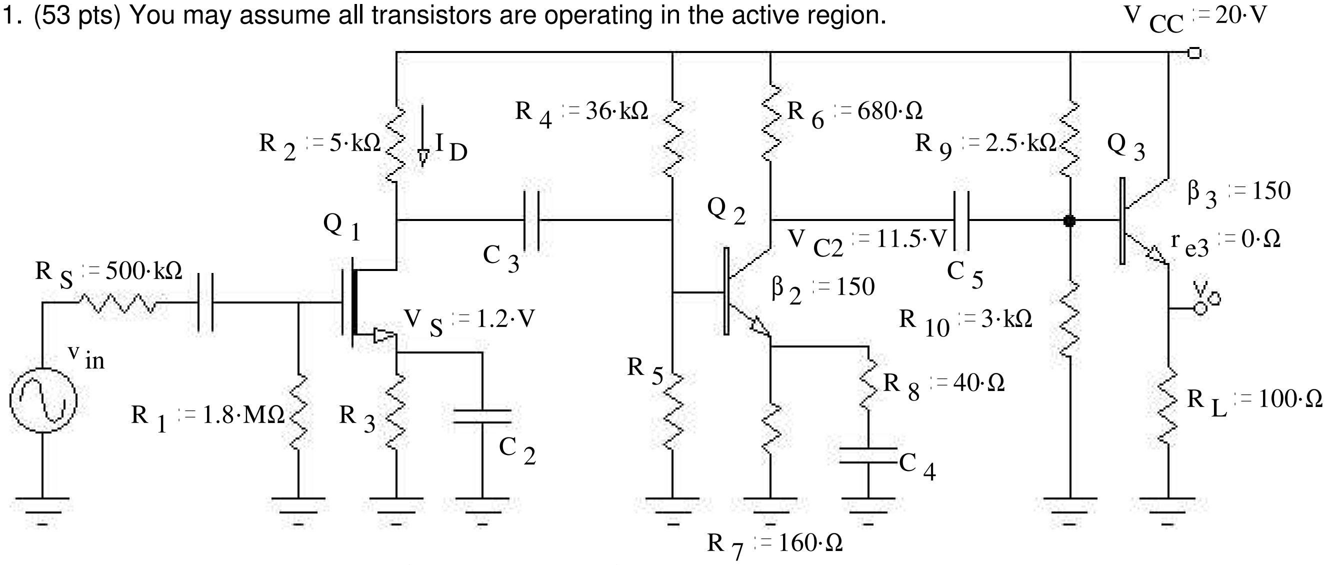
 (The space between problems has been removed.)

1. (53 pts) You may assume all transistors are operating in the active region.



$V_{t1} := -2 \cdot V$ $I_{DSS1} := 18.75 \cdot mA$ $V_{A1} := 60 \cdot V$ Assume that $V_{A2} = V_{A3} = \infty$

a) V_S = 1.2 V, what is the value of I_D? Neglect V_{A1} for this part. $I_D = ?$

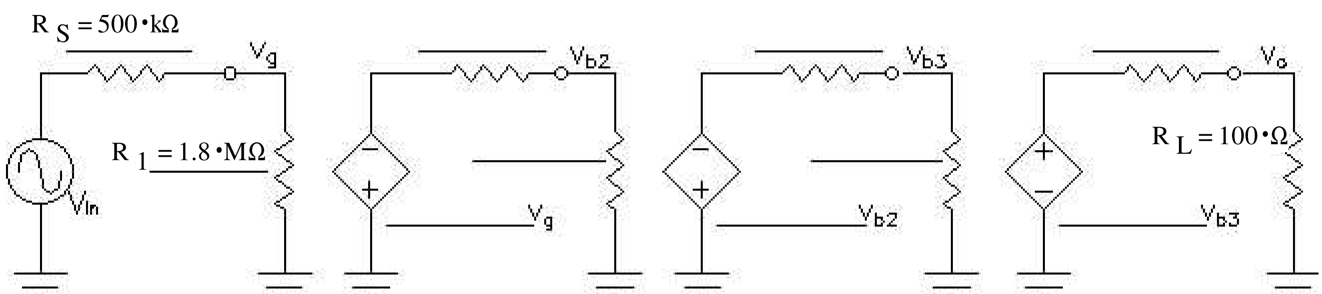
b) The DC bias voltage at the collector of Q_2 is 11.5 V. What is the collector current (I_C), the emitter voltage (V_E), and the base voltage (V_B) of Q_2? You may neglect I_B for these calculations.

