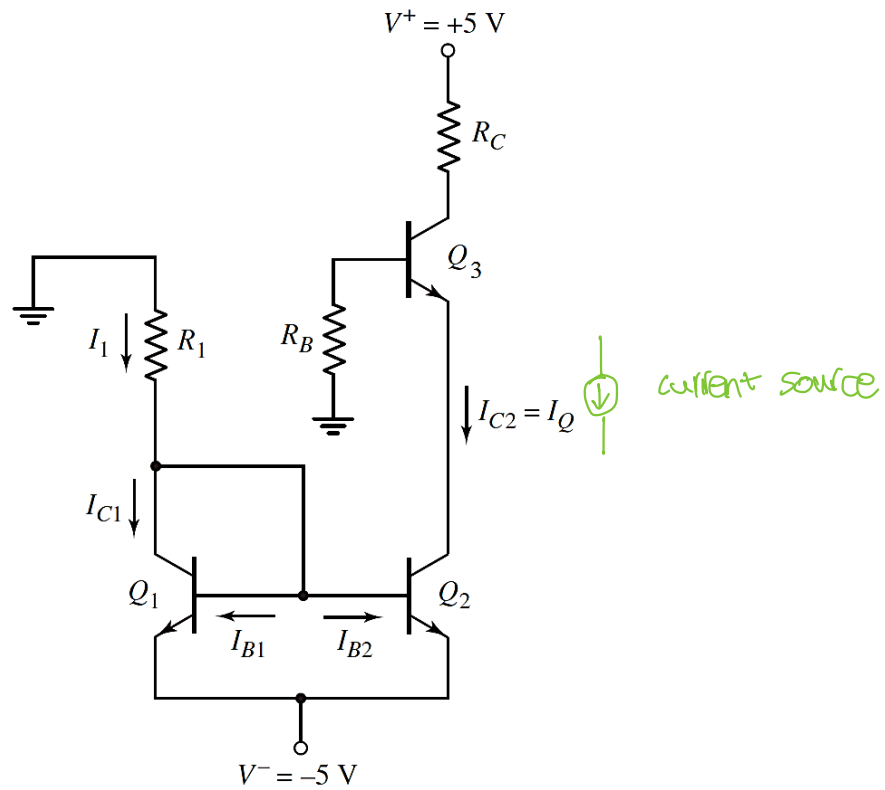


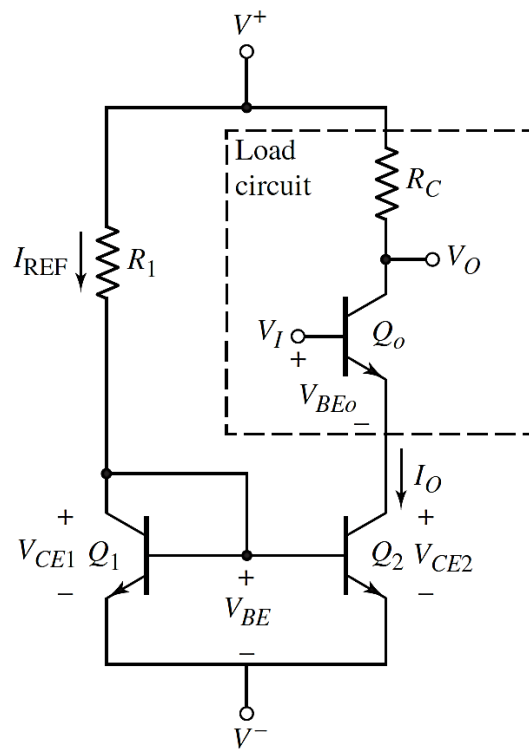
Practice Problem Set # 4

ENEL 469

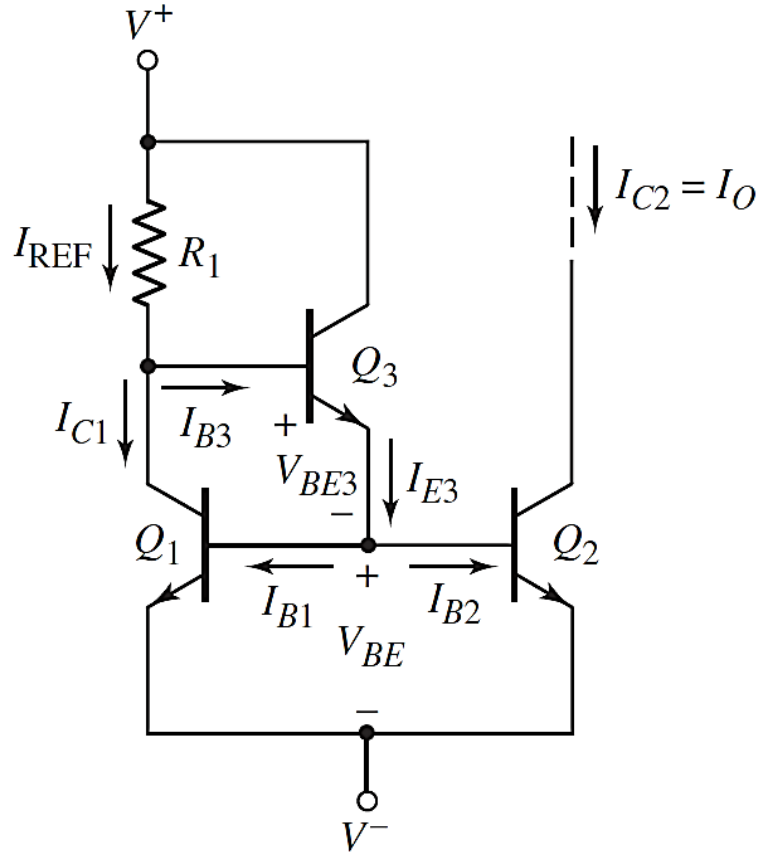
1. Consider the circuit shown below where all the transistors are identical and,  $R_1 = 10 \text{ k}\Omega$ ,  $R_B = 100 \text{ k}\Omega$ ,  $R_C = 2 \text{ k}\Omega$ ,  $\beta = 50$ ,  $V_{BE(ON)} = 0.7 \text{ V}$  and  $V_A = \infty$ . Find  $I_{B1}$ ,  $I_{B2}$ ,  $I_{B3}$ ,  $V_{CE2}$ , and  $V_{CE3}$ . Do not ignore base currents.



2. Consider the following circuit with the parameters:  $V^+ = 5\text{ V}$ ,  $V^- = -5\text{ V}$ ,  $R_1 = 9.3\text{ k}\Omega$ ,  $\beta = 50$ ,  $V_{BE(ON)} = 0.7\text{ V}$ , and  $V_A = 80\text{ V}$ . Determine the change in  $I_0$  as  $V_{CE2}$  changes from  $0.7\text{ V}$  to  $5\text{ V}$ .



