1. Given the following data for a highway curve to the left: $\Delta = 33^\circ 30' 00''$, $R = 1455.00'$, $T = 437.91$, $L = 850.72$, $LC = 838.65$, $D = 03^\circ 56' 15''$ and the following table of deflections and chords:

<table>
<thead>
<tr>
<th>Station</th>
<th>Deflection</th>
<th>Sub-chord</th>
<th>Chord</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC 78 + 26.29</td>
<td>00° 00' 00''</td>
<td>0.00'</td>
<td>0.00'</td>
</tr>
<tr>
<td>79 + 00</td>
<td>01° 27' 05''</td>
<td>73.71</td>
<td>73.71</td>
</tr>
<tr>
<td>80 + 00</td>
<td>03° 25' 13''</td>
<td>99.98</td>
<td>173.61</td>
</tr>
<tr>
<td>81 + 00</td>
<td>05° 23' 21''</td>
<td>99.98</td>
<td>273.31</td>
</tr>
<tr>
<td>82 + 00</td>
<td>07° 21' 29''</td>
<td>99.98</td>
<td>372.68</td>
</tr>
<tr>
<td>83 + 00</td>
<td>09° 19' 37''</td>
<td>99.98</td>
<td>471.62</td>
</tr>
<tr>
<td>84 + 00</td>
<td>11° 17' 45''</td>
<td>99.98</td>
<td>570.00</td>
</tr>
<tr>
<td>85 + 00</td>
<td>13° 15' 53''</td>
<td>99.98</td>
<td>667.70</td>
</tr>
<tr>
<td>86 + 00</td>
<td>15° 14' 01''</td>
<td>99.98</td>
<td>764.62</td>
</tr>
<tr>
<td>PT 86 + 77.01</td>
<td>16° 45' 00''</td>
<td>77.01</td>
<td>838.65</td>
</tr>
</tbody>
</table>

There are stakes in the ground at the PC, PI, and PT. In all questions relating to angles set or sighted, you must specify telescope position.

A. There are no obstructions to prevent setting out stakes from the PC as far as station 85 + 00 with your electronic total station. How will you set a stake at station 85 + 00? Be specific in terms of angle set for the back sight, where the back sight is, and angle set for pointing at 85 + 00. Also, what distance you will measure to 85 + 00 and where you will measure this distance from?

B. You are trying to set a stake at station 86 + 00 and can see through some tree leaves well enough to see a plumb bob string, but cannot get enough reflectance from a prism to your total station to measure a distance along the sight line. You have a three-person field crew. How will you set a stake at station 86 + 00? Be specific in terms of angle set for the back sight, where the back sight is, and angle set for pointing at 86 + 00. Also, what distance you will measure to 86 + 00 and where you will measure this distance from?

C. You have been able to stake out stations from the PC as far as 81 + 00, but must now move your total station to station 81 + 00 to stake out the rest of the curve. How will you stake out station 82 + 00? Be specific in terms of angle set for the back sight, where the back sight is, and angle set for pointing at 82 + 00. Also, what distance you will measure to 82 + 00 and where you will measure this distance from?

D. Station 81 + 00 is the low point of a curve and consequently catch basins are to be installed at this station. While you are set at this station (from C., above), you will stake out the position of the catch basins. The pavement is to be 30 feet wide. How will you do this? Be specific in terms of angle set for the back sight, where the back sight is, and angle set for pointing toward the catch basin locations. Also, what distance you will measure to the catch basin locations, and where you will measure this distance from?

E. From station 81 + 00, you are able to stake out stations as far as 83 + 00. How will you stake out station 84 + 00? Be specific in terms of angle set for the back sight, where the back sight is, and angle set for pointing at 84 + 00. Also, what distance you will measure to 84 + 00 and where you will measure this distance from?
1.A. Total Station @ PC. - Sight 00° 00' 00", telescope inverted, back along tangent line OR Sight 00° 00' 00", telescope normal, on PI. Now set 13° 15' 53" LEFT, and with telescope in the normal position, instrument is pointed along the line of the chord from the PC to station 85 + 00. Measure 667.70' along this line from the instrument to a prism and set a stake at 85 + 00.

1.B. Total Station @ PC. - Sight 00° 00' 00", telescope normal, on PI. Set 15° 14' 01" LEFT, and with telescope in the normal position, instrument is pointed along the line of the chord from the PC to station 86 + 00. Measure 99.98' from 85 + 00 and swing this distance slowly along an arc until the end of the tape intersects the 15° 14' 01" LEFT sight line from the PC. Set a stake at this point for station 86 + 00. ALTERNATIVELY, you may move the instrument up to station 85 + 00 and continue staking the curve from there, using a process similar to that described in 1.C., below.

