UNIVERSITY OF CALIFORNIA
College of Engineering
Department of Electrical Engineering
and Computer Sciences

Professor Oldham

Fall 1999

EECS 40 — MIDTERM #1

29 September 1999

Name: SOLUTIONS
Last, First

Student ID: _____

TA: ❑ Kusuma
❑ Chang

Guidelines:

1. Closed book and notes except 1 page of formulas.
2. You may use a calculator.
3. Do not unstaple the exam.
4. Show ***all your work and reasoning on the exam*** in order to receive full or partial credit.
5. This exam contains 12 pages plus the cover page and 2 sheets of scratch paper included at the end of the exam. You can remove these from the rest of the exam if you wish.

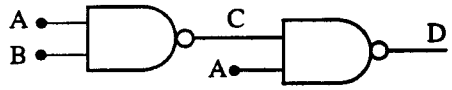
Problem	Points Possible	Your Score
1	20	
2	15	
3	15	
4	20	
5	15	
6	15	
Total	**100**	

$K = 10^3$
$m = 10^{-3}$
$\mu = 10^{-6}$
$n = 10^{-9}$
$p = 10^{-12}$
$f = 10^{-15}$

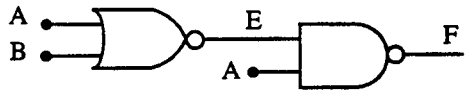
Problem 1 "Static Logic" (20 points)

Fill in the logic values in the table below for input values given. Note that the value for "C" is given as an example.

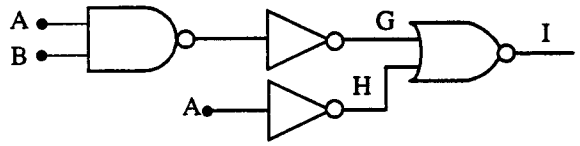
a)



b)



c)



Fill in boxes → (zero or 1)

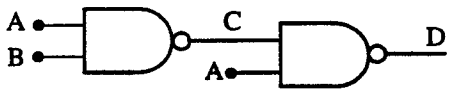
	Intermediate Values and Outputs for A = 1, B = 0						
	C	D	E	F	G	H	I
Value	1	0	0	1	0	0	1

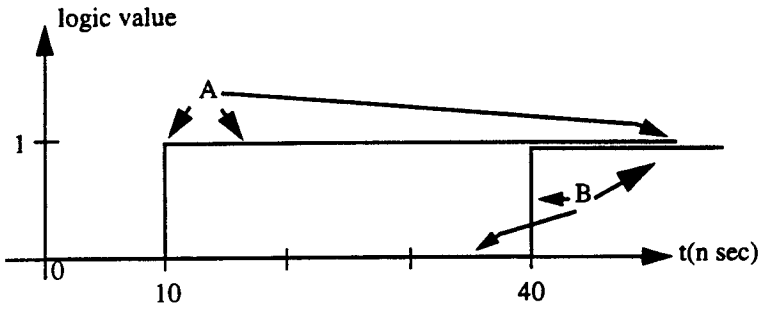
Prob. 1 (cont.)

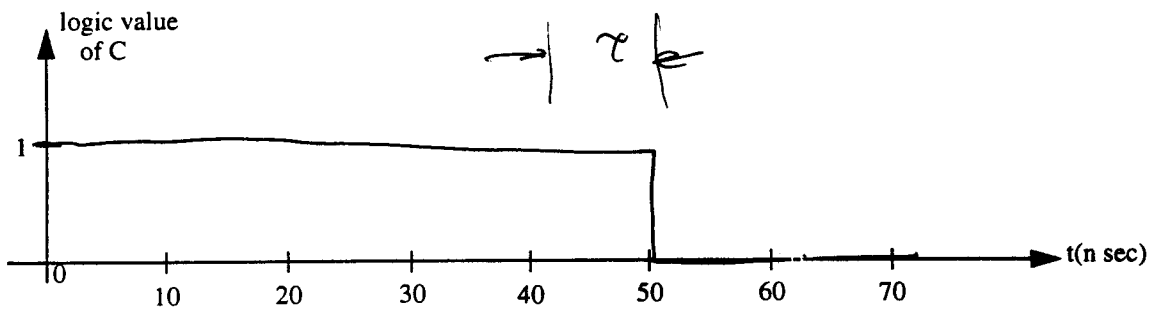
e) All logic blocks in the above figures have a unit gate delay of 10n sec.