3. Consider the circuit shown below having the parameters:  $V^+ = 3\text{ V}$ ,  $V^- = -3\text{ V}$ , and  $R_1 = 30\text{ k}\Omega$ . The parameters of the transistors  $Q_1$  and  $Q_2$  are  $V_{BE1,2(\text{on})} = 0.7\text{ V}$  and  $\beta = 120$ . The parameters of the transistor  $Q_3$  are  $V_{BE3(\text{on})} = 0.6\text{ V}$  and  $\beta_3 = 80$ . Assume  $V_A = \infty$  for all three transistors. Determine the value of each current indicated in the circuit.



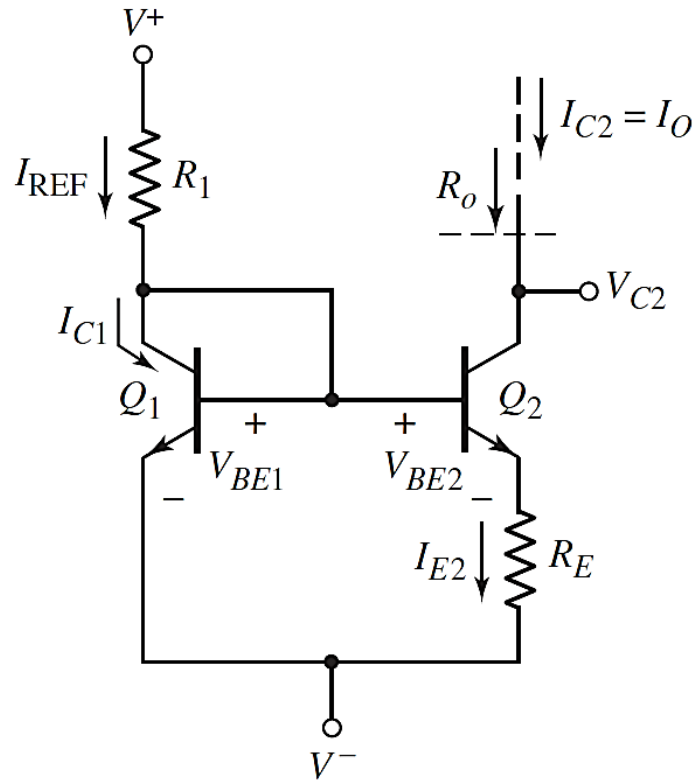
4. Design a Widlar current source (find the values of  $R_1$  and  $R_E$ ) as shown in the following figure with the specifications:

