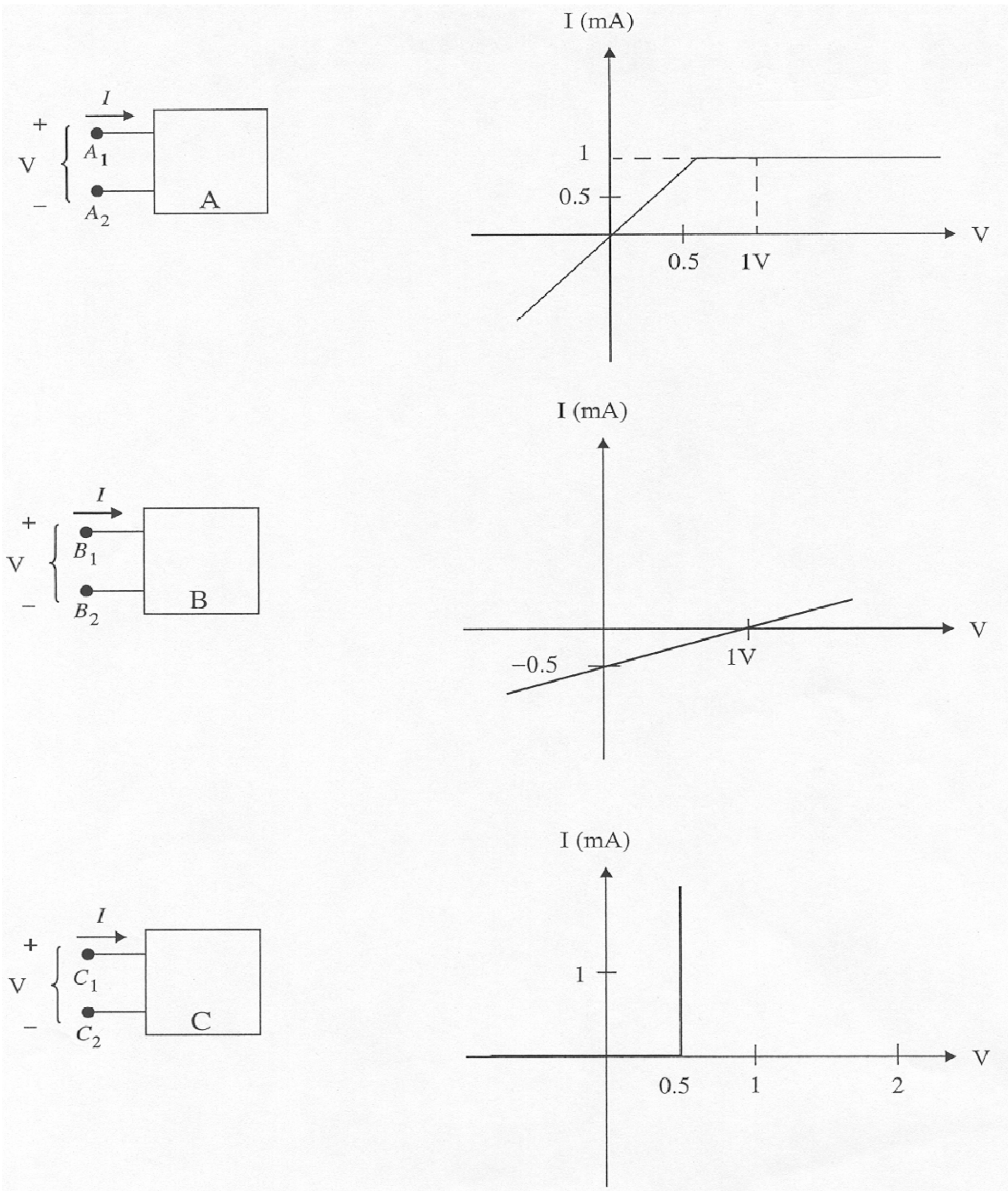
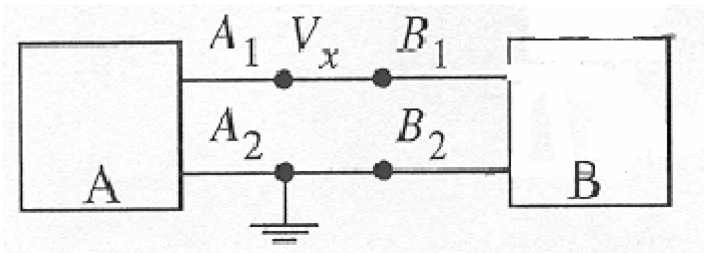
EECS 40 – MIDTERM #2
Professor Oldham
Fall 2000

<u>Problem 1 (12 points)</u>

The boxes A, B, C have the following I-V characteristics:.