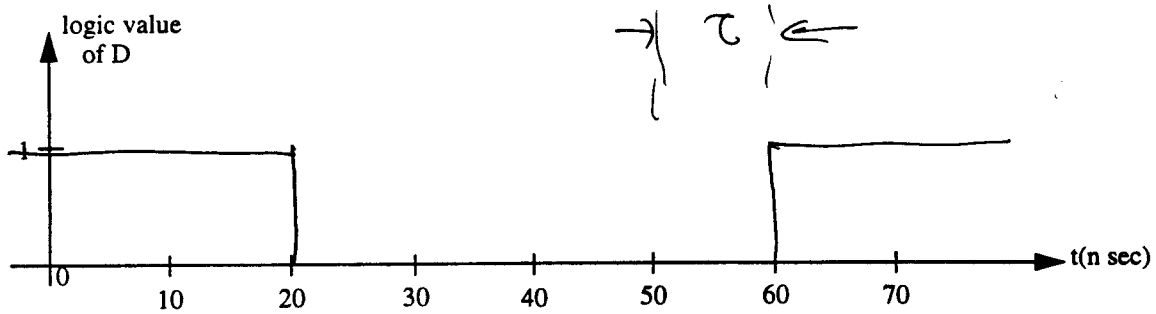
Show the logic values versus time (for t = 0 to 70n sec) for outputs C and D of example a), given the logic input values (A and B) shown below:

a)





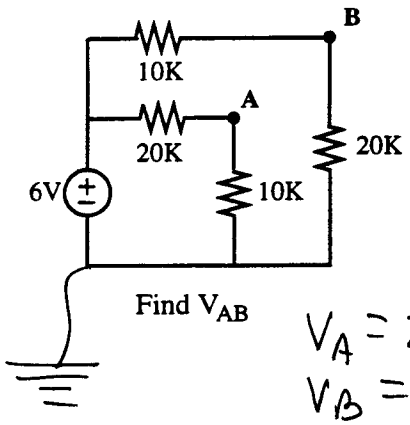




Problem 2 "Circuit Solution by Inspection" (15 points)

Each of these problems should take no more than 1-2 minutes. WRITE ANSWER IN PLACE PROVIDED. There is no partial credit on these mini-problems.

a)



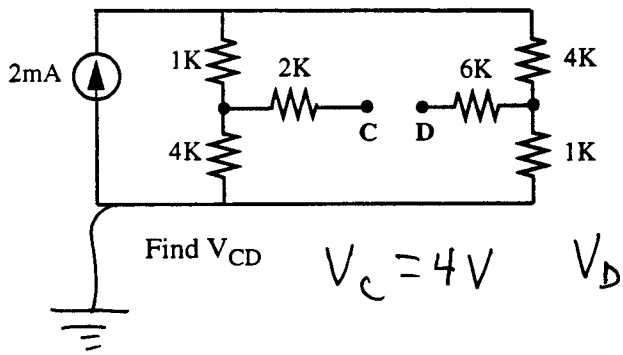
$V_A = 2$

$V_B = 4$

V_{AB} = −2 V

b)

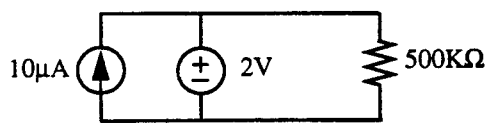
SPLITS 1 mA EACH SIDE



$V_C = 4V$ $V_D = 1V$

V_{CD} = 3 V

c)



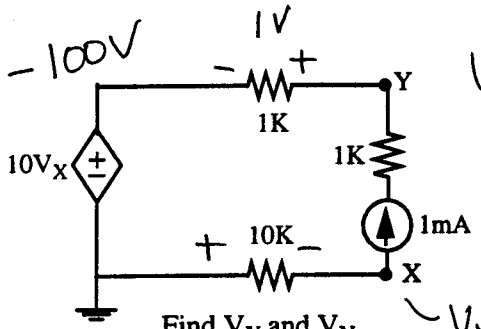
Find power dissipated in 500K resistor

P = 8μ W

$$\frac{V^2}{R} = \frac{4}{.5 \times 10^6}$$

Problem 2 (cont.)

d)



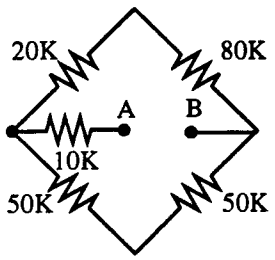
Find V_X and V_Y

$V_4 = -100 + 1$

$V_X = -10V$

V_X = −10V V	
V_Y = −99 V	

e)