$V_{C2} := 11.5 \cdot V$ $I_{C2} = ?$ $V_{E2} = ?$ $V_{B2} = ?$

c) What is the value of R_5? DO NOT neglect I_B. $\beta_2 := 150$ R_5

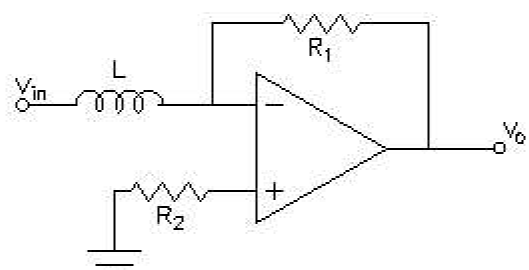
d) Fill in the resistor blanks in the small signal model below with numbers. Fill in the dependent source blanks with gain factors. I've done a few calculations you may find useful.

$$R_{e2} := \frac{1}{\frac{1}{R_7} + \frac{1}{R_8}} \qquad R_{e2} = 32 \cdot \Omega$$



2. (19 pts) The op amp is ideal.

a) Find an expression for $v_o(t)$ as a function of $v_{in}(t)$ for the circuit.



Relations you may find useful:

$$v_C = \frac{1}{C} \cdot \int_{-\infty}^{t} i_C \, dt \qquad i_L = \frac{1}{L} \cdot \int_{-\infty}^{t} v_L \, dt$$

$$i_C = C \cdot \frac{d}{dt} v_C \qquad v_L = L \cdot \frac{d}{dt} i_L$$

b) Does this circuit perform any special mathematical operation?

c) Find an expression for $V_o(j\omega)$ / $V_{in}(j\omega)$ for the circuit above.

d) This circuit functions as a: (circle one or more)

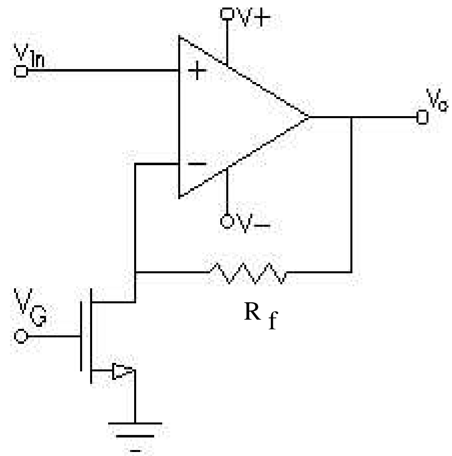
1) high-pass filter 2) low-pass filter 3) no type of filter 4) voltage follower 5) simple amplifier

3. (12 pts) The circuit shown is operated so that v_{DS} is small.

   a) Find an expression for v_o as a function of v_{in} and V_G.

   Note: remember, you've looked at this circuit before in lab.

   b) What effect does V_G have on v_o / v_{in}, IE, what good is this circuit?



4. (12 pts) In the lab you built the circuit shown.

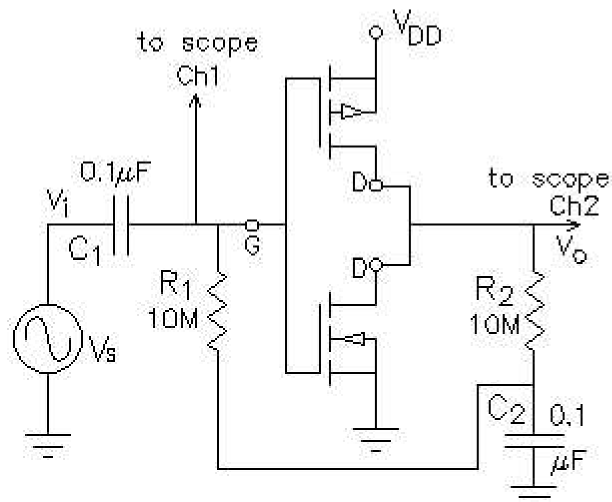
   a) What is the purpose of R_1 and R_2?

   b) What is the purpose of C_2?

   c) There is a problem here with one of the scope connections. What is the problem?