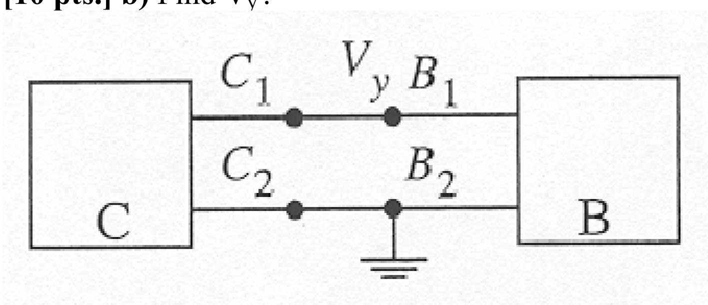


[10 pts.] a) Find V_x .



V_x = ______________

[10 pts.] b) Find V_y .

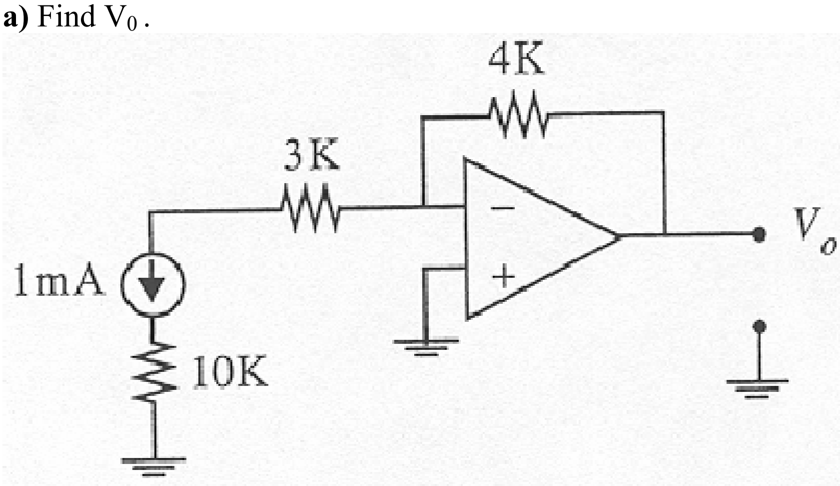


V_y = ______________

Problem 2 (12 points)

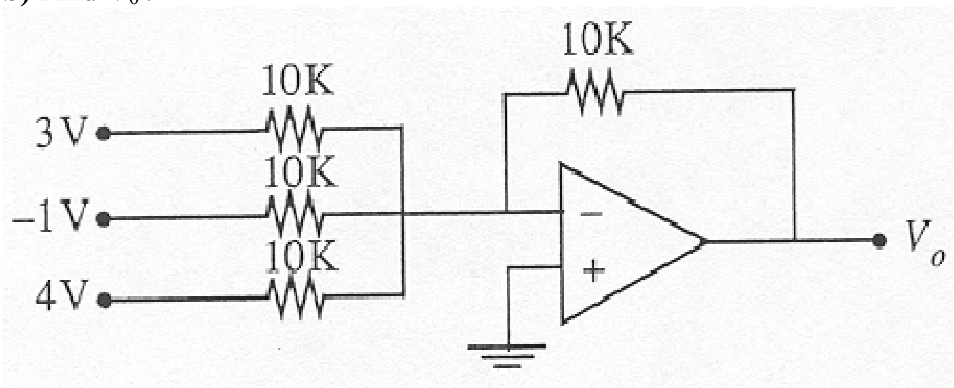
In this problem, assume that the op-amps are nearly ideal but with ouput voltages limited by $\pm$ 5V rails.

a) Find V_0 .



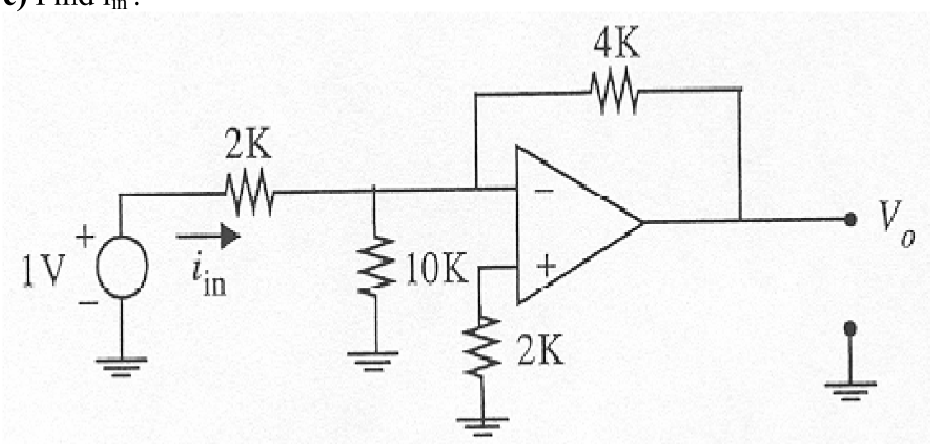
V_0 = ______________(V)