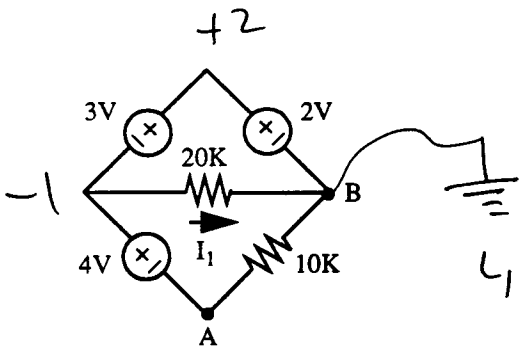


Find R_{AB}

$10k + 100k \| 100k$

R_{AB} = 60 KΩ

f)

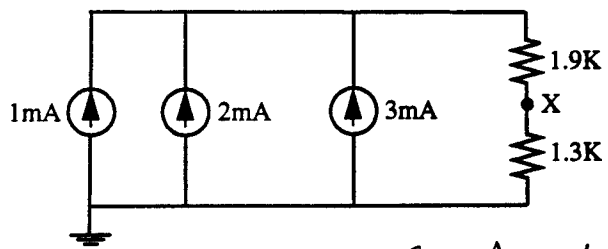


Find I_1

$4_1 = \frac{-1}{20K}$

I_1 = −50μA μA

g)



Find V_X

$6mA \times 1.3K$

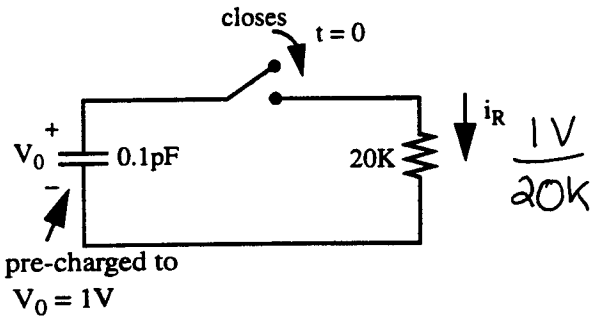
$= 7.8V$

V_X = 7.8 V

Problem 3 "Initial Conditions" (15 points)

In each of the problems below, find the value of the current or voltage just after the switch moves ($t = 0^+$). (What is requested is just a numerical value, NOT an equation or function of time.)

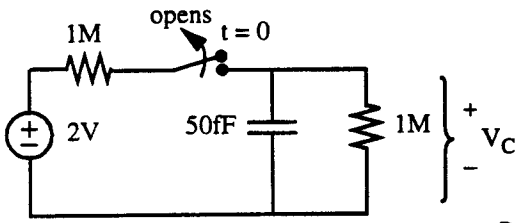
a)



$\frac{1V}{20K}$

i_R = 50 μA

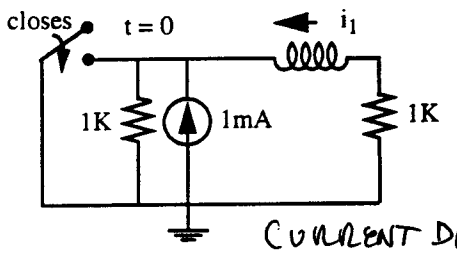
b)



VOLTAGE DIVIDER
⇒ PRECHARGE = 1V

V_C = 1 V

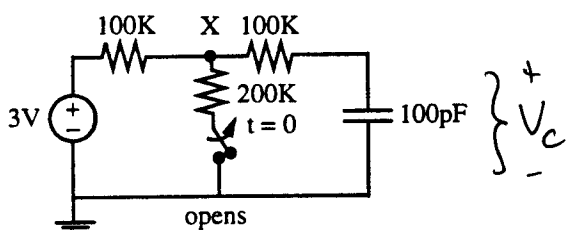
c)



CURRENT DIVIDER $t<0$
SO $i_1 = -\frac{1}{2}$ mA

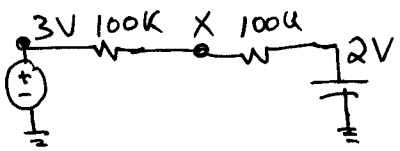
i_1 = −0.5 mA

d)



