1. The BJT has the parameters $\beta = 199$ and $V_{BE} = 0.65\, V$. It is given that $V^+ = +15\, V$, $V^- = -15\, V$, $R_1 = 300\, k\Omega$, and $R_2 = 33\, k\Omega$.
   (a) Solve for $R_E$ such that $I_C = 2\, mA$.
   (b) What is the maximum value that $R_C$ can have for the BJT to remain in the active mode?

\[
V_{BB} = \frac{V^+ R_2 + V^- R_1}{R_1 + R_2} = -12.027\, V \\
R_{BB} = R_1 || R_2 = 29.73\, k\Omega
\]

\[
V_{BB} - V^- = \frac{I_C}{\beta} R_{BB} + V_{BE} + \frac{I_C}{\alpha} R_E \\
\Rightarrow R_E = \frac{V_{BB} - V^- - V_{BE}}{I_C - \frac{R_{BB}}{\beta}} = 1007\, \Omega
\]

\[
V_{CB} = (V^+ - I_C R_C) - \left(V_{BE} + \frac{I_C}{\alpha} R_E + V^-\right) > 0 \\
\Rightarrow R_C = \frac{1}{I_C} \left[V^+ - \left(V_{BE} + \frac{I_C}{\alpha} R_E + V^-\right)\right] < 13.66\, k\Omega
\]

2. The BJT active mode currents are given by the equations $i_C = I_{S0} \left(1 + v_{CE}/V_A\right) \exp(v_{BE}/V_T)$, $i_B = i_C/\beta$, and $\beta = \beta_0 \left(1 + v_{CE}/V_A\right)$. Describe how these equations are used to plot the transfer, output, and input characteristic curves. Show how the parameters $g_m$, $r_0$, and $r_\pi$ in the hybrid-pi model are defined on the curves. Assume the Q-point values $I_C$, $V_{CE}$, and $V_{BE}$. Answers: The plots of the characteristic curves are covered in the class notes. At the Q point, $g_m$ is the slope of the transfer characteristic curve, $r_0$ is the reciprocal of the slope of the output characteristic curve, and $r_\pi$ is the reciprocal of the slope of the input characteristic curve.