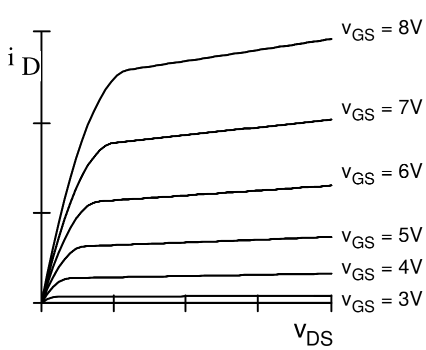
   Hint: remember that to the circuit, the scope looks like a 1 MΩ resistor to ground (10 MΩ with a 10x probe).

   d) Modify the drawing to show how the scope should be hooked up to avoid the problem.



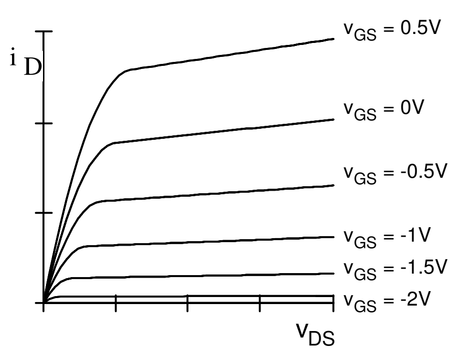
5. (36 pts) A number of FET characteristic curves are shown below. You will also find a number of FET symbols labeled A through J and, on the next page, a number of i_D vs v_{GS} curves labeled 1 through 7. Your job is to write the matching letters and numbers beneath each characteristic curve in the blanks provided. Write down every answer possible. <u>Each blank may have 0, 1, or more answers</u>. Answers may be used more than once.

   You start with the max possible points, -2 pts per wrong or missing answer.
   Remember, Blanks may have more than 1 answer, or none at all.



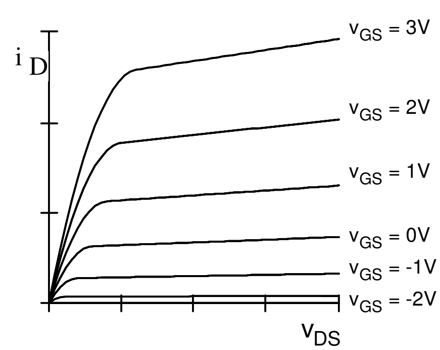
Transistors: ___________

i_D vs v_{GS} curves: ___________



Transistors: ___________

i_D vs v_{GS} curves: ___________



Transistors: ___________

i_D vs v_{GS} curves: ___________

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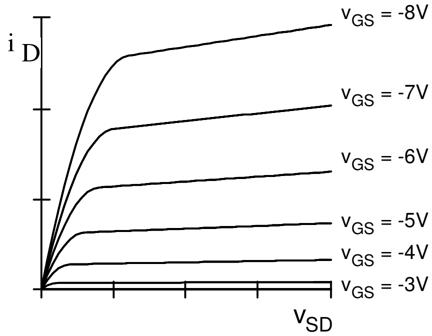
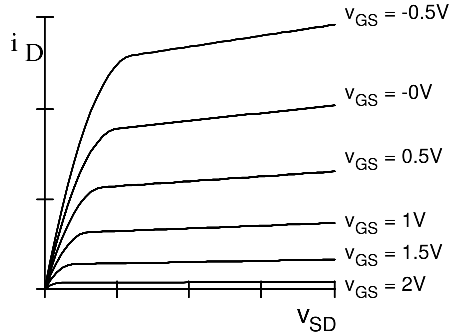


