NAME ______________________________ NETID ____________

MIDTERM EXAM 2

(Closed book)

ECE 442

April 12, 2007

7:00 p.m. – 8:30 p.m.

Instructions: Write your name, and NetID where indicated. You are allowed to use one formula sheet ($8^{1/2} \times 11$) and a calculator. This examination consists of 4 problems. Each problem is worth 25 points. Show all work in order to receive partial credit.

Problem 1	Problem 2	Problem 3	Problem 4	Total

Formula Sheet

DIODE

$$I_D = I_S(e^{V_D/V_T} - 1)\text{, where } V_T = \frac{k_B T}{q} = 26\text{ mV}$$

BIPOLAR (NPN forward active $I_B>0$, $V_{CE}>V_{CE,sat}$)

$$I_C = I_S e^{V_{BE}/V_T} \cdot \left(1+\frac{V_{CE}}{V_A}\right) \cong I_S e^{V_{BE}/V_T} \text{ where } V_T = \frac{k_B T}{q} = 26\text{ mV}$$

$$I_C = \alpha I_E$$

$$I_C = \beta I_B \cdot \left(1+\frac{V_{CE}}{V_A}\right) \cong \beta I_B$$

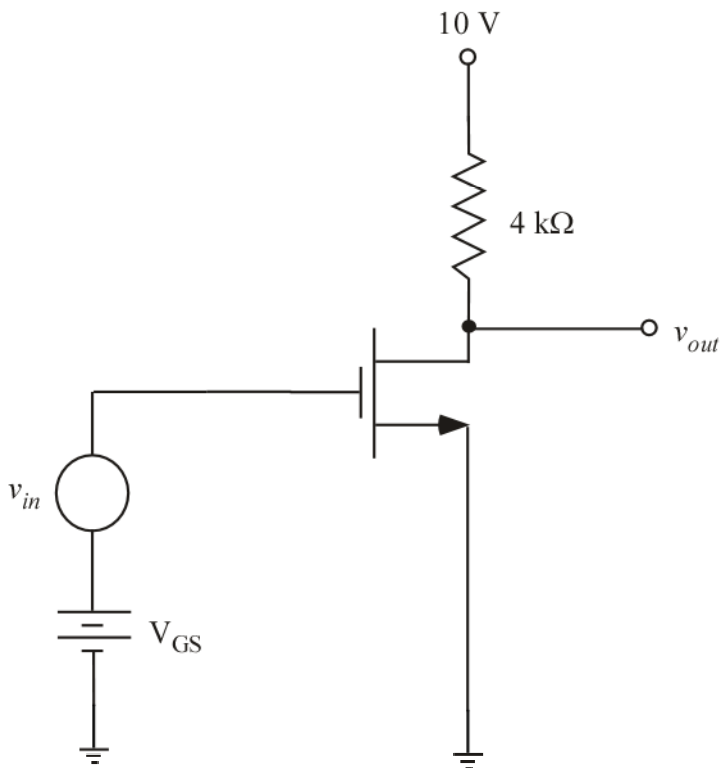
$$\alpha = \frac{\beta}{\beta+1}$$

MOSFET (long channel model equations)
Define $V_{DSP} = V_{GS}-V_T$, where V_T is the threshold voltage

