A. Pre-laboratory work

1. Read and understand section 5.5 on dc biasing. This circuit shown in Fig. 1 has the same dc biasing scheme as that discussed in section 5.5.1 and shown in Fig. 5.43. So, you can use the same analysis procedure to solve for the voltages and currents everywhere.

2. Read and understand section 5.7.1 on the common-emitter (CE) amplifier.

3. PSPICE simulate the characteristics of 2N3904. As shown below, properly assign values for the collector voltage \( V_c \) and the base current \( I_{base} \), in a nested sweep loop. The resulting plot is similar to that shown in Fig. 5.21: the collector current versus \( V_{CE} \), as the base current is stepped from zero to, for example, 100\( \mu \)A. **Show this simulation result in your pre-laboratory report.**

4. Now, analyze the circuit shown in Fig. 1. First, choose the operating point of 2N3904 using the result that you obtained earlier. You pick \( V_{CC} \), and the values of the resistors and capacitors, and carry out PSPICE analysis for the dc voltages at all nodes and currents in all branches. Put down the dc solutions on the circuit diagram. Note that \( V_{CC} \) must offer proper dc bias to the base, such that the emitter-base pn junction is forward-biased, and the collector-base pn junction is...
reverse-biased. That is, the goal is to make the bipolar transistor work in the middle of the active region.

5. Discuss your design criteria for selecting the values of (1) $R_1$ and $R_2$; (2) $C_1$ and $C_2$; (3) $R_E$; (4) $C_E$; and (5) $R_{load}$. (Explain why $R_1$ is chosen to be roughly 1kohm, or, why $C_1$ is picked to be 1µF.)

6. Carry out ac analysis and obtain the voltage gain (which is defined to be $V_{output}/V_{input}$), as a function of frequency.

7. Small signal analysis: First, identify the operating point ($Q$, the quiescent point) in the transistor characteristics. Put down the dc current $I_c$. Follow the steps in section 5.6, calculate for $g_{m}$, $r_e$, and $r_n$. Put down your derivation and the results in the pre-lab report.

8. Calculate the ac voltage gain. Derive the expression first, and then plug in the values. Put down the calculated gain in your pre-laboratory report.

B. What to do in the laboratory

1. Measure the “current-voltage characteristics of 2N3904 in the common-emitter configuration. Shown below, $V_1$ and $V_2$ are two dc voltages that you can adjust manually. $R_1$ and $R_2$ are resistors for reading the current through it. That is, the base current $I_B=(V_c-V_d)/R_1$, and the collector current $I_C=(V_a-V_b)/R_2$. The procedure is to first select $R_1$ to be, for example, 1kohm. Keep $V_2=0$. Increase $V_1$ slowly, until you measure a small (of the order of 1mV by DMM) voltage across $R_1$. Then, increase $V_2$ from zero up to ~ 10V at 0.1V steps. Record the measured voltages and currents. Plot the current-voltage characteristics in your post-lab report.

2. Implement your circuit shown in Fig. 1. Start from the dc biasing to the transistor, i.e., use only the 2N3904, $R_1$, $R_2$, $R_C$, $R_E$ and $V_{CC}$ only.

3. Measure the dc characteristics --- dc voltages and currents every where. Verify that the bipolar transistor is in the middle of its active region. Observe the quiescent point, defined by the dc value of $I_c$, $V_{CE}$, and $I_{base}$. How different is it from your designed position that you described in your pre-lab report? You may want to make adjustments, so that the output voltage can have the largest voltage swing.

4. Once the transistor is tuned to be working in the active region, proceed with the amplifier experiment. Finish the rest of the circuit. Use a small $V_{input}$: the amplitude should be much less than 26mV, yet large enough so that we have
enough signal/noise ratio for a steady measurement. Measure the voltage gain, and observe and record the dependence of the voltage gain and phase shift on the frequency of $V_{\text{input}}$. Record the two data. Determine how you would describe such dependence in your final report.

5. Observe the dependence of the voltage gain on the $R_{\text{load}}$. Vary the value of $R_{\text{load}}$ by several orders of magnitude. Determine how you would describe such dependence, and understand why there is such a dependence.

6. Observe the dependence of the voltage gain on amplitude and waveform of $V_{\text{input}}$. Determine how you would describe such dependence in your final report.

C. Post-laboratory report questions, in addition to your report on data and your additional observation

1. Present data. Arrange the order, so that your report shows your good understanding to the subject.

2. Hand calculate the low ($f_L$) and high ($f_H$) 3-dB frequencies. Compare your calculation with your PSPICE calculation. Add your opinion.

3. What is the typical applications of the CE amplifier in practice?