1.C. Total Station @ 81 + 00. - Sight 00° 00' 00", telescope inverted on the PC. Now place the telescope in the normal position, set 07° 21' 29" LEFT and measure 99.98' along that line from the instrument to set a stake at 82 + 00.

1.D. Total Station @ 81 + 00. - Set 05° 23' 21" RIGHT, telescope normal, on the PC. Now set 90° 00' 00" RIGHT and with the telescope normal, measure along that line 15' to set the inner catch basin. Then invert the telescope and measure 15' along that line to set the outer catch basin. Alternatively, for the outer catch basin, you may set 90° 00' 00" LEFT or 270° 00' 00" RIGHT, telescope normal.

1.E. Total Station @ 83 + 00. - Sight 05° 23' 21" LEFT, telescope inverted, on 81 + 00. Invert the telescope to the normal position, set 11° 17' 45" LEFT and measure 99.98', along that line, from the instrument, to set a stake at 84 + 00.
2. Report all curve data $\Delta$, $R$, $D$, $L$, $T$, $LC$, $PC$, $PT$, $\pi$, Station, and a table of deflection angles, chords, and sub-chords to lay out curves to the right in half station intervals for either A or B below. In both cases, PI station is $11 + 08.84$.

A. $D = 20^\circ 00' 00''$ and $\Delta = 40^\circ 12' 20''$

B. $R = 575.00'$ and $\Delta = 15^\circ 06' 10''$

\[ L = \frac{R \Delta \pi}{180} = \frac{286.48(40.205556^\circ)}{57.2958} = 201.03' \]

\[ T = R \tan \frac{\Delta}{2} = 286.48 \tan 20.102778^\circ = 104.85' \]

\[ LC = 2R \sin \frac{\Delta}{2} = 2(286.48) \sin 20.102778^\circ = 196.93' \]

$\Delta = 40^\circ 12' 10''$ and $D = 20^\circ 00' 00''$ GIVEN

$\phi_{100} = \frac{D}{2} = \frac{20}{2} = 10,000,000^\circ = 10^\circ 00' 00''$

$\phi_1 = \frac{\phi_{100}}{100} = \frac{D}{200} = \frac{20}{200} = 0.100000^\circ$

\[
\begin{align*}
\text{PI} & \quad 1108.84 \quad 11 + 08.84 \\
- T & \quad 104.85 \quad 10 + 03.99 \\
\text{PC} & \quad 1003.99 \quad 10 + 03.99 \\
+ L & \quad 201.03' \\
\text{PT} & \quad 1205.02 \quad 12 + 05.02' \\
\end{align*}
\]

\[ \phi_{46.01} = 46.01(0.100000) = 4.601000^\circ = 04^\circ 36' 04'' \]

\[ \phi_{50} = 50(0.100000) = 5.000000^\circ = 05^0 00' 00'' \]

\[ \phi_{5.02} = 5.02(0.100000) = 0.502000^\circ = 00^\circ 30' 07'' \]

Subchords for 46.01' = $2 \sin \phi_{46.01} = 2(286.48) (\sin 04^\circ 36' 04'') = 45.96'$

for 50.00' = $2 \sin \phi_{50} = 2(286.48) (\sin 05^0 00' 00'') = 49.94'$

for 5.02' = $2 \sin \phi_{5.02} = 2(286.48) (\sin 00^\circ 30' 07'')$

Chords for all stations = $2 \sin \phi_{\text{station}}$ SEE TABLE

eg. for 11 + 50' $2(286.48) \sin 14^\circ 36' 04'' = 144.44'$
### 2. A. continued

<table>
<thead>
<tr>
<th>Station</th>
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<th>Sub-chord</th>
<th>Chord</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC 10+03.99</td>
<td>00° 00' 00&quot;&lt;br&gt;+ 04° 36' 04&quot;</td>
<td>0.00'</td>
<td>0.00'</td>
</tr>
<tr>
<td>10+50</td>
<td>04° 36' 04&quot;&lt;br&gt;+ 05° 00' 00&quot;</td>
<td>45.96'</td>
<td>45.96'</td>
</tr>
<tr>
<td>11+00</td>
<td>09° 36' 04&quot;&lt;br&gt;+ 05° 00' 00&quot;</td>
<td>49.94'</td>
<td>95.56'</td>
</tr>
<tr>
<td>11+50</td>
<td>14° 36' 04&quot;&lt;br&gt;+ 05° 00' 00&quot;</td>
<td>49.94'</td>
<td>144.44'</td>
</tr>
<tr>
<td>12+00</td>
<td>19° 36' 04&quot;&lt;br&gt;+ 00° 30' 07&quot;</td>
<td>49.94'</td>
<td>192.21'</td>
</tr>
<tr>
<td>PT 12+05.02</td>
<td>20° 06' 11&quot;</td>
<td>5.02'</td>
<td>196.93'</td>
</tr>
</tbody>
</table>

\[
\frac{A}{2} = \frac{40° 12' 20"}{2} = 20° 06' 10" \checkmark 11'' \checkmark
\]

