Homework 5

1. **Purpose:** Understanding the common-emitter amplifier. In the circuit below, assume the *npn* BJT is operating in forward-active mode. Let $\beta = 130$, $V_A = 60$ V, and $V_{BE} = 0.7$ V. Assume the capacitors have negligible impedance at the frequency of the ac signal.

Given, $V_{CC}=12$ V, $R_{sig}=1k\Omega$, $R_1=240k\Omega$, $R_2=160k\Omega$, $R_C=15k\Omega$ and $R_L=100k\Omega$

(a) What are the purposes of capacitors $C_1$, $C_2$, and $C_3$ in this circuit?

(b) Determine all DC terminal voltages and currents as well as the small-signal voltage gain $A_v (=v_o/v_{sig})$ of the amplifier circuit if $R_E = 12$ kΩ.

(c) Repeat part (b) with $R_E = 80$ kΩ.

(d) If the goal is to maximize the voltage gain, what general design rule for common-emitter amplifiers can you infer from the results of parts (b) and (c)?

![Figure 1. BJT amplifier circuit.](image)

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**Note:** The figure is not transcribed here due to the nature of the task. The circuit includes a BJT with bias resistors and capacitances at various points, illustrating the setup described in the text.
2. **Purpose**: Coupling diodes and BJTs
   In the circuit below, find the Q-point of both the Zener diode and BJT. Assume the BJT is biased in the forward-active regime, that $V_Z = 5V$, $R_Z = 0 \, \Omega$, $\beta = 100$ and $V_{BE} = 0.7V$.

![Figure 2. Zener diode with BJT.](image)

3. **Purpose**: BJT application in circuit designing
   Assume forward active mode bias and identical BJTs $Q_1$ and $Q_2$ in the following “current mirror” circuit.
   Given, $R_2 = 10k\Omega$, $R_3 = 1k\Omega$, $R_7 = 100\Omega$, $R_8 = 100\Omega$, $\beta = 416.4$, and $I_S = 6.73 \, \text{fA}$.

   (a) Find the current flowing in $R_3$ and compare it to the current flowing in $R_2$.
   *Note: it may be helpful to use Ebers Moll model only for determining collector currents in the two transistors, but otherwise use Beta/CVD model.*

   (b) What happens to the currents if $R_3$ is replaced with a $5k\Omega$ resistor?

![Figure 3. Current mirror circuit.](image)