The material we have covered so far this semester is summarized (but NOT limited to) below:

1. Understand the basic operation of a BJT:
   - Cutoff, saturation, active. Analyze a circuit for all current equations and voltages (current relationships)
     - Make sure to be able to take a Thevenin Equivalence and use Resistance Reflection Rules.
2. Understand the bias point concept for linear amplification.
3. Be able to separate the DC and AC analysis for a circuit containing a BJT.
4. Be able to analyze a circuit (with or without cap in it) containing a BJT for DC operation.
5. Be able to draw a small-signal model of a BJT circuit.
6. Analyze a small-signal circuit to find overall gain, midband gain, input resistance, and output resistance.
7. Determine \( \omega_L \) and \( \omega_H \) or \( f_L \) and \( f_H \).

Example 1

Use: \( r_o, |V_{BE}|=0.7, \beta=50 \)

\( V_{sig} = 20+0.001\sin(20t) \)

For DC analysis, assume that the capacitors are open

(a) Solve for the DC currents:
   a. \( I_B = 11 \mu A \)
   b. \( I_E = 5.7 \mu A \)
   c. \( I_C = 5.6 \mu A \)

(b) Solve for the DC voltages:
   a. \( V_B = 15.4 \text{V} \)
   b. \( V_E = 14.7 \text{V} \)
   c. \( V_O = 17.2 \text{V} \)

(c) What region of operation is this transistor acting? **ACTIVE** \( V_C > V_B > \frac{15.4 \text{V}}{17.2 \text{V}} \)

(d) Sketch the total instantaneous waveform observed for Vo if \( Vo/V_{sig}=5 \text{V} / \text{V} \).

\[ V_{o, total} = 17.2 + 5 \sin(20t) \]
Example 2

Use:  \textbf{ignore} \ r_e \ \text{and} \ r_x, \ |V_{BE}|=0.7, \ \beta=100, \ V_T=25\text{mV} \\
V_i = 10+0.002\sin(20t)

r_x = 50\Omega, \ g_m = 50\text{mA/V}

For the following hybrid-\pi equivalent circuit below, find the following values:
(a) \( R_{in} \) (input resistance —ignore only the input source, \( V_s\text{sig} \) and include all resistors at the emitter)
(b) \( R_{out} \) (output resistance—include all resistors at the collector (no load is connected))
(c) midband gain, \( \frac{V_o}{V_s\text{sig}} \)

\[
\begin{align*}
R_{in} &= 8.9\Omega \\
R_{out} &= 7.5\Omega \\
\frac{V_o}{V_s\text{sig}} &= -26\text{V/V}
\end{align*}
\]
Example 3

For the circuit shown below, draw the AC small-signal equivalent circuit (use hybrid-\(\pi\) or model T). Make sure that everything is labeled in terms of the transistor number. (e.g. \(g_m\), \(v_{ce}\), etc.). Include \(r_o\) for all transistors. \(v_{sig} = 0.001 \sin(10t)\) AC. Assume that the capacitors act as a short.

Example 4

Use: \(g_m = 80 \text{ mA/V, } V_T = 25 \text{ mV, } \beta = 100\), ignore \(r_o\) and use \(r_s = 20\Omega\). Use the attached datasheet for all other values: (Assume C1 yields the highest pole value.)

(a) What frequency pole value does C1 create? (express the answer in rad/sec.)

(b) What is the frequency range for this circuit? (Hint: Find the high frequency value)

(a) \(47.8 \text{ rad/sec}\)

(b) \(7.5 \text{ Hz to } 459 \text{ kHz}\)
Example 5

\[ |V_{BE}| = 0.7, \beta = 100, V_T = 25\text{mV}, \text{ignore } r_o \text{ and } r_x, v_{sig} = [2 + 0.1\sin(\omega t)] \text{Volts}. \] Assume that the capacitor acts as an open for DC operation and short for AC operation. Does this circuit operate as a \textbf{linear} AC amplifier? If so, what is the gain, \( \frac{V_o}{V_{sig}} \), of the following circuit? \textbf{If not, explain why.} Assume output is taken at collector of transistor. If in saturation, use the datasheet values to determine \( \beta_{\text{forced}} \).