Bias voltages:  $V^+ = 5\text{ V}$ ,  $V^- = -5\text{ V}$

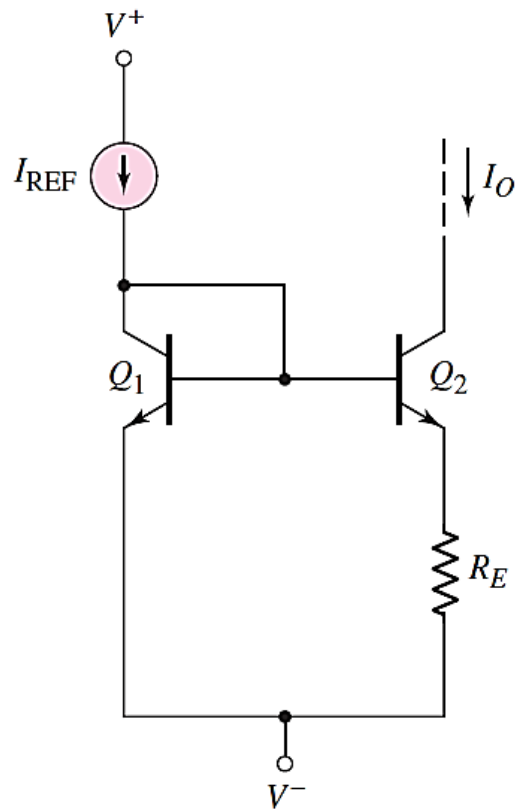
Currents:  $I_{\text{REF}} = 1\text{ mA}$  and  $I_0 = 12\text{ }\mu\text{A}$ .

The transistors  $Q_1$  and  $Q_2$  are described as  $V_{\text{BE}} = 0.8\text{ V}$  at  $I_C = 10\text{ mA}$  and  $\beta = 50$ .

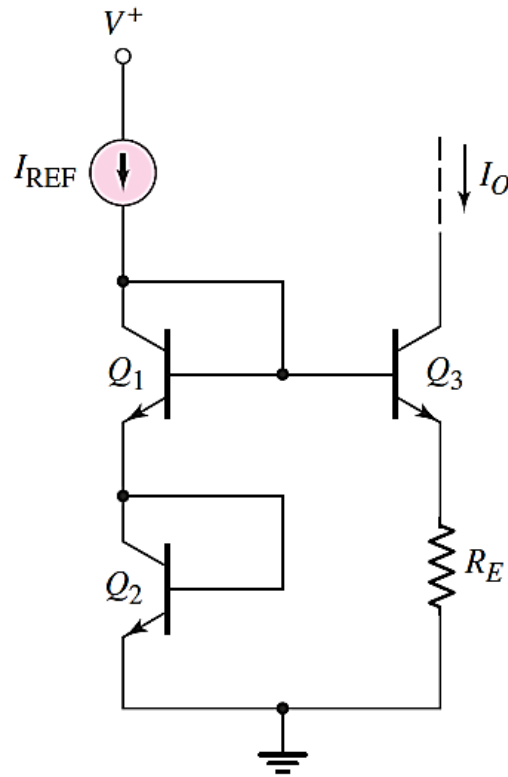
Do not ignore base currents.



5. In the following circuit assume that  $I_{REF} = 120\ \mu\text{A}$ ,  $I_{S1} = I_{S2} = 2 \times 10^{-16}\ \text{A}$ . a) Find  $V_{BE1}$ , b) If  $I_0 = 50\ \mu\text{A}$ , determine  $V_{BE2}$  and  $R_E$ , c) Find  $I_0$  if  $R_E = 700\ \Omega$ , what is  $V_{BE2}$ ?



6. Consider the circuit shown below. Neglect base currents and assume  $V_A = \infty$ . Determine the value of  $R_E$  such that  $I_O = I_{REF} = 100 \mu\text{A}$ . Assume  $V_{BE} = 0.7 \text{ V}$  at a collector current of  $1 \text{ mA}$ .



7. For the circuit shown in the following figure assume transistor parameters  $|V_{BE}| = |V_{EB}| = 0.7 \text{ V}$  for all transistors except Q3 and Q6 and let  $\beta = \infty$ . Find the collector current in each transistor. *This question requires trial and error method for finding  $I_{C3}$  and  $I_{C6}$ .*