b) Find V_0 .



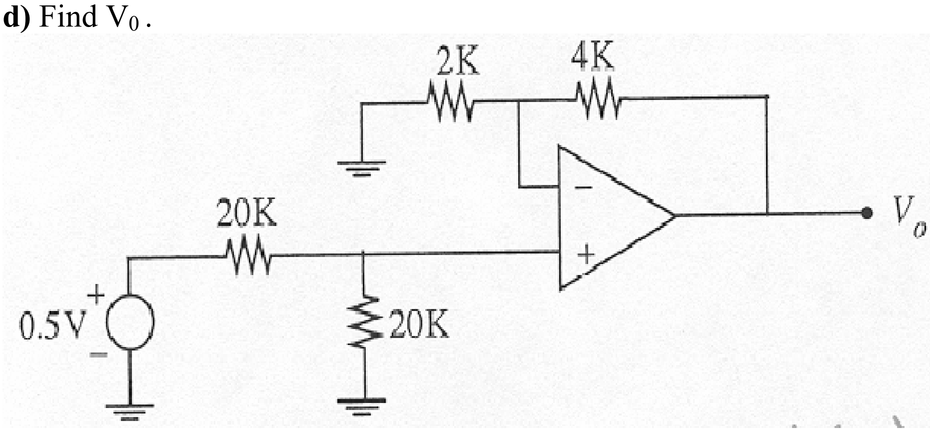
V_0 = ________(V)

c) Find i_{in} .



i_{in} = ________(mA)

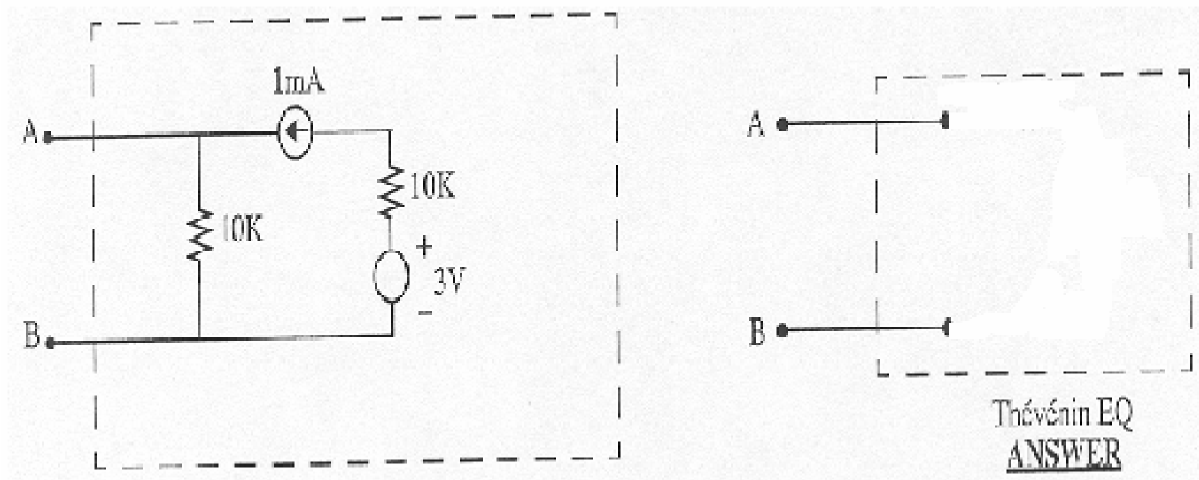
d) Find V_0 .



