American University of Beirut
Department of Electrical and Computer Engineering
EECE 311 – Electronics II
Fall 2005 – 2006 (Section 2)
Quiz 1 – November 11, 2005
Closed Book – 90 minutes

P1	**/28**
P2	**/30**
P3	**/16**
P4	**/16**
P5	**/10**
Grade	**/100**

NAME:______________________________ ID Number: ________________________

I have neither given nor received aid on this exam

SIGNATURE

Problem 1 [28 points]

For the common-source amplifier shown in Figure 1, assume that $k'_n = 0.2$ mA/V^2, $(W/L) = 5$, $V_{tn} = 0.5$ V, $\gamma = 0$, and $\lambda = 0$. The current source I is 40 µA.

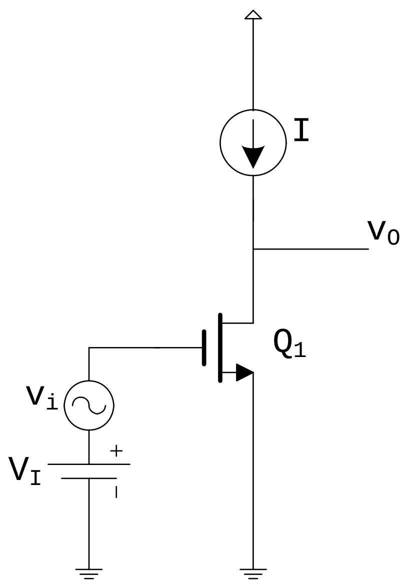

Figure 1

a) What is the required value of the DC voltage V_I? [4 points]
b) What is the minimum value of the output voltage v_O to ensure saturation-region operation for the MOSFET? [4 points]
c) The current source output resistance is 100 KΩ. Assume in the small-signal analysis that $\lambda_n = 0.1$ V^{-1}. Find the voltage gain v_o/v_i. [4 points]
d) The current source is implemented using the circuit shown in Figure 2, where Q_2 and Q_3 are matched. Assume that $k'_p = 0.08$ mA/V^2, $V_{tp} = -0.54$ V. Find (W/L) for Q_2 and Q_3 if both are operating at an overdrive voltage $|V_{OV}| = 0.2$ V. [4 points]

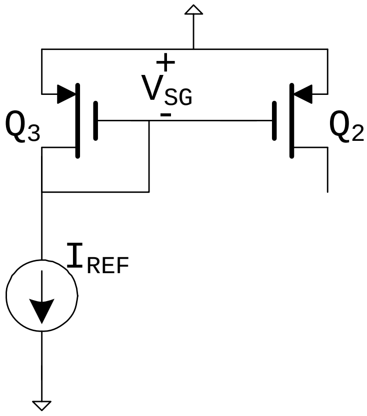

Figure 2

e) Find the value of V_{SG} in Figure 2. [4 points]
f) What is the output resistance of the current source as implemented in Figure 2? Assume in the small-signal analysis that $|\lambda_p| = 0.12\ V^{-1}$. [4 points]
g) What is the maximum value of the output voltage of the amplifier in Figure 1, taking into consideration that the current source is as implemented in Figure 2, to ensure saturation-region operation for all MOSFETs? [4 points]

Problem 2. [30 points]

Consider the common-emitter amplifier shown in Figure 3. The BJT parameters are $V_{BE(active)} = 0.7$ V, $\beta = 60$, $V_A = 80$ V. Assume I = 0.5 mA. *Implicit assumption: The signal source resistance is large and the source does not affect the DC bias.*

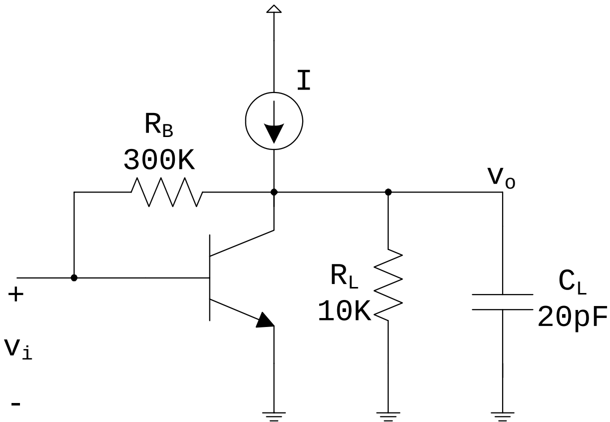

Figure 3

a) Find the value of the DC collector current I_C, and the DC output voltage V_O. Neglect the Early effect in your DC analysis. [6 points]

<u>Assume in the following that the small-signal output resistance of the current source is 100 KΩ.</u>

b) Use Miller's theorem to find the small-signal input resistance at low frequencies. [6 points]

c) Use the method of open-circuit time constants to determine the 3-dB frequency for this amplifier. Assume that the BJT capacitances are C_π = 1 pF and C_μ = 1 pF. [9 points]
d) Calculate the low-frequency gain in dB. [6 points]
e) Show the asymptotic magnitude Bode plot for the amplifier assuming a single dominant pole at the frequency calculated in part (c). [3 points]

Problem 3. [16 points]

Consider the current source circuit shown in Figure 4. Assume that for the two MOSFETs $k'_n = 0.2$ mA/V^2, $(W/L) = 10$, $V_{tn} = 0.4$ V, $\gamma = 0$. Neglect channel-length modulation in the DC analysis.