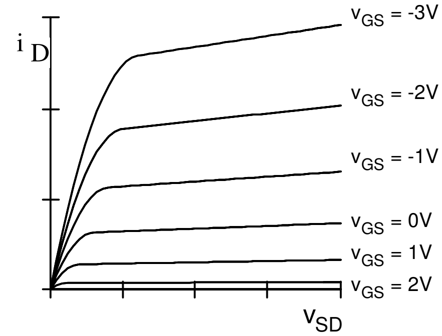
Transistors: ___________

i_D vs v_{GS}
curves: ___________



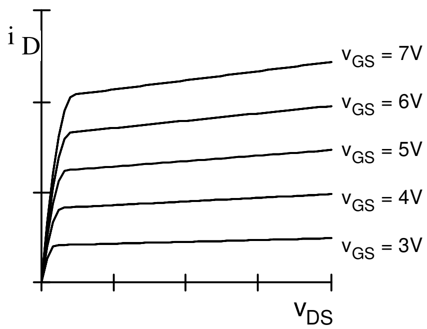
Transistors: ___________

i_D vs v_{GS}
curves: ___________



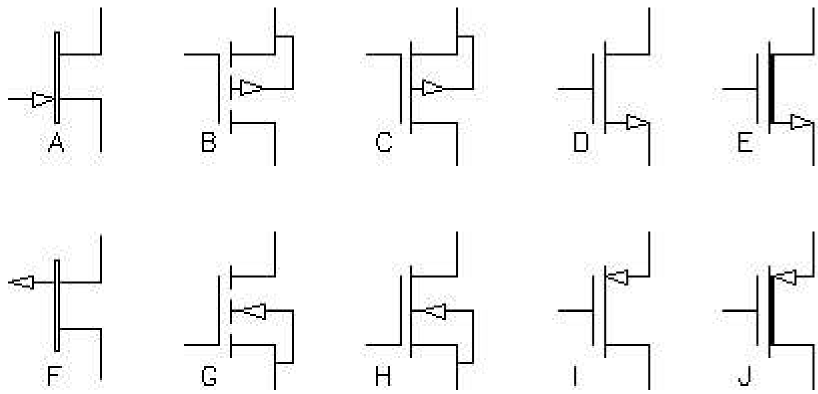
Transistors: ___________

i_D vs v_{GS}
curves: ___________

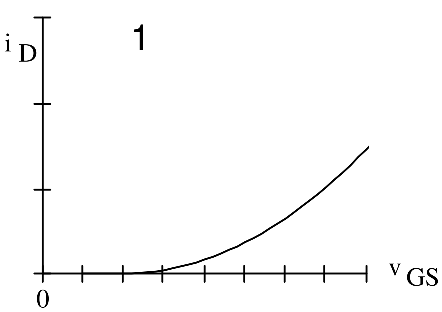


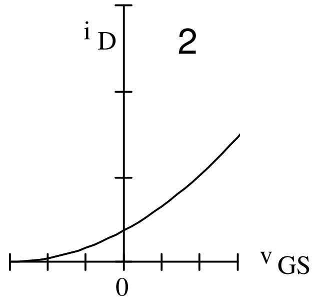
Transistors: ___________

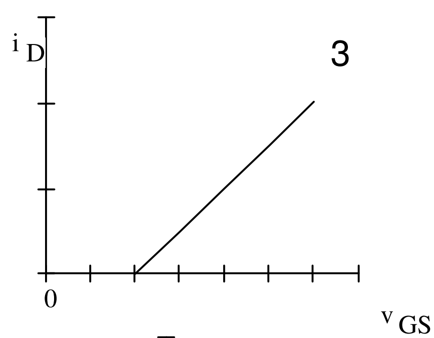
i_D vs v_{GS}
curves: ___________

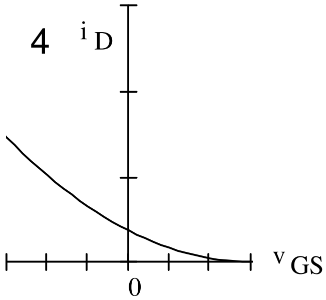


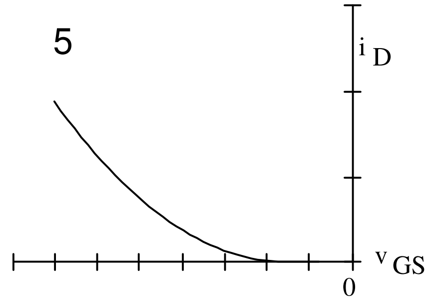
i_D in saturation region





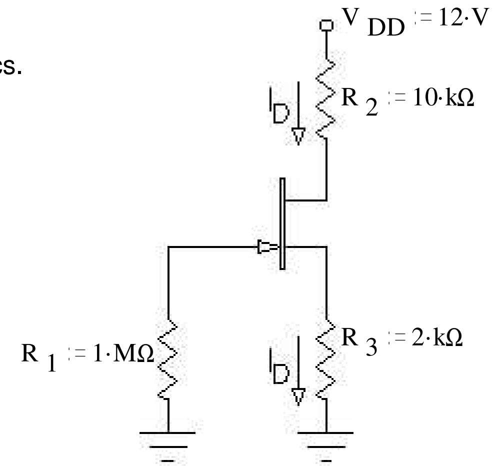






6. (16 pts) The transistor in the circuit shown has the following characteristics.

