Due in the "EE 105 box" near 125 Cory Hall by 5pm on Friday 9/14/2012.

Read Sections 4.4–6 in B. Razavi: Fundamentals of Microelectronics

1. a) An npn transistor is voltage biased with $V_{BE} = 750\,\text{mV}$. Calculate the collector current $I_C = I_{ca}$ in the forward active region (i.e. the BC diode is reverse biased).
   b) Calculate the value of V_{BE} such that $I_C = I_{ca}/100$.

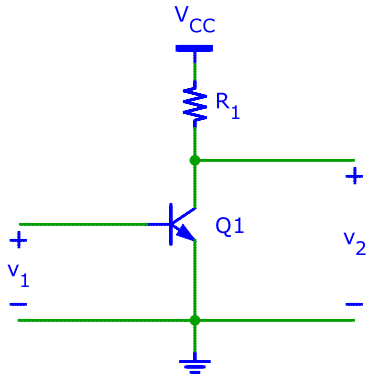
   Use the following device parameters: $I_s = 1\,\text{fA}$, $\beta = 100$, and $V_A \to \infty$.

2. a) Plot the collector current I_C versus V_{CE} for $I_B = 1\,\mu\text{A}$ of an npn BJT.
   b) Suggest an application of the BJT in this configuration and discuss its nonidealities.

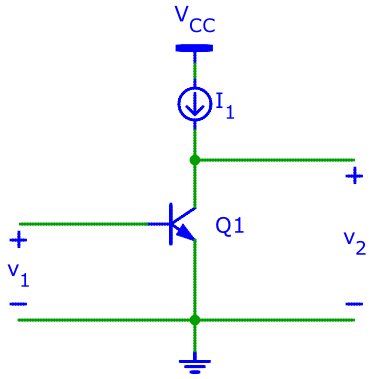
   Use the following device parameters: $I_s = 1\,\text{fA}$, $\beta = 100$, and $V_A \to \infty$.

3. Amplifier design usually consists of finding the small signal parameters to meet specifications and then determining the correct bias currents and voltages to achive the desired small signal parameter values.
   Determine I_C, I_B, V_{BE}, r_π and r_o for $g_m = 10\,\text{mS}$.
   Use the following device parameters: $I_s = 1\,\text{fA}$, $\beta = 100$, and $V_A = 100\,\text{V}$.

4. a) Calculate the value of the small signal voltage gain $a_v = \frac{dv_2}{dv_1}$ at $v_2 = V_{cc}/2$ for $V_{cc} = 5\,\text{V}$ and $R_1 = 1\,\text{k}\Omega$. Ignore the Early effect (i.e. $V_A \to \infty$).
   b) Repeat for $R_1 = 10\,\text{k}\Omega$.
   c) Suggest a design modification that doubles the magnitude of a_v for the same power dissipation in R_1 as part (b). Specify all component values.



5. a) In the circuit below R_1 is replaced by an ideal current source I_1. Calculate the small signal voltage gain $a_v = \frac{dv_2}{dv_1}$ at 300 K when Q_1 is in the forward active region.
   Use the following device parameters: $I_s = 1\,\text{fA}$, $\beta = 100$, and $V_A = 100\,\text{V}$.
   Note what the solution does *not* depend on. This understanding will come in handy when you design more complicated circuits.
   b) Suggest a circuit for realizing the current source. Draw the complete schematic including Q_1 and the required biasing.
   Hint: use a BJT. If you had a choice, what value would you pick for the Early Voltage V_A?



6. Forward biasing the BC diode of an npn transistor results in an additional base current that effectively lowers the value of β. Determine V_{CE} at which β degrades by 5 % from the nominal value for $V_{BE} = 720\,\text{mV}$. The nominal beta is 120.

7. In the circuit below v_1 and $R_1 = 10\,\text{k}\Omega$ represent a microphone, and $R_2 = 2\,\text{k}\Omega$ models a headset. The source V_{BE} is a dc biasing source you are free to adjust to an appropriate value (specify). Draw the schematic diagram of an amplifier and specify all component values such that the magnitude of the small signal voltage gain v_2/v_1 is at least 10. This problem has more than one correct solution. Available devices: BJT's (npn and pnp) with $I_s = 1\,\text{fA}$, $\beta = 100$, and $V_A = 100\,\text{V}$, ideal voltage and current sources, resistors.