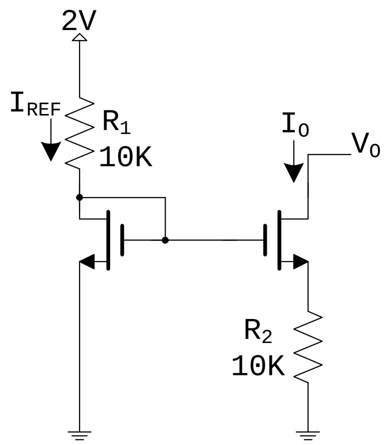

Figure 4

a) Find the value of I_{REF}. [4 points]
b) Find the value of I_O. [4 points]
c) What is the minimum output voltage? [4 points]
d) What is the output resistance of the current source? Assume in the small-signal analysis that $\lambda = 0.08$ V^{-1}. [4 points]

Problem 4. [16 points]

Assume in this problem that $r_o \gg r_\pi$ and that r_x is negligible. *Implicit assumption: The signal source resistance is large.*
a) Using Miller's theorem, show that the 3-dB frequency for a common-emitter amplifier similar to that shown in Figure 5(a), and loaded by an ideal current source is approximately: $f_H = \dfrac{1}{2\pi\beta r_o C_\mu}$. [4 points]

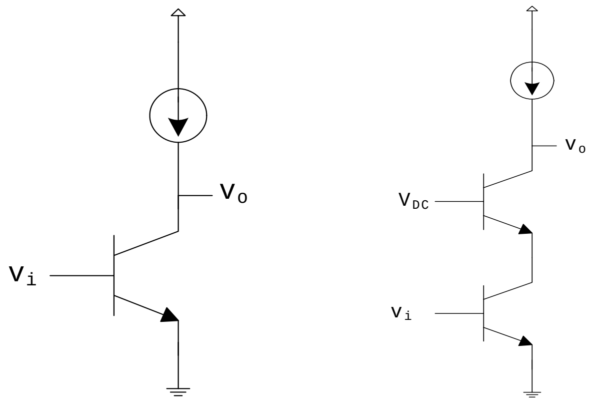

Figure 5(a) Figure 5(b)

b) If the current source has an output resistance approximately equal to r_o, find *approximate expressions* for the output resistance of the amplifier (in terms of r_o), the open-circuit voltage gain (in terms of $A_0 = g_m r_o$), and the 3-dB frequency (in terms of f_H.) [3 points]

c) If the current source has an output resistance equal to βr_o, find *approximate expressions* for the output resistance of the amplifier (in terms of r_o), the open-circuit voltage gain (in terms of A_0), and the 3-dB frequency (in terms of f_H.) [3 points]

The circuit is now modified to become a cascode amplifier as shown in Figure 5(b).

d) If the current source has an output resistance equal to r_o, find *approximate expressions* for the output resistance of the amplifier (in terms of r_o), the open-circuit voltage gain (in terms of A_0), and the 3-dB frequency (in terms of f_H.) [3 points]

e) If the current source has an output resistance equal to βr_o, find *approximate expressions* for the output resistance of the amplifier (in terms of r_o), the open-circuit voltage gain (in terms of A_0), and the 3-dB frequency (in terms of f_H.) [3 points]

Problem 5. [10 points]

For the op-amp circuit shown in Figure 6, find the CMRR in dB when R_1 = 10 KΩ, R_2 = 47 KΩ, R_3 = 1.8 KΩ, R_4 = 8.2 KΩ. Assume that the op-amp is ideal.

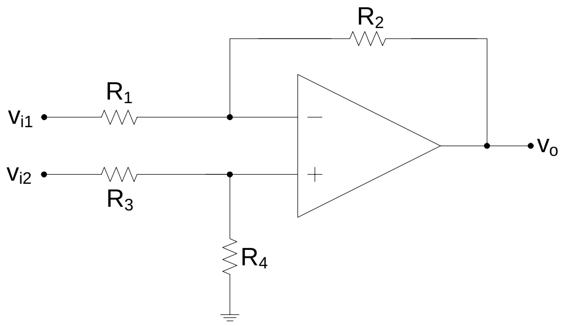

Figure 6