NAME _____ NETID _____

MIDTERM EXAM 1

(Closed book)

ECE 442 March 1, 2007

7:00 p.m. – 8:30 p.m.

Instructions: Write your name, and NetID where indicated. You are allowed to use a calculator. This examination consists of 5 problems. Each problem is worth 20 points. Show all work in order to receive partial credit.

Problem 1	Problem 2	Problem 3	Problem 4	Problem 5	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 $I_B > 0$, $V_{CE} > V_{CE,sat}$)

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

$$I_C = \alpha I_E$$

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

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

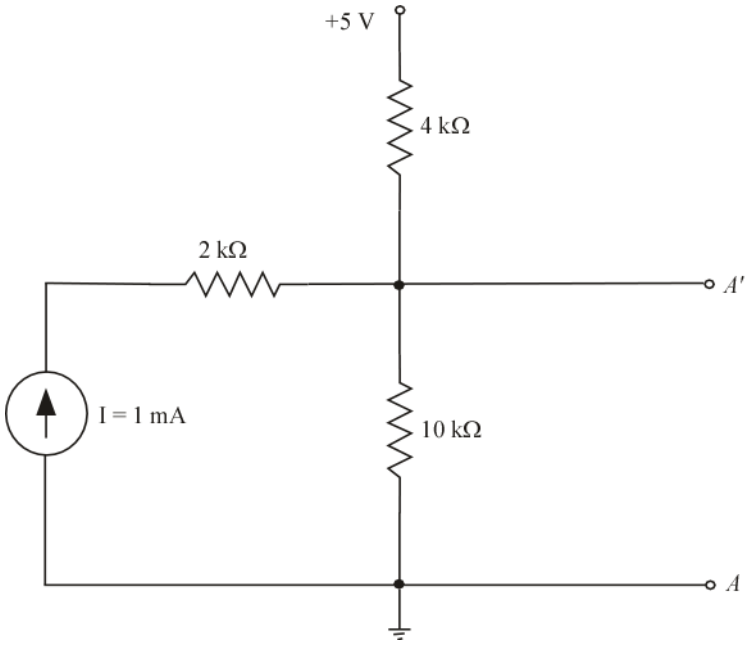
MOSFET (long channel model equations)

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 $V_T = V_{To} - \gamma \cdot \left(\sqrt{\lvert V_{SB} \rvert + 2\phi_F} - \sqrt{2\phi_F} \right)$ $V_{GS} \geq V_T, \ I_D = 0$

1. If the output of a filter falls with frequency at a rate of -6dB/octave, how many dB per decade does the output fall?

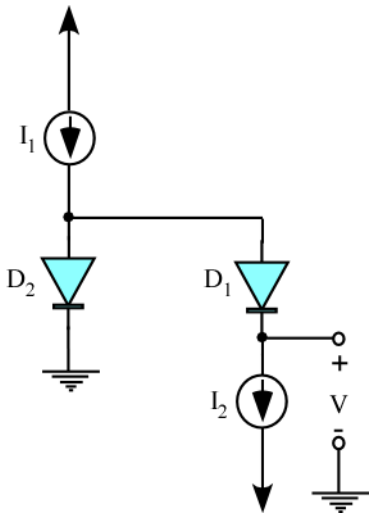
2. Determine the Thévenin equivalent circuit for the network in the figure. Form the Thévenin equivalent across the terminals *A'-A*



3. In the circuit shown, D_1 has a saturation current that is 10 times larger than that of D_2.

(a) If $I_1 = 10$ mA and $I_2 = 2$ mA, find the voltage V

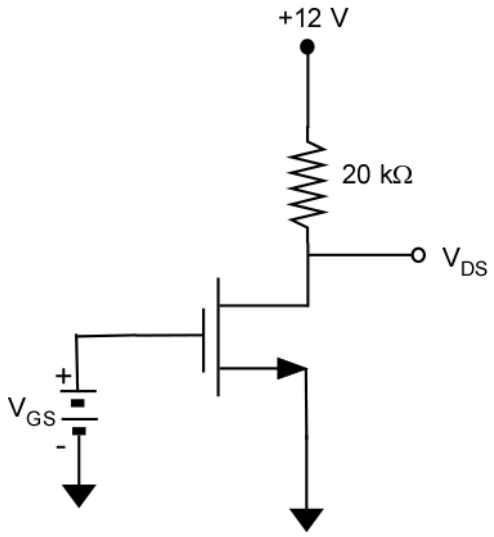
(b) If I_1 is maintained at 10 mA, what current I_2 is needed to obtain a value for V of 52 mV?



4. For the MOSFET circuit shown, $\mu WC_{ox}/2L = 80\mu A/V^2$, $V_T = 0.9$ V, $\lambda = 0$.

(a) What value must V_{GS} have to bring the device from the active region to the edge of the cutoff region?

(b) What value must V_{GS} have to bring the device from the active region to the edge of the triode region?



5. Give a CMOS realization of the function

$$\overline{Y} = A\overline{B} + C\,.$$

Show the finished schematic and assume that input variables and complements are available to drive the system.