1. Shown below are the output and transfer characteristic for a NPN BJT. The thermal voltage is $V_T = 25.9$ mV. When the collector to emitter voltage is $10$ V and the base current is $25 \mu A$, what is the collector current? Using this bias point, what is the Early Voltage, the zero bias current gain $\beta_0$ and the zero bias saturation current $I_{SO}$?

\[ V_A = 115.5 \text{ V} \]

\[ I_C = 1.68 = 6.8 \text{ mA} \]

\[ \beta_0 = \frac{I_C}{I_B} \]

\[ 252.5 \text{ mV} \]

\[ I_{SO} = \frac{I_C}{1 + \frac{V_{CE}}{V_A}} \]

\[ I_{SO} = 3.678 \times 10^{-14} \text{ A} = 36.8 \text{ GA} \]

\[ V_{BE} = 0.67 \text{ V} \]

\[
\begin{array}{|c|c|c|c|}
\hline
I_C & V_A & \beta_0 & I_{SO} \\
\hline
6.8 \text{ mA} & 115.5 & 233 & 36.8 \text{ GA} \\
\hline
\end{array}
\]
2 Shown below is a single stage common emitter amplifier with a bipolar power supply using a NPN BJT as the active device. It is specified that $V^+ = 15 \text{ V}$, $V^- = -15 \text{ V}$, $C_1 = C_2 = C_E = 300 \mu\text{F}$, $R_B = 100 \text{ k}\Omega$, $R_E = 73 \text{ k}\Omega$, $R_T = 5.1 \text{ k}\Omega$, $R_O = 3.3 \text{ k}\Omega$, and $R_L = 15 \text{ k}\Omega$. For the calculations assume that the base-to-emitter dc voltage drop is 0.65 V, $\beta = \infty$, and the Early voltage is infinity for each transistor. Assume that the thermal voltage is 25.9 mV. Determine $I_{C_1}, V_{C_1}, V_{C_3}, V_{C_4}$, and $A_v = \frac{v_o}{v_i}$ where $A_v$ is the small signal midband voltage gain.

\[ \beta = \infty \]
\[ \alpha = \frac{\beta}{\beta + 1} = 1 \]

\[ I_T R_T + V_{BE} + V^- = 0 \]
\[ I_T = -\frac{(V_{BE} + V^-)}{R_T} = 2.814 \text{ mA} \]

\[ I_T = I_{c_3} = I_{c_1} = I_{E_1} = I_{c_1} = 2.814 \text{ mA} \]

\[ V_{C_1} = V^+ - I_{c_1} R_C = 5.715 \text{ V} \]

\[ V_{C_3} = -I_T R_T = -14.35 \text{ V} \]

\[ V_{BE} = -V_{BE} = 0 \]

\[ V_{E_1} = V_{BE} - V_{BE} = -0.65 \text{ V} \]

\[ V_{C_4} = V_{E_1} - I_{E_1} R_E = -0.855 \text{ V} \]

\[ I_{E_1} = \frac{V_T}{I_{E_1}} = \frac{25.9 \text{ mV}}{2.814 \text{ mA}} = -32.9 \text{ V} \]

<table>
<thead>
<tr>
<th>$I_{C_1}$</th>
<th>$V_{C_1}$</th>
<th>$V_{C_3}$</th>
<th>$V_{C_4}$</th>
<th>$A_v$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.81 m</td>
<td>5.715</td>
<td>-14.35</td>
<td>-0.855</td>
<td>-32.9</td>
</tr>
</tbody>
</table>
3. Shown below is a BJT common base amplifier. Assume that the dc voltage drop from base to emitter for each $\alpha$ is 0.65 V, the Early voltage is infinity, the thermal voltage is 25.9 mV and $\beta = \infty$. The power supply voltage is $V^+ = 15$ V. The component values are: $R_E = 730\, \Omega$, $R_B = 92\, k\Omega$, $R_C = 6.8\, k\Omega$, $R_L = 20\, k\Omega$ and $R_T = 11.2\, k\Omega$. Each of the capacitors is 1\, \mu F. Determine $I_{C1}, V_{C1}, V_{C3}$, and $A_v$ the small-signal midband voltage gain $A_v = v_o/v_i$.

\[
\beta = \infty
\]

\[
\alpha = \frac{\beta}{\beta + 1} = 1
\]

\[
I_{B1} = I_{B2} = I_{B3} = 0
\]

\[
I_T R_T + VBE + V^- = 0 \Rightarrow I_T = \frac{-V^- - VBE}{R_T} = 1.281\, mA
\]

\[
I_T = I_{C3} = I_{C4} = I_{E1} = I_{C1} = 1.281\, mA
\]

\[
V_{c1} = V^+ - I_{C1} R_C = 6.287\, V
\]

\[
V_{c3} = -I_T R_T = -14.35\, V
\]

\[
A_v = \alpha \frac{R_{C1} R_L}{R_C + R_E} = 6.865
\]

<table>
<thead>
<tr>
<th>$V_{C1}$</th>
<th>$I_{C1}$</th>
<th>$V_{C3}$</th>
<th>$A_v$</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.29</td>
<td>1.281 mA</td>
<td>-14.35</td>
<td>6.865</td>
</tr>
</tbody>
</table>