A. Pre-laboratory work

1. Read and understand section 5.7.6 on the common collector amplifier, or the emitter follower.

2. Understand 2N3904. PSPICE simulate the characteristics of the transistor 2N3904. The circuit is shown below. Step the base current while sweeping the collector voltage. Record and plot the collector current as a function of VCE, for $0 < I_{\text{base}} < I_{\text{base max}}$. The $I_{\text{base max}}$ is determined by your simulation: at a high base current the transconductance becomes diminished.

3. Spice simulation of the emitter follower amplifier circuit shown in Fig. 1. Draw the ac small signal equivalent. Hand calculate the four important quantities --- the input impedance, the output impedance, the voltage gain, and the current gain. The circuit is different from the textbook example, because we use the emitter resistor $R_E$, instead of the current source.

4. **Show simulation results in your pre-laboratory report.** In your simulation, you need to assign “proper” values to the components.
   a. Based on the transistor characteristics, what is the proper dc bias voltage range?
   b. $V_S$ is a pure ac sine-wave source. What is the maximum amplitude?
c. $R_{\text{base}}$ is the base resistance. What is the proper value? Explain.
d. $R_E$ is the emitter resistance. What is the proper value? Explain.
e. $R_{\text{Load}}$ is the load resistance. What is the proper value? Explain.
f. $C_{C1}$ is the coupling capacitance. What is the proper value? Explain.
g. Design your amplifier so that the ac voltage gain is maximized. How much is it? Show Bode plots for the amplitude and phase versus frequency.
h. Increase and decrease the $R_{\text{Load}}$ by one order of magnitude, and show the resulting Bode plots. Discuss why the change.

5. Simple observations to the circuit characteristics:
   a. Choose a quiescent point, so that the emitter follower allows a maximum signal swing. So, position the quiescent point at the middle of the span of the I-V curves.
   b. The goal above will determine the dc power supply values. We can make the power supplies symmetric, i.e., $V^+$ is equal to $V^-$. (For example, ±15V will do.)
   c. The value of the coupling capacitor is supposed to be large to allow ac to pass. The higher the frequency, the less the impedance. But, there are practical limitations due to materials. Study the various capacitors and determine which value is a good compromise.
   d. The load resistance can be as small as zero (a short) or as large as infinity (open). One $R_{\text{Load}}$ value often used in practice is 50ohm, as in the case of the RG-59 coaxial cable that can pass up to 10GHz. But, to drive a 50ohm cable, the output impedance of the emitter follow should also be 50ohm. This is accomplished by choosing the right values of the $R_E$.

B. What to do in the laboratory
1. Wire up the amplifier, implement your circuit like that shown in Fig. 1. Verify the dc biasing to the transistor. Record the currents and voltages everywhere.
2. Verify that the 2N3904 is working properly, and the Q-point is near what you have design it to be.
3. Measure the ac characteristics. Use a small $V_{\text{input}}$ to begin with, where the amplitude is much less than 26mV, yet large enough so that we have enough signal/noise ratio. Measure the voltage gain, and observe and record the dependence of the voltage gain and phase shift on the frequency of $V_{\text{input}}$. Determine how you would describe such dependence in your final report. (For example, the voltage gain is $x$ from $f_1$ Hz to $f_2$ Hz, and it is reduced to $x/2$ at $f_3$ Hz. The phase change is $\theta_1$ degrees from $f_1$ Hz to $f_2$ Hz, and it changes to $\theta_2$ degrees at $f_3$ Hz, etc.
4. Measure the output impedance. Keep the input signal small (yet large enough so that you do your observation). Keep the coupling capacitor. Observe the dependence of the voltage gain on the $R_{\text{Load}}$. Vary the value of $R_{\text{Load}}$ and observe the dependence of the voltage gain versus $R_{\text{Load}}$ of magnitude. When the load resistance is large, the voltage gain is high. When the load resistance drops to the output impedance, the voltage gain is half of its value with $R_{\text{Load}}$ open. As $R_{\text{Load}}$ becomes smaller and smaller, the output voltage eventually diminishes. Determine how you would describe such dependence, and understand why there is such dependence. [Tip: Use ac coupling to the scope to center your ac signal.
Change the sensitivity, so that you see a full swing on the screen. This makes the reading easier.

5. Measure the input impedance. Use scope to read the voltage at both sides of the base resistor. This voltage difference allows you to calculate for the ac current. Obtain the impedance by taking the voltage to current ratio.

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.

7. Observe the voltage gain at the low frequency limit. Find the -3dB frequency caused by the coupling capacitance.

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

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

2. What is the typical applications of the CC amplifier in the real world?