NMOS	PMOS
Triode Region (Linear) $V_{GS} > V_T$ & $V_{DS} < V_{DSP}$, $I_D = \frac{W}{L}\cdot k'\left((V_{GS}-V_T)\cdot V_{DS} - \frac{V_{DS}^2}{2}\right)$	Triode Region (Linear) $V_{GS} < V_T$ & $V_{DS} > V_{DSP}$, $I_D = \frac{W}{L}\cdot k'\left((V_{GS}-V_T)\cdot V_{DS} - \frac{V_{DS}^2}{2}\right)$
Active Region (Saturation) $V_{GS} > V_T$ & $V_{DS} \geq V_{DSP}$, $I_D = \frac{W}{L}\cdot\frac{k'}{2}\cdot(V_{GS}-V_T)^2\cdot[1+\lambda\cdot V_{DS}]$	Active Region (Saturation) $V_{GS} < V_T$ & $V_{DS} \leq V_{DSP}$, $I_D = \frac{W}{L}\cdot\frac{k'}{2}\cdot(V_{GS}-V_T)^2\cdot[1-\lambda\cdot V_{DS}]$
Body Effect $V_T = V_{To} + \gamma\cdot\left(\sqrt{\lvert V_{SB}\rvert + 2\phi_F} - \sqrt{2\phi_F}\right)$ $V_{GS} \leq V_T$, $I_D = 0$	Body Effect $V_T = V_{To} - \gamma\cdot\left(\sqrt{\lvert V_{SB}\rvert + 2\phi_F} - \sqrt{2\phi_F}\right)$ $V_{GS} \geq V_T$, $I_D = 0$

PROBLEM 1 [25 points]

For the amplifier shown $\mu W C_{ox}/2L$ = 3 mA/V^2, λ =0.02/V, and V_T = 1.0 V.



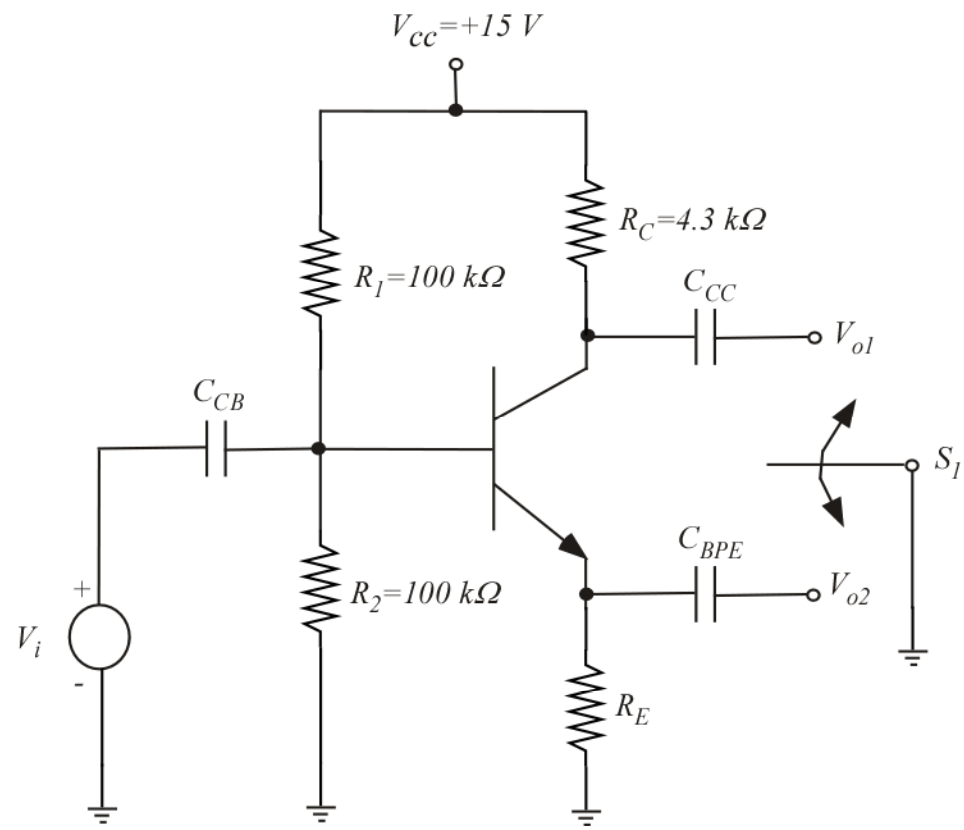
(a) Calculate V_{DSQ} when V_{GSQ} = 1.5 V (15 pts).