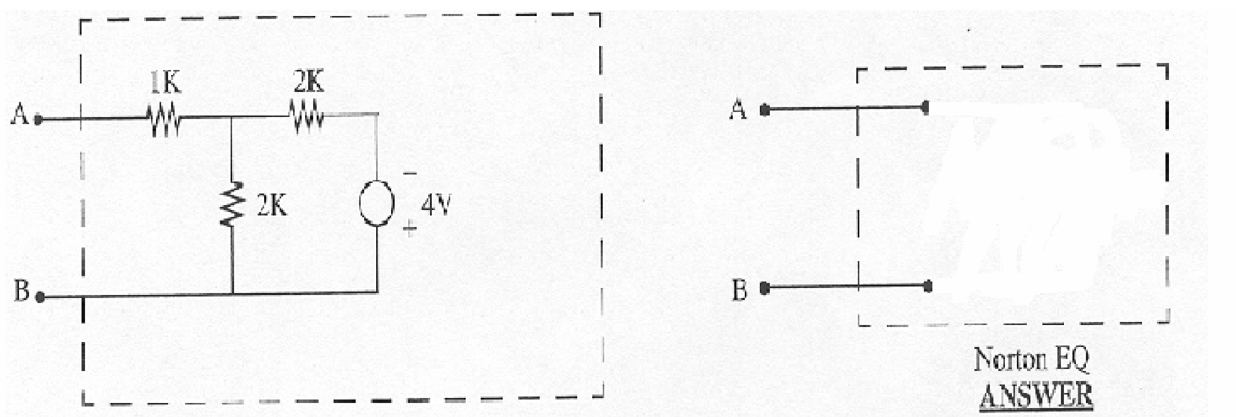
V_0 = ________(V)

Problem 3 (10 points)

[5 pts.] a) Find the Thevenin Equivalent circuit of the stuff in the box. Draw this Thevenin circuit in the answer box. **Note:** No credit unless the circuit is drawn in the answer box.



[5 pts.] b) Find the Norton Equivalent circuit of the stuff in the box. Draw this Norton circuit in the answer box. Again, no credit unless the circuit is drawn in the answer box.



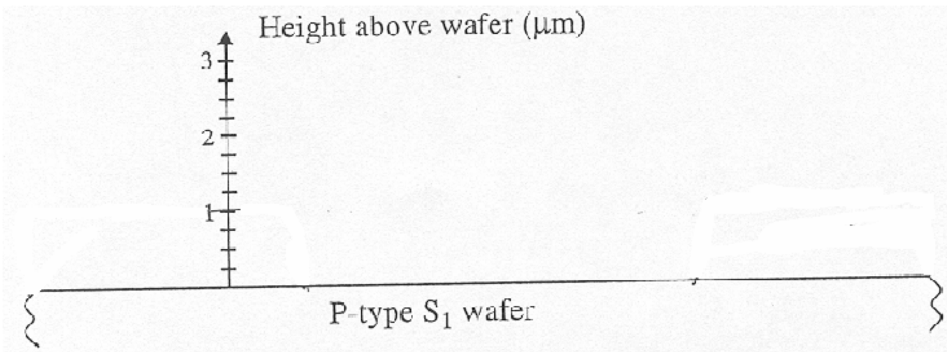
Problem 4 (16 points)

Consider the following process that refers to the figure on the opposite page.

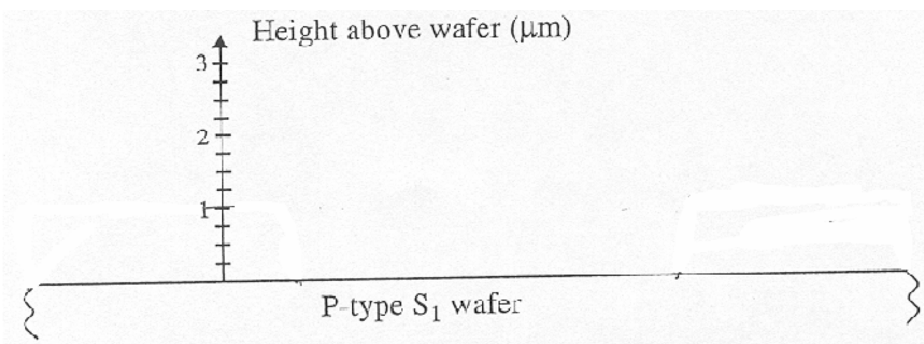
1. Start with p-type wafer.
2. Deposit 1um (1000nm) oxide.
3. Deposit 0.5um polysilicon. ("Poly 1")
4. Pattern polysilicon with mask (P1). (clearfield)
5. Pattern oxide with mask (OX). (darkfield)
6. Deposit 50nm oxide
7. Deposit 0.5um polysilicon ("poly 2")