**2. B**

\[
\Delta = 15° 06' 10" \text{ and } R = 575.00' \text{ Given}
\]

\[
D = \frac{5729.58}{R} = \frac{5729.58}{575.00} = 9.964483° = 09°57'52"
\]

\[
T = R \tan \frac{\Delta}{2} = 575 \tan 07°33'05" = 575 \tan 7.551389° = 76.22'
\]

\[
L = 100 \frac{\Delta}{D} = 100 \frac{15° 10' 27"}{9.964483} = 151.57'
\]

\[
L = \frac{R \Delta \pi}{180} = \frac{575(15° 10' 27")}{57.2958} = 151.57' \checkmark
\]

\[
L_C = 2 R \sin \frac{\Delta}{2} = 2(575)(\sin 7.551389°) = 151.13'
\]

\[
\begin{align*}
\text{P1} & : 1108.84 \quad 11+08.84 \quad \text{for deflections} \\
- T & : 76.22
\end{align*}
\]

\[
\begin{align*}
\text{PC} & : 1032.62 \quad 10+32.62 \\
+ L & : 151.57 \\
\text{PT} & : 1184.19 \quad 11+84.19
\end{align*}
\]

\[
\begin{align*}
L_1 & = 1050.00 \\
L_2 & = 50.00' \\
L_3 & = 1184.19
\end{align*}
\]

\[
\begin{align*}
L_1 & = 1050.00 \\
L_2 & = 50.00' \\
L_3 & = 1184.19
\end{align*}
\]

\[
\begin{align*}
L_1 & = 1050.00 \\
L_2 & = 50.00' \\
L_3 & = 1184.19
\end{align*}
\]

\[
\begin{align*}
L_1 & = 1050.00 \\
L_2 & = 50.00' \\
L_3 & = 1184.19
\end{align*}
\]
2. B. continued

\[ \phi_\infty = \frac{D}{2} = \frac{9.964483^\circ}{2} = 4.982242^\circ = 04^\circ 58'56" \]

\[ \phi_1 = \frac{\phi_\infty}{100} = \frac{D}{200} = 0.049822^\circ \]

\[ \phi_{17.38} = 17.38(0.049822^\circ) = 0.865914^\circ = 00^\circ 51'57" \]

\[ \phi_{50} = 50(0.049822^\circ) = 2.491121^\circ = 02^\circ 29'28" \]

\[ \phi_{3419} = 34.19(0.049822^\circ) = 1.703428^\circ = 01^\circ 42'12" \]

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>PC 10+32.62</td>
<td>00°00'00&quot; + 00°51'57&quot;</td>
<td>0.00'</td>
<td>0.00'</td>
</tr>
<tr>
<td>10+50</td>
<td>00°51'57&quot; + 02°29'28&quot;</td>
<td>17.38'</td>
<td>17.38'</td>
</tr>
<tr>
<td>11+00</td>
<td>03°21'25&quot; + 02°29'28&quot;</td>
<td>49.98'</td>
<td>67.34'</td>
</tr>
<tr>
<td>11+50</td>
<td>05°50'53&quot; + 01°42'12&quot;</td>
<td>49.98'</td>
<td>117.17'</td>
</tr>
<tr>
<td>PT 11+84.19</td>
<td>07°33'05&quot;</td>
<td>34.18'</td>
<td>151.13' L.C</td>
</tr>
</tbody>
</table>

\[ \Delta \phi = \frac{15^\circ 06'10"}{2} = 07^\circ 33'05" \]

Sub-chords for
- 17.38' = 2R sin \( \phi_{17.38} \) = 2(575)(sin 00°51'57") = 17.38'
- 50.00' = 2R sin \( \phi_{50} \) = 2(575)(sin 02°29'28") = 49.98'
- 34.19' = 2R sin \( \phi_{3419} \) = 2(575)(sin 01°42'12") = 34.18'

Chords for all stations = 2R sin \( \phi_{\text{Station}} \) - SEE TABLE

eg for 11+50, 2(575)(sin 05°50'53") = 117.17'