Note: Manufacturer spec sheet gives $\beta = 100$ for 2N3904 transistor.

**Experiment 1: Poor biasing**

Set $R_B = 1.5 \, \text{M}\Omega$, $R_C = 5 \, \text{k}\Omega$, $V_{CC} = 15 \, \text{V}$ and a 2N3904 BJT.

**Circuit Analysis:**

a) Compute $I_C$, $I_B$, and $V_{CE}$.

**PSpice Simulation:**

b) Simulate the circuit with PSpice (bias point details only) and compare values of $I_C$, $I_B$, $V_{CE}$, and $V_{BE}$ from PSpice simulations with your circuit analysis.

c) Rerun your PSpice simulations for temperatures of 0 and 60°C. Make a table of $I_C$, $I_B$, $V_{CE}$, and $V_{BE}$ for the above temperatures and that of part b (which is for default temperature). Explain your observations.

**Lab Exercise:**

d) Set up the circuit and measure $I_C$, $I_B$, $V_{CE}$, and $V_{BE}$. Note that these measurements are not straightforward. In some cases, you have to measure the quantities “indirectly.” Compare your measurements of $I_C$, $I_B$, $V_{CE}$, and $V_{BE}$ with your PSpice simulations.

e) Set the voltmeter to measure $V_{CE}$. Hold the transistor between two fingers without touching the rest of the circuit. Transistor will warm up slightly by your body temperature. What happens to $V_{CE}$ as transistor warms up? Explain your observations.

**Experiment 2: Good biasing**

Set up the circuit with a 2N3904 transistor, $R_2 = 12 \, \text{k}\Omega$, $R_1 = 39 \, \text{k}\Omega$, $R_C = 2 \, \text{k}\Omega$, $R_E = 1 \, \text{k}\Omega$, and $V_{CC} = 15 \, \text{V}$.

**Circuit Analysis:**

a) Compute $I_C$, $I_B$, and $V_{CE}$.

**PSpice Simulation:**

b) Simulate the circuit with PSpice (bias point details only) and compare values of $I_C$, $I_B$, $V_{CE}$, and $V_{BE}$ from PSpice simulations with your circuit analysis.

c) Rerun your PSpice simulations for temperatures of 0 and 60°C. Make a table of $I_C$, $I_B$, $V_{CE}$, and $V_{BE}$ for the above temperatures and that of part b (which is for default temperature). Explain your observations. Compare your results with Experiment 1.
*Lab Exercise:*

d) Set up the circuit and measure $I_C$, $I_B$, $V_{CE}$, and $V_{BE}$. Compare your measurements with your PSpice simulations. Explain why they may be different.

e) Set the voltmeter to measure $V_{CE}$. Hold the transistor between two fingers without touching the rest of the circuit. Transistor will warm up slightly by your body temperature. What happens to $V_{CE}$ as transistor warms up? Explain your observations.

f) Compare your results from this experiment with those of Experiment 1.

**Experiment 3: Current Mirror**

Set up the circuit with the matched Si transistors of THAT 300 chip (Note Q1 and Q2 of the chip are matched. So are Q3 and Q4). Set $V_{CC} = 5$ V, $V_{EE} = -3$ V, and $R = 1$ kΩ. The circuit is powered with two voltage sources. Common of power supply is the ground for this circuit.

*Circuit Analysis:*
a) For what values of $V_{C2}$ the circuit acts as a current mirror?
b) Compute $I_o$ for the case that the circuit is a current mirror.

*Lab Exercise:*
c) With the potentiometer set to a low value, measure current $I_o$ and voltage $V_{C2}$. Increase the resistance of the potentiometer while monitoring $I_o$ and $V_{C2}$. Record values of $I_o$ and $V_{C2}$ for $V_{C2} = 5, 4, 3, ...$ V. Continue increasing the resistance of potentiometer until the circuit does not behave like a current mirror. Record the corresponding $V_{C2}$ value and compare with part a. Tabulate the data and explain your observations.

**Experiment 4: Biasing with a current mirror**

We now use the current mirror of experiment 3 to bias a 2N3904 transistor (Q3) with $R_C = 500$ Ω.

*Circuit Analysis:*
a) Compute $I_C$, $I_B$, $V_{BE}$, and $V_{CE}$ of Q3 (see also part c)

*Lab Exercise:*
b) Set up the circuit and measure $I_C$, $V_{CE}$, and $V_{BE}$ of Q3. Compare your measurements with circuit analysis of part a.

c) Remove $R_C$ from the circuit and repeat part a and b.

d) Summarize your observations of the three biasing schemes of this lab.