8. Pattern poly 2 with mask (P2). (clearfield)
9. Implant donors 10^14 /cm^2 and anneal to depth of 0.25um
10. Deposit 0.5um oxide
11. Pattern oxide with mask (C). (darkfield)
12. Deposit 0.5um Al
13. Pattern Al with mask (M). (clearfield)

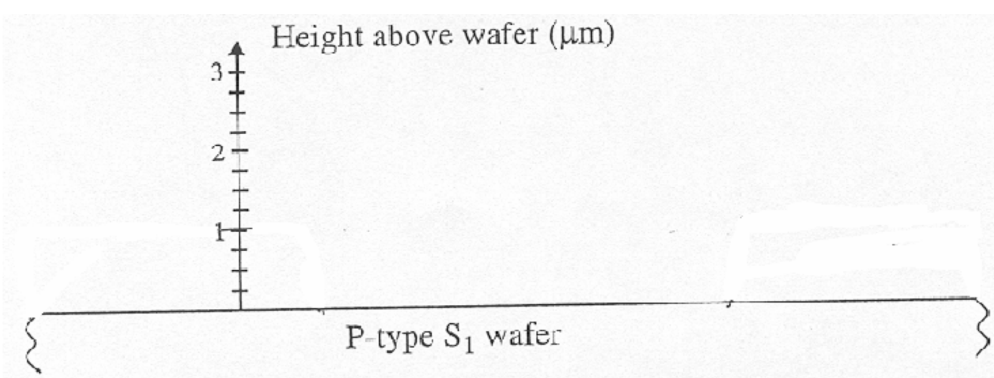
[5 pts.] a) Show cross-section A-A after completion of Step 5.



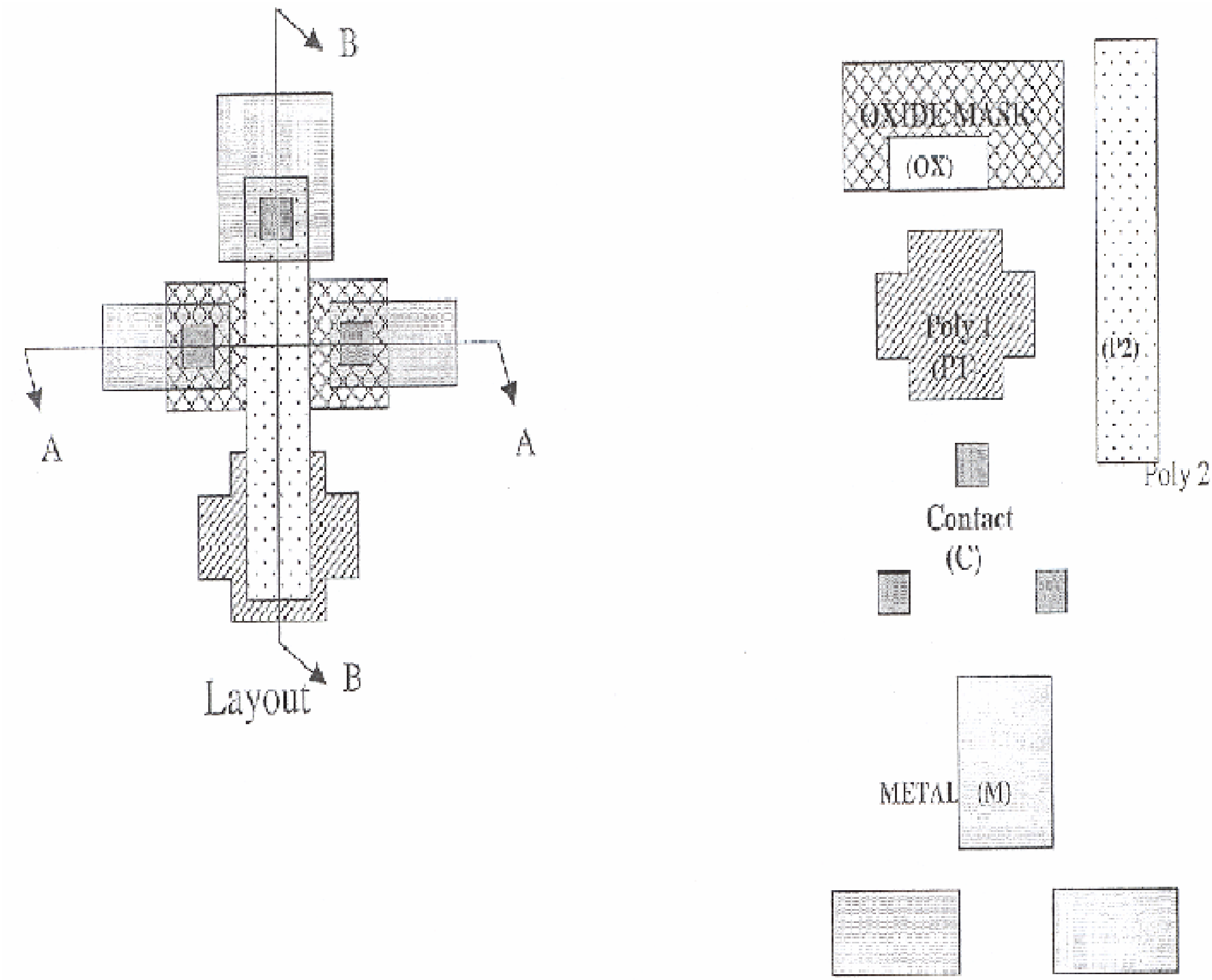
[5 pts.] b) Show cross-section B-B after completion of Step 9.



