Announcements:
- HW#7 online and due Friday via Gradescope
- Lab#5 online (this is your first project)
  - Due Tuesday, Nov. 12, 5 p.m.
- Graded Midterm and solutions passed back last time … but I also have the leftovers and solutions today that you can pick up at the end of class
- Z scores also coming back today

Lecture Topics:
- Example: Common Emitter Amplifier
- Frequency Response (if we get this far)

Last Time:
- Going through a Common Emitter Amplifier small-signal analysis example
- Now, continue with this …
Graphically, here's what we're looking to do:

Apply an input here

Determine the resulting output here

Apply an input here

Determine the resulting output here

1. Determine the DC operating point
   - i.e., find the relevant DC voltages at all nodes and DC currents through all branches
   - Draw the DC circuit
     - Eliminate independent AC small-signal sources
       - Short AC voltage sources
       - Open AC current sources
     - Open all capacitors (in particular, open the bypass/coupling capacitors)
     - Use DC transistor models
       - this might entail nonlinearity in some cases, but approximations can alleviate

\[ V_{CE} = +12V \]

\[ R_S = 100 \]

\[ V_B = 1V \]

\[ I_{BS} = 1 \text{mA} \]

\[ \frac{V_{CE}}{R_C} = 3 \text{K} \]

\[ R_E = 2.3K \]

\[ 1.01V \]

\[ 0.04V \]

\[ N_S (DC) \]

\[ N_S (AC S.S.) \]

\[ N_{S1} = V_{B1} + N_{S1} \text{ (total DC)} \]

\[ N_{S2} = V_{B2} + N_{S2} \text{ (total AC)} \]

\[ V_B = V_{CE}(\frac{R_2}{R_1+R_2}) = (12)(\frac{3k}{40k}) = 3V \]

\[ R_{BB} = R_1/R_2 = (10k) / (30k) = 7.5k \]
② Determine the elements in the small-signal transistor model(s)
   - If more than one transistor, might need to determine SS element values for several of them
     \[ g_m = \frac{I_e}{V_{T}} = \frac{1m}{25m} = 0.04 V \\
     \text{Re} = \frac{V_e}{I_e} = \frac{100}{1m} = 100 k\Omega \]

     \[ R_e = \frac{100}{0.04} = 2.5 k\Omega \]
     \[ \text{Re} = \frac{1}{g_m} = \frac{1}{0.04} = 25 S \]

③ Obtain the small-signal circuit
   - Eliminate independent DC sources
     - Short DC voltage sources
     - Open DC current sources
     - Short large coupling capacitors (C’s > 10μF)
     - Use small-signal transistor models

\[ \text{Diagram of the circuit} \]
Use standard circuit analysis (i.e., KCL or KVL with superposition) to determine the parameters of interest.

- Usually, the parameters of interest include:
  - Gain, $A_v$
  - Input Resistance, $R_i$
  - Output Resistance, $R_o$
  - Low Frequency Cut-off, $\omega_b$
  - High Frequency Cut-off, $\omega_h$

- Determine all of these during small-signal analysis.
- The total gain of the simplified amplifier circuit takes the form:

$$\frac{V_o}{V_i} = \frac{R_i}{R_i + R_s} A_v \frac{R_L}{R_L + R_o}$$

For ideal case:

- $R_i = \infty$
- $R_o = 0$
- $R_L = 0$
- $R_c \ll R_L$

**Amplifier Gain**

- $A_v \approx \frac{\beta}{R_i} \big|_{R_i \to \infty}$
- $A_v \approx \frac{V_o}{V_i} \big|_{R_i \to \infty}$
- $g_m(R_o R_c) = A_v$

- $A_v \approx -g_m R_c$
- $R_o \gg R_c$

$$A_v \approx -120$$