Delta L = (L_x \div LS)^2 \times DE$$

Formulas for computing spiral curve information is shown on the following page.

TRANSITION (SPIRAL) CURVE FORMULAE



| | |
|--|---|
| LS = Length of Spiral | V = Short Tangent |
| L = Length of Circular Curve | X = Tangent Distance for SC |
| R = Radius of Circular Curve | Y = Tangent Offset of the SC |
| TC = Tangent of Circular Curve | k = Simple Curve Coordinate (Abscissa) |
| T = Tangent Distance | p = Simple Curve Coordinate (Ordinate) |
| Δ = Deflection Angle Between the Tangents | ϕ _c = Deflection Angle of Spiral Curve |
| DE = Spiral Angle | TS = Tangent to Spiral |
| Δ _c = Central Angle Between the SC and CS | SC = Spiral to Circular Curve |
| ES = External Distance | CS = Circular Curve to Spiral |
| LH = Long Chord | ST = Spiral to Tangent |
| U = Long Tangent | |

SPIRAL CURVE FORMULAS

| | |
|--|--|
| $DE = \frac{(28.6479 \times LS)}{R}$ | $TC = R \times [\tan(\frac{\Delta_c}{2})]$ |
| $Z = 0.01745 \times DE$ | $\Delta_c = \Delta - (2 \times DE)$ |
| $X = \frac{LS \times [1 - (Z^2 \div 10) + (Z^4 \div 216)]}{R}$ | $p = \frac{Y - [R \times (1 - \cos(DE))]}{\sin(\Delta)}$ |
| $Y = \frac{LS \times [(Z \div 3) - (Z^3 \div 42) + (Z^5 \div 1320)]}{R}$ | $k = \frac{X - [R \times (\sin(DE))]}{\sin(\Delta)}$ |
| $L = \frac{(R \times \Delta_c)}{57.2958}$ | |

TO CALCULATE T AND ES OF A SIMPLE CURVE WITH EQUAL SPIRALS

$$T = \frac{[(R + p) \times \tan(\frac{\Delta}{2})] + k}{\sin(\Delta)}$$

$$ES = \frac{[(R + p) \times \text{exsec}(\frac{\Delta}{2})] + p}{\sin(\Delta)}$$

$$ES = \frac{[(R + p) \div \cos(\frac{\Delta}{2})] - R}{\sin(\Delta)}$$

TO CALCULATE THE TANGENT DISTANCES OF A SIMPLE CURVE WITH UNEQUAL SPIRALS

$$T_{in} = \frac{[(R + P)_2 \div \sin \Delta] - [(R + p)_1 \times \cot \Delta] + k_1}{\sin \Delta}$$

$$T_{out} = \frac{[(R + p)_1 \div \sin \Delta] - [(R + p)_2 \times \cot \Delta] + k_2}{\sin \Delta}$$