[5 pts.] c) Show cross-section B-B after completion of Step 12.



Problem 4 Figure



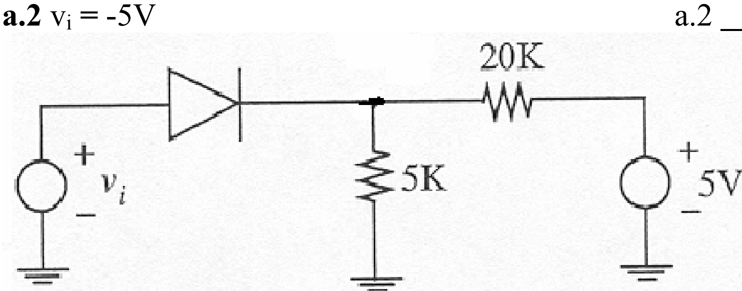
Problem 5 (12 points)

Assume in this problem that all diodes are perfect rectifiers.

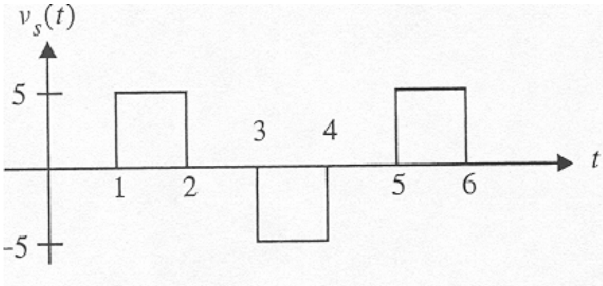
[6 pts.] a) Find V_x when:

a.1 $v_i = 9V$ a.1 ________________(V)

a.2 $v_i = -5V$ a.2 ________________(V)

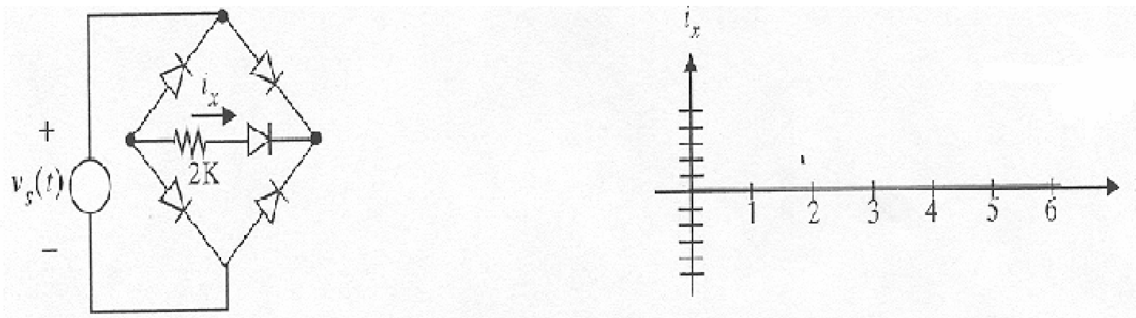


[6 pts.] b)

