Instructions, notes, and hints:

Provide the details of all solutions, including important intermediate steps. You will not receive credit if you do not show your work.

Some problems might require good engineering approximations or assumptions to be applied. In those cases, your answer might differ considerably from the posted answer. Given typical device variations and component tolerances, some amount of discrepancy is often reasonable. If you justify any approximations you make, you will be given full credit for such answers.

Prob. 5.113: For Parts (c) and (d), remember that the output voltage varies sinusoidally around a DC (quiescent) average value. You need to find the maximum output voltage swing for which the MOSFET does not enter the cut-off or triode regions.

Assignment:

Problem 5.113 in the textbook, plus the following additional problems:

1. In the CE amplifier shown below, assume that all of the capacitors act as shorts at the operating frequency and that $V_A \to \infty$. Also assume that the bias network is designed so that $V_{CC}$ is evenly divided between $R_C$, $V_{CE}$, and $R_E$. Show that the maximum possible small-signal open-circuit gain magnitude (i.e., for $R_L \to \infty$) is given by

$$|A_{vo}|_{max} = \frac{|v_o|}{v_{in}}_{max} = \frac{V_{CC}}{3nV_T}$$

Calculate the maximum possible gain at room temperature for $V_{CC} = 12$ V, 5 V, and 1.8 V, and briefly discuss the implications.
2. Find the small-signal constraint on $v_{in}$ for the CB amplifier shown below. That is, what must be the relationship between $v_{in}$ and $v_{be}$ to ensure that the small-signal condition $v_{be} << nV_T$ is satisfied? All capacitors act as shorts at the operating frequency.

![CB Amplifier Diagram]

3. In the CS amplifier shown below, assume that all of the capacitors act as shorts at the operating frequency and that $\lambda = 0$. Also assume that the bias network is designed so that $V_{DD}$ is evenly divided between $R_D$, $V_{DS}$, and $R_S$. Show that the maximum possible small-signal open-circuit gain magnitude (i.e., for $R_L \to \infty$) is given by

$$|A_{vo}|_{\text{max}} = \left| \frac{v_o}{v_{in}} \right|_{\text{max}} = \frac{2V_{DD}}{3V_{OV}} \quad \text{[factor 2 added to numerator],}$$

Calculate the maximum possible gain at room temperature for $V_{OV} = V_{GS} - V_I = 0.5$ V and $V_{DD} = 12$ V, 5 V, and 1.8 V, and briefly discuss the implications.

![CS Amplifier Diagram]

(continued on next page)
4. For the common-gate (CG) amplifier shown below, find symbolic expressions in terms of the values of the resistors and $g_m$ for

a. the small-signal voltage gain $A_v = v_o/v_{in}$.

b. the input resistance $R_{in}$ seen by the signal source.

c. the output resistance $R_o$ seen by the load.

You may assume that $\lambda = 0$. Also, the values of $C_i$, $C_o$, $C_G$, and $C_{DD}$ are large enough that they act as shorts at the operating frequency.