**Problem 1:** For the common-emitter amplifier shown below:

(a) Find the small signal voltage gain $v_o/v_i$ as a function of $R_S$, $R_L$, $\beta$, $V_A$, and collector current $I_C$. Do not ignore $r_o$ in this problem.

(b) Determine the value of DC collector bias current $I_C$ that maximizes the small signal voltage gain. What is the voltage gain at the optimum $I_C$? Explain qualitatively why the gain falls at very high and very low collector currents.

**Problem 2:** In this problem, we examine the effect of temperature on the bias stability. It is found that the $I_S$ of the npn transistor shown below has a temperature coefficient $\left(\frac{1}{I_S} \frac{dI_S}{dT}\right)$ of 3300 ppm/°C near 300 K. Also, $\beta_F = 200$ at 300 K, and has a temperature coefficient $\left(\frac{1}{\beta_F} \frac{d\beta_F}{dT}\right)$ of 2000 ppm/°C. You are given that $I_S = 10^{-15}$ A at 300 K. Assume that the values of $V_{BB}$, $R_B$ and $R_C$ are independent of temperature.

(a) Find the values of $R_B$ and $R_C$ to make $I_C = 500 \mu$A and $V_O = 2.5$ V at 300 K.

(b) Derive the temperature coefficient of the collector current $\left(\frac{1}{I_C} \frac{dI_C}{dT}\right)$ at $T = 300$ K.

(c) Compute the temperature dependence of the quiescent output voltage $\left(\frac{dV_O}{dT}\right)$ in V/°C at $T = 300$ K.
Problem 3: Consider the following transistor circuit.

(a) With $V_{BE} = 0.7 \text{ V}$ and $\beta = 400$, calculate the transistor operating point (find $I_C$ and $V_{CE}$).

(b) Due to a manufacturing mix-up, some of your transistors have $\beta = 100$. Find $I_C$ for the new transistors.

(c) Find new values for the base-biasing resistors so that $I_C$ only changes by 10% when $\beta$ falls from 400 to 100.

(d) Refer again to the circuit in part (a). Due to temperature fluctuations in your operating environment, $V_{BE}$ sometimes drops as low as 0.5V. Find $I_C$ under this condition.

(e) How should the transistor be biased so that $I_C$ only changes by 10% if $V_{BE}$ falls from 0.7V to 0.5V?
Problem 4: A EFCB (emitter-follower common-base) connection is illustrated below. Determine the overall small signal voltage gain $v_o/v_i$, input resistance, and output resistance. You may neglect $r_o$ for this problem.