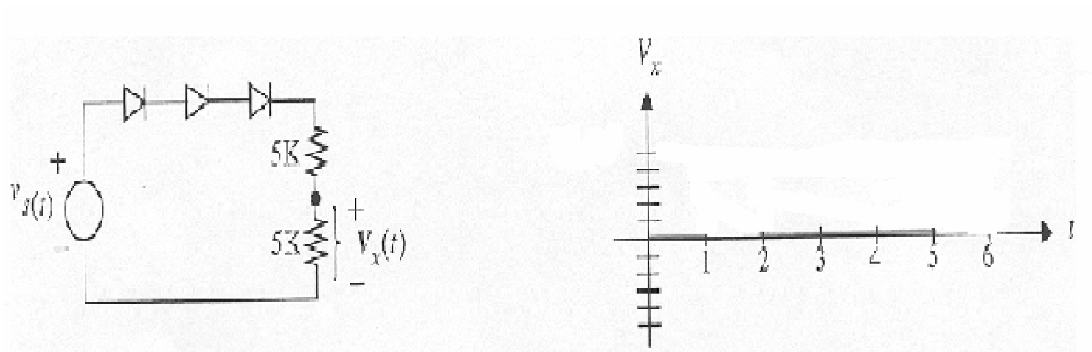


Sketch the unknown i_x or V_x for the following circuits with the inout waveform shown above.

b.1

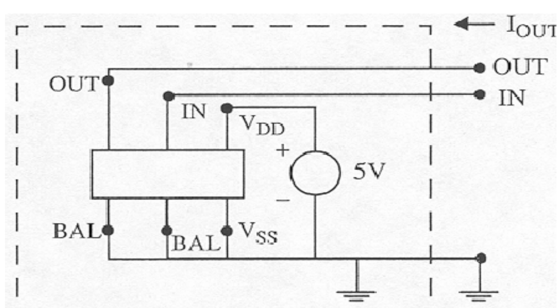


b.2



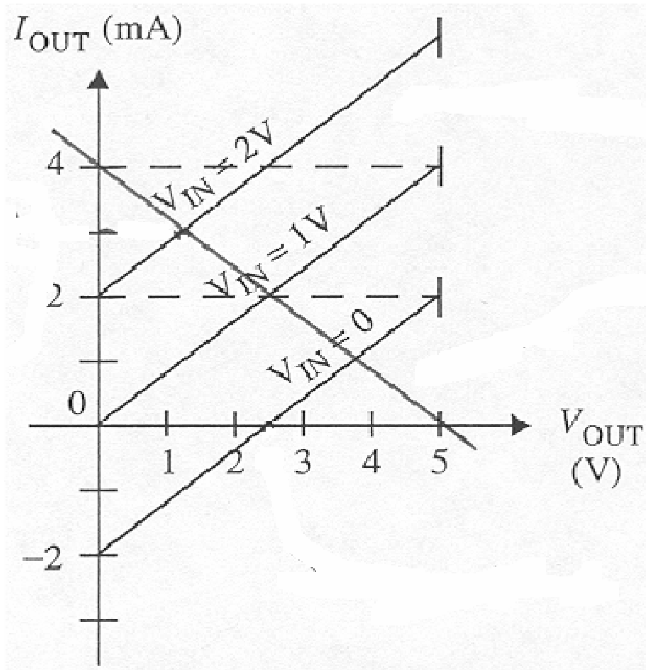
<u>Problem 6 (12 points)</u>

In the lab you encounter a 6-terminal device labeled as follows: One terminal is labeled "Vss", so you ground it. Another is labeled "V_{DD}", so you hook it to a +5V supply. Two are labeled "Bal", not knowing what they might be you simply ground them. The remaining two terminals are labeled "IN" and "OUT".



So what you now have is essentially a 3-terminal device to study. You proceed to take a series of I-V measurements at one value of v_{in} .

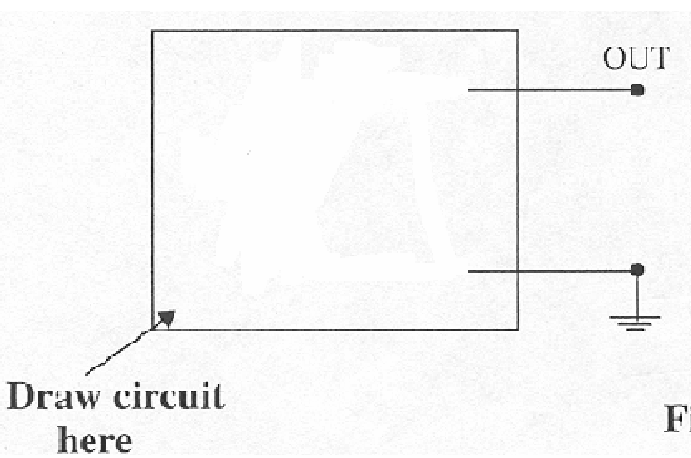
You obtain:



[4 pts.] a) What is the open circuit value of V_{out} for V_{in} = 0V?

