Midterm Examination # 1

Electronic Circuits I - ECSE-330B
February 17th 2005, 8:35 AM – 9:55 AM
Professor Ramesh Abhari

Pertinent Information:

1) This is a closed-book examination, no notes permitted.

2) This examination consists of 4 questions with total possible points of 32. Partial point distribution is indicated in brackets.

3) Only the Faculty Standard Calculator is permitted.

4) Show your work: answers without justification will not receive marks. State any assumption you find necessary to complete your answer.

Last Name	
First Name	
Student Number	

Question	Mark
1	/6
2	/9
3	/10
4	/7
Total	/32

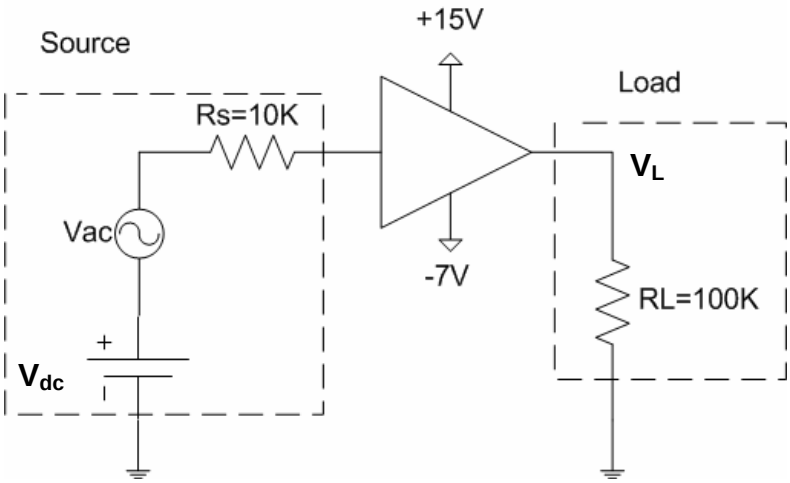
- Name: **Student Number:** **-**

Question #1 (6 pts)

A voltage amplifier has the open circuit voltage gain of $A_v = 2$, an input resistance R_{in} of 100KΩ, and an output resistance R_o of 10KΩ. The amplifier has a linear characteristic with output saturation at 15V and –7V.

(a) Draw the voltage transfer characteristic of this amplifier. (1 pt)

The amplifier is inserted into the following circuit:



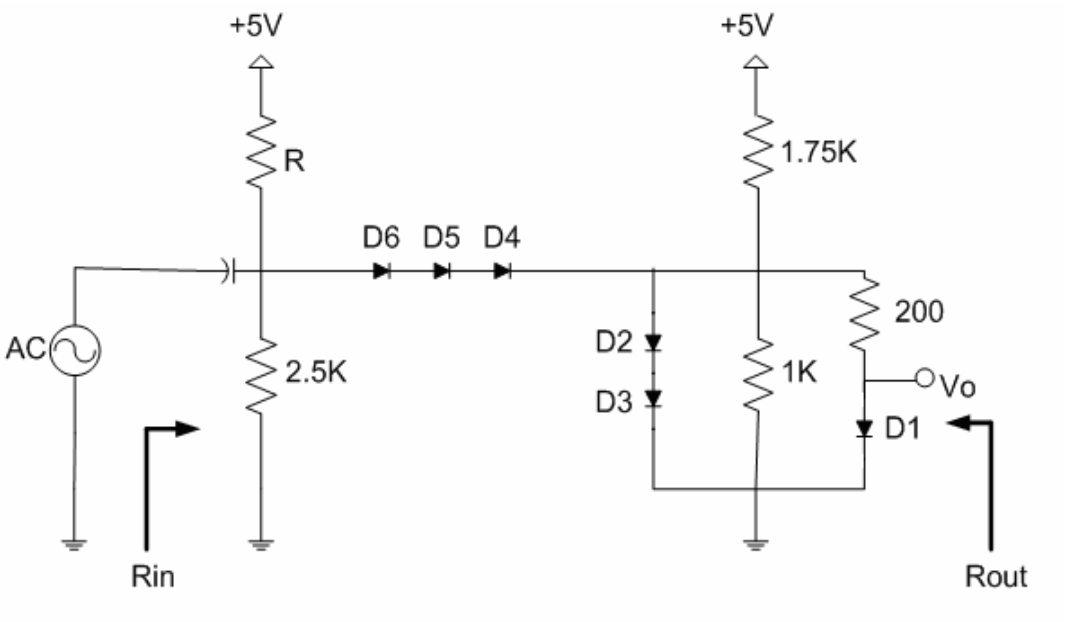
(b) Determine V_{dc} so that the largest possible output swing can be obtained without voltage clipping. (2 pts)

(c) Assuming V_{dc}=0 and V_{ac}=13.2cos(2000x2πt) Volt, draw the voltage waveform at the output. (1 pt)

(d) Consider V_{dc}=0, V_{ac}=1cos(2000x2πt) mVolt, and the source resistance and the load resistance remain R_s=10KΩ and R_L=100KΩ, respectively. How many stages of the amplifier are required to obtain the overall voltage gain (V_L/V_{ac}) of at least 5.5? (2 pts)

Question #2 (9 Points)

In the following circuit, all diodes are identical and $I_s = 10^{-9} A, n = 2, V_T = 25mV$.