PROBLEM 1 (continued)

(b) Calculate the midband voltage gain for the stage (10 pts).

PROBLEM 2 [25 points]

For the circuit shown, assume that β is very large. Also $C_\mu = 1$ pF and $\omega_T = 5$ GHz. It is desired to have a dc collector current of 1 mA. Use $V_{BEON} = 0.7$ V and assume that all coupling and bypass capacitors are midband short circuits.



(a) Determine the proper value for R_E

PROBLEM 2 (continued)

$R_E =$ ____________________

(b) The switch S_1 is set in the off position (as shown in the figure) and the output is collected at V_{o1}. What is the midband voltage gain?

$A_{MB} =$ ____________________

(c) The switch S_1 is now connected to V_{o1} and the output is collected at V_{o2}. What is the midband voltage gain?

$A_{MB} =$ ____________________

PROBLEM 2 (continued)

(d) Next, the switch S_1 is connected to V_{o2} and the output is collected at V_{o1}. What is the midband voltage gain?

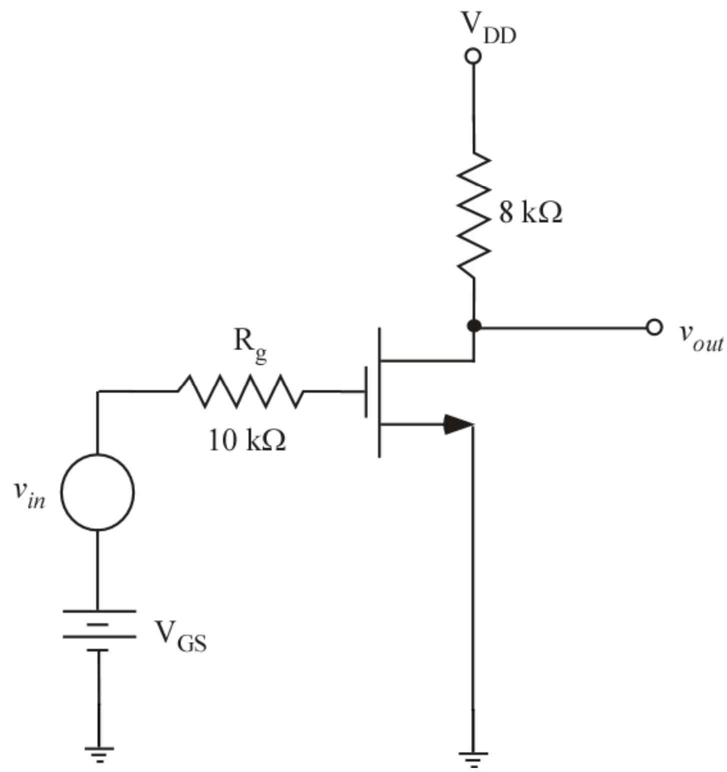
A_{MB} = ____________________

(e) Determine the upper 3dB corner frequency for the common-emitter configuration of this amplifier.

f_{3dB} = ____________________

PROBLEM 3 [25 points]

Consider the MOSFET circuit shown below, with g_m=3 mA/V and r_{ds}=63 kΩ. Assume that C_{gs}=1 pF and C_{gd}=0.1 pF.



(a) Draw the midband equivalent circuit

PROBLEM 3 (continued)

(b) Calculate the midband voltage gain

(c) Draw the high-frequency equivalent circuit

PROBLEM 3 (continued)

(d) Calculate the upper corner frequency

(e) Calculate the unity current-gain frequency point f_T

PROBLEM 4 [25 points]

For the opamp circuit shown, determine the values of:

(a) $v_1 \Rightarrow v_1 = 0$ since it is a virtual ground

(b) $i_1 \Rightarrow$

(c) $i_2 \Rightarrow$

(d) $v_o \Rightarrow$

(e) $i_L \Rightarrow$

(f) $i_o \Rightarrow$