V_{out} = ____________________

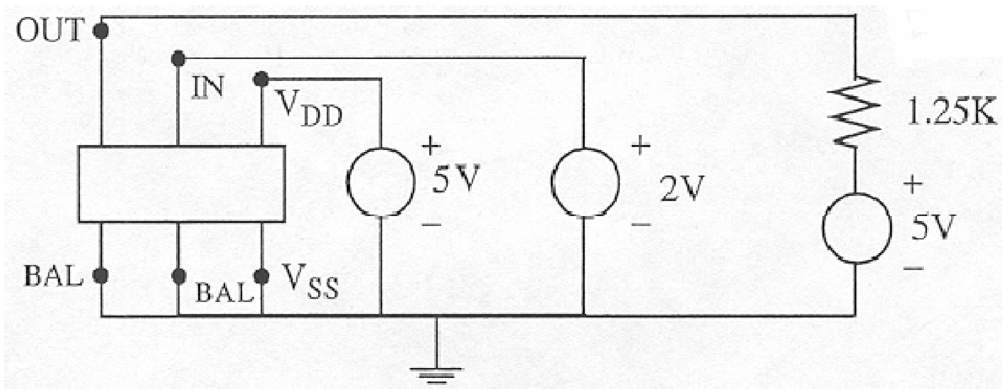
[4 pts.] b) Draw the Thevenin Equivalent circuit of the output for each of the input values given (R_{TH} and V_{TH} may be a function of the input voltage), and fill out the table.



V_{IN}	R_T	V_T
0		
1		
2		

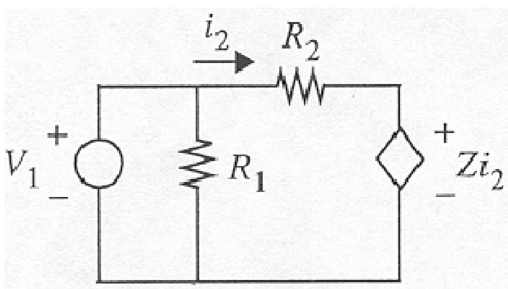
Fill out table

[4 pts.] c) Find I_x (10% accuracy is good enough).



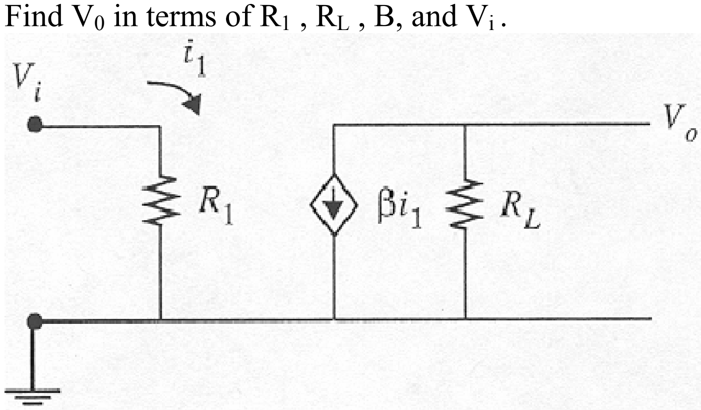
Problem 7 (12 points)

a) Find i_2 in terms of R_1 , R_2 , Z, and V_1 .



i_2 = _______________

b) Find V_0 in terms of R_1 , R_L , B, and V_i .



V_o = ______________

c) In the same circuit as (b), if R_1 = 10K, R_L = 10K, B = 100, and V_i = 0.01V, what is V_0 ?

V_o = ______________

Problem 8 (14 points)

Scientists at Stanford are excited about discovering a new low-mobility semiconductor "Xanium." The electron mobility in Xanium is 0.5cm^2/V sec and the saturation drift velocity is 10^6 cm/sec.

They construct a field effect transistor with this material using an insulator of such a thickness that the capacitance per unit area is 10^-7 coul/cm^2. The transistor length L is 0.5um and the width W is 10um. They find that the threshold voltage is 2.0V. Your job is to predict their experiment results.

a) What is the induced charge per unit area in the channel at a gate-soucre voltage V_{GS} of 5V?

V_o = ________(units?)

b) What is the source-drain resistance at V_{GS} = 1V?

R = _________(ohms)

c) What is the source-drain resistance at V_{GS} = 5V?

R = _________(ohms)

d) In a bulk n-type sample of Xanium that is 0.5um long (in the direction of current flow), how large a voltage would be required to observe velocity saturation? (Hint: Do NOT be too surprised by the answer.)

V = _________(V)

e) Would velocity saturation be observed in this transistor (for drain voltages of 5V or less)?

Y or N _____________

Why? ______________