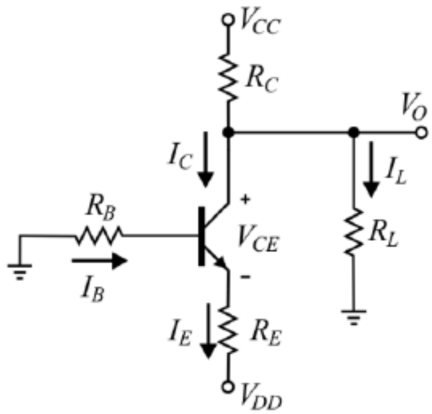
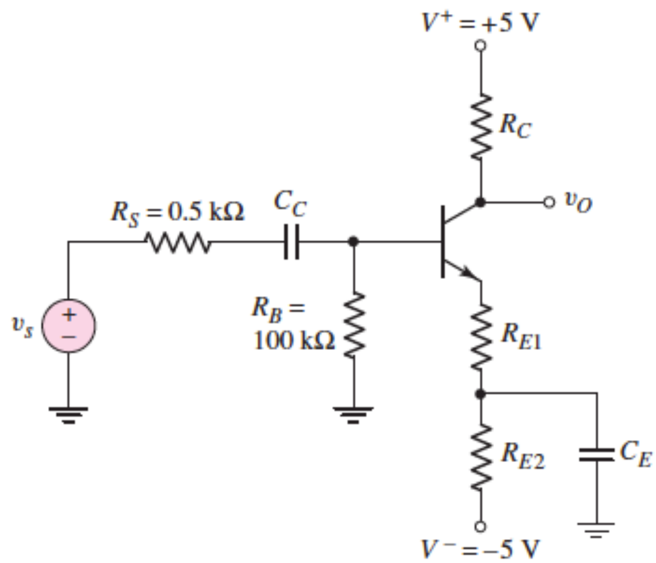
1. (15 points) **DC load line.**
   For the circuit below, determine the dc load line equation for the BJT, incorporating β. That is, do not assume that $I_E \simeq I_C$. Take $R_C = R_E = R_L = 5K\Omega$, $V_{CC} = 12$, $V_{DD} = -5V$, and $\beta = 100$.



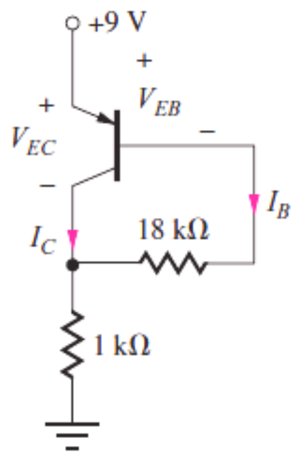
2. (35 points) **CE Amplifier.**
The Common-emitter amplifier circuit shown below is to be designed to amplify a 12 mV sinusoidal signal from a microphone to 0.4V sinusoidal output signal. Take $r'_e = 125\Omega$, and $R_{E2} = 20K\Omega$, $\beta_{DC} = 100$, and $\beta_{ac} = 110$



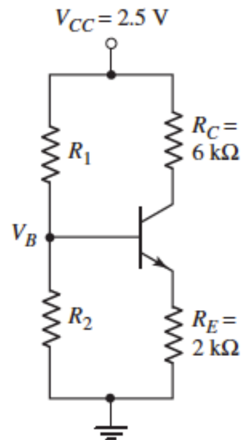
1. (10 points) Find R_C and R_{E1}.
2. (10 points) Draw the small signal ac model for the amplifier. Find $R_{in(base)}$, $R_{in(tot)}$, and the overall voltage gain v_s/v_0 of the amplifier.
3. (5 points) Draw the ac collector voltage.
4. (5 points) We add a coupling capacitor to the output of the amplifier. Draw the source and the output ac voltages.
5. (5 points) Assume now that the bypass capacitor is removed. Compare the new overall voltage gain to the previous one.

3. (20 points) **PNP transistor and variations of temperature.**

For the circuit shown below. Assume $\beta_{DC} = 50$. The V_{EB} is 0.7V at 25°C and decreases 2.5mV per degree Celsius increase in temperature. At a temperature T°C > 25°C, the collector current is 6.14 mA. Find T. (Neglect any change in β_{DC}.)

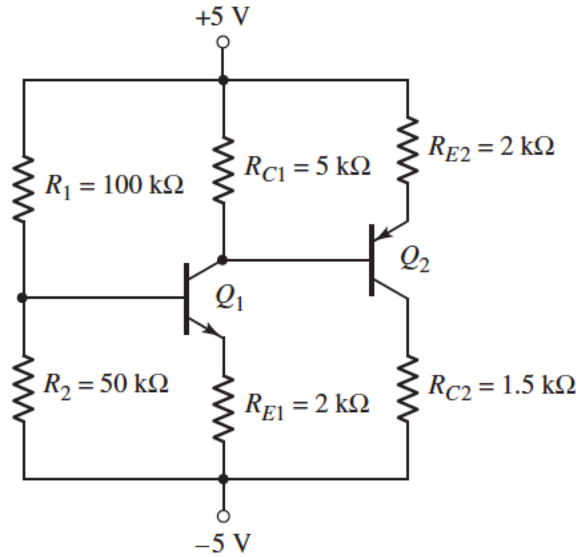


4. (30 points) **Voltage divider.**
For the voltage divider bias circuit shown below, assume that the current gain is $\beta_{DC} = 120$.



1. (15 points) Design the circuit such that $I_{CQ} = 0.15$ mA and $R_{TH} = 200K\Omega$.
2. (15 points) Due to an intense increase in temperature, the current gain doubles. Determine the percentage change in the value of V_{CEQ}.

Bonus (20 points)
Consider the following multi-stage transistor circuit. Take $\beta = 100$.



Calculate the dc voltages at each node and the dc currents through the resistors.