By using the *exponential model* for all diodes:

(a) Determine R such that V_o=0.75V. (3 pts)

(b) Derive the general expression for the small signal resistance of a diode. (1 pt)

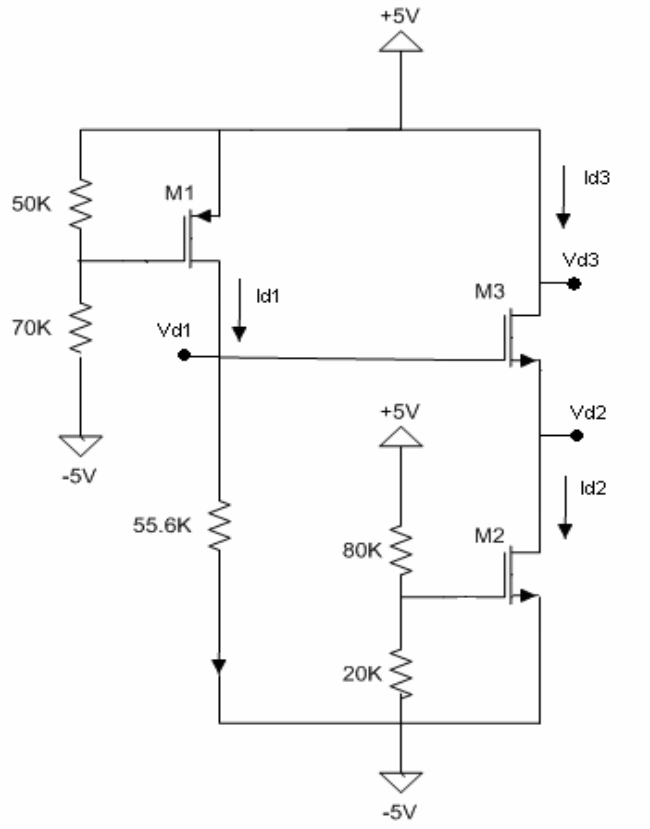
(c) Draw the small signal equivalent circuit for the circuit shown above. Make sure to calculate the numerical values of the small signal resistances of all diodes. (3 pts)

(d) From the small signal equivalent circuit, calculate the small signal input and output resistances, R_{in} and R_{out}. (2 pts)

Question #3 (10 Points)

Consider the following MOSFET circuit with the device parameters and supply voltages shown in the diagram. The channel length modulation can be ignored for all transistors, however, the body effect should be included if it seems necessary.

(a) Calculate all drain currents and voltages; i.e. Id1, Id2 and Id3, and Vd1, Vd2, and Vd3. Make sure to verify the assumption you make for the mode of operation of M1, M2 and M3. (10 pts)



$\mu_n C_{ox} = 50\mu A/V^2$

$(\frac{W}{L})_n = 2$

$V_{T0n} = 1V$

$\gamma_n = 0.5V^{1/2}$

$2\varphi_n = 0.6V$

$\mu_p C_{ox} = 25\mu A/V^2$

$(\frac{W}{L})_P = 2$

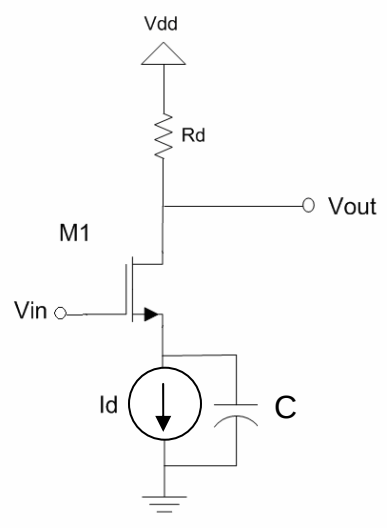
$V_{T0p} = -1V$

$\gamma_p = 0.5V^{1/2}$

$2\varphi_p = -0.6V$

Question #4 (7 Points)

In the following NMOS amplifier, *Id* is an ideal independent current source and the channel length modulation cannot be ignored.



(a) Discuss whether the body effect should be included in the DC and AC analysis of this circuit. (2 pt)

(b) Draw the small signal model. (2 pts)

(c) Derive an expression for $A_v = \frac{V_{out}}{V_{in}}$. (1 pts)

(d) From the small signal model, find R_{in} and R_{out}. (2 pts)