$I_{DSS} := 20 \cdot mA$ $\quad V_t := -2 \cdot V$ $\quad \lambda := 0$

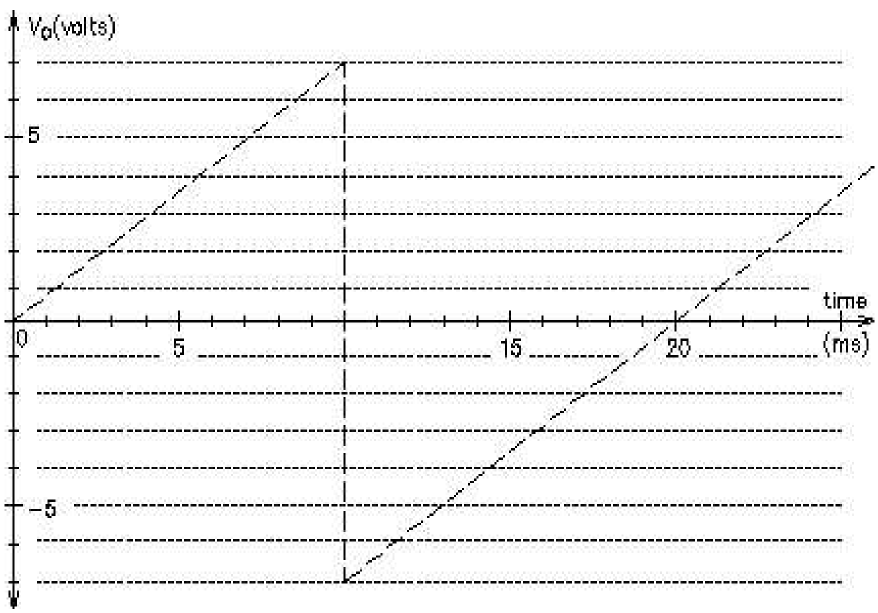


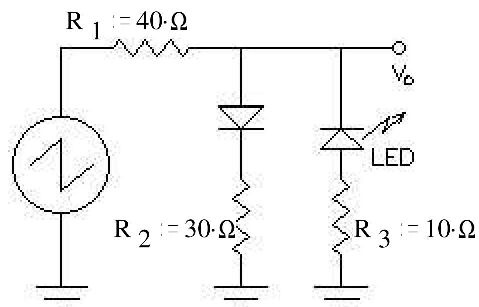
a) Assume saturation. Find I_D.

b) Was the assumption of saturation OK? yes no

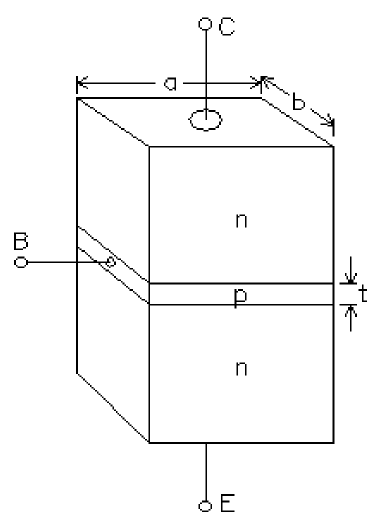
How do you know? (circle one)

7. (18 pts) A voltage waveform (dotted line) is applied to the circuits shown. Accurately draw the output waveform (v_o) you expect to see. Use the constant-voltage-drop models for the diodes. Label important times and voltage levels.





8. (18 pts) Let's pretend that we can make a transistor like the one shown, with the dimensions a, b, and t, as shown



$$\beta = \frac{i_C}{i_B} \qquad i_C = I_S \cdot e^{\frac{v_{BE}}{V_T}}$$

a) If I double the dimension t, β will:

i) increase ii) decrease iii) stay about the same iv) can't tell

b) If I double the dimension t, I_S will:

i) increase ii) decrease iii) stay about the same iv) can't tell

c) If I double the dimension b, β will:

i) increase ii) decrease iii) stay about the same iv) can't tell

d) If I double the dimension b, I_S will:

i) increase ii) decrease iii) stay about the same iv) can't tell

e) If I double the doping in the emitter region, β will:

i) increase ii) decrease iii) stay about the same iv) can't tell

f) If I double the doping in the emitter region, I_S will:

i) increase ii) decrease iii) stay about the same iv) can't tell

9. Do you want your grade and scores posted on my door and on the internet? Yes No (Circle one)

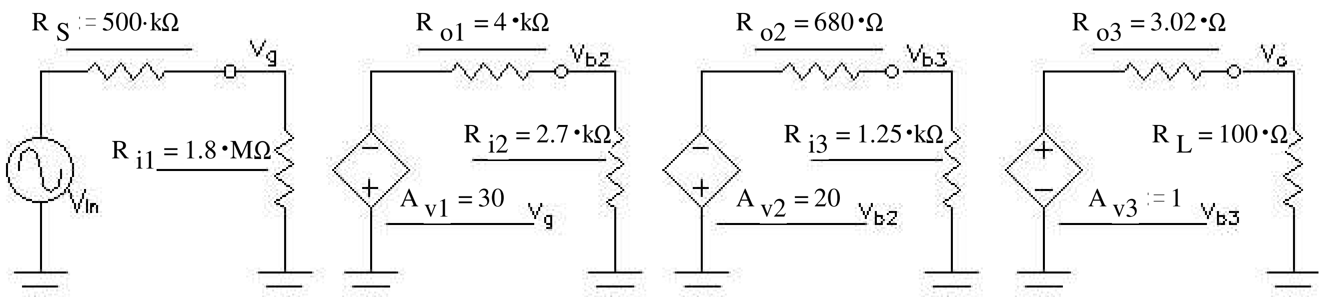
If your answer is yes, then provide some sort of alias or password: ______________________

The grades will be posted on my door in alphabetical order under the alias that you provide here. I will not post grades under your real name. The internet version will be an excel spreadsheet which you can download. Both will show all your homework, lab, and exam scores.

Answers

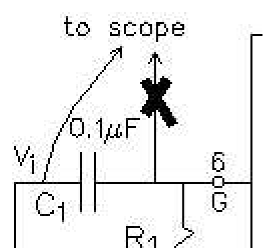
1. a) 3mA b) 12.5mA, 2V, 2.7V c) 6.8kΩ

d)



2. a) $v_o = -\frac{R_1}{L}\cdot\int_{-\infty}^{t} v_{in}\,dt$ b) Integration c) $\frac{V_o(j\omega)}{V_{in}(j\omega)} = \frac{-R_1}{j\cdot\omega\cdot L}$ d) 2

3. a) $v_o = v_{in}\cdot\left[1 + R_f k_n\cdot\frac{W}{L}\cdot\left(V_{GS} - V_t\right)\right]$ b) V_G controls the gain



4. a) bias b) Filter out signal c) Scope loads down bias circuit d) Move scope to left side of C_1.

5. Transistors: ___G_D____ Transistors: ___A______ Transistors: __H_E____

i_D vs v_{GS} curves: ___1_______ i_D vs v_{GS} curves: ___2______ i_D vs v_{GS} curves: ___2_______

Transistors: ___B_I_____ Transistors: ___F______ Transistors: __C_J_____

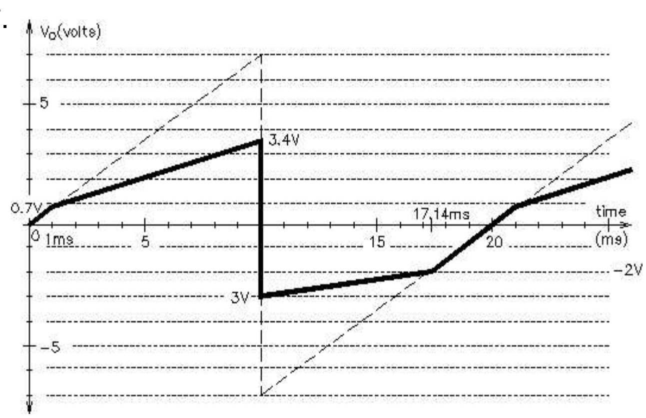
i_D vs v_{GS} curves: ___5_______ i_D vs v_{GS} curves: ___4_______ i_D vs v_{GS} curves: ___4_______

Transistors: ___none____

i_D vs v_{GS} curves: ____3______

6. a) 0.8mA b) yes, $V_D = 4V > V_G = 0V$

7.



8. a) ii b) ii c) iii d) i e) i f) iii

EE 2100 Final

Name ______________________________

Scores:

page 1 __________ / 53 pts

page 2 __________ / 43 pts

page 3 __________ / 52 pts

page 4 __________ / 32 pts

Total __________ / 180 pts