For $t<0$ $V_X = V_C = \frac{200}{300} \times 3 = 2V$

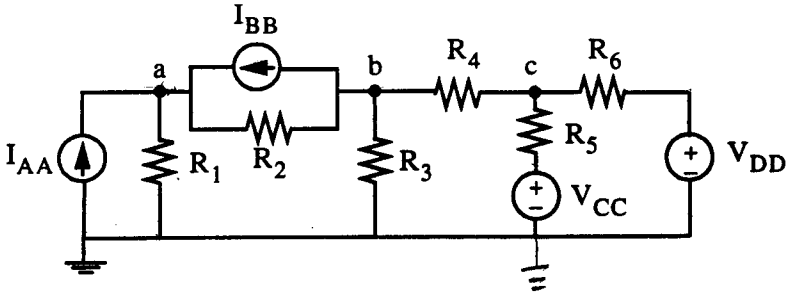
For $t>0^+$



V_X = 2.5 V

Problem 4 "Nodal Analysis" (20 points)

a. For the circuit below you are asked to write sufficient equations to find the unknowns. **You MUST put the equations into the space indicated.** Do any scratch work on the page opposite. **Do not solve.**



Unknowns: V_a, V_b, V_c

Node a : $I_{AA} + \frac{0 - V_a}{R_1} + I_{BB} + \frac{V_b - V_a}{R_2} = 0$

Node b : $\frac{V_b - V_a}{R_2} + I_{BB} + \frac{V_b - 0}{R_3} + \frac{V_b - V_c}{R_4} = 0$

Node c : $\frac{V_b - V_c}{R_4} + \frac{V_{cc} - V_c}{R_5} + \frac{V_{DD} - V_c}{R_6} = 0$

PROB 4 THANKS TO THANH-XUAN NGUYEN !

Write final equations here:

$$I_{AA} - \frac{V_a}{R_1} + I_{BB} + \frac{V_b - V_a}{R_2} = 0 \quad \checkmark$$

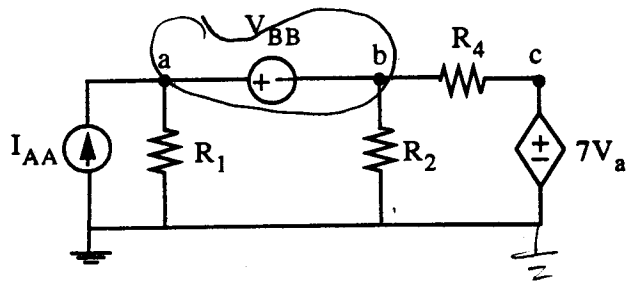
$$\frac{V_b - V_a}{R_2} + I_{BB} + \frac{V_b - 0}{R_3} + \frac{V_b - V_c}{R_4} = 0 \quad \checkmark$$

$$\frac{V_b - V_c}{R_4} + \frac{V_{cc} - V_c}{R_5} + \frac{V_{DD} - V_c}{R_6} = 0 \quad \checkmark$$

10/10

Problem 4 (cont.)

b. Similar to part a, you are asked to write sufficient equations to find the unknowns. Do not solve. **You must** put the equations in the space indicated below.



Unknowns: V_a, V_b, V_c

Supper node: $I_{AA} + \frac{0 - V_a}{R_1} + \frac{0 - V_b}{R_2} + \frac{V_c - V_b}{R_4} = 0$

$V_a - V_b = V_{BB}$

$V_c = +7 V_a$

Put final form for equations here:

$I_{AA} - \frac{V_a}{R_1} - \frac{V_b}{R_2} + \frac{V_c - V_b}{R_4} = 0$ ✓

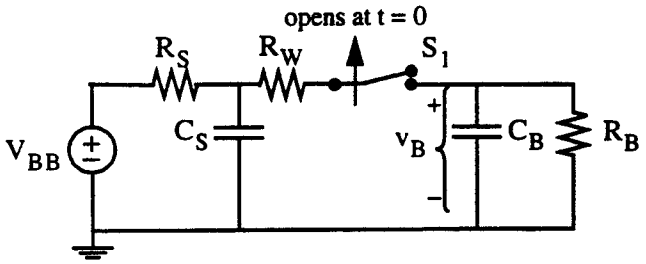
$V_a - V_b = V_{BB}$ ✓

$V_c = 7 V_a$ ✓

10/10

Problem 5 (15 points)

The following circuit is used to study one phase of the operation of a DRAM cell — the slow decay of a stored "1". First the switch S_1 is closed and kept closed to write a "1". Then it opens and the storage capacitor C_B is supposed to maintain the stored information. In this memory, a valid "1" is any voltage v_B in the range of 1 to 3V.



V_{BB} = 2V
C_S = 100pf
C_B = 50fF
R_S = 10K
R_B = $10^{13}\Omega$
R_W = 100Ω

$RC = C_B R_B = 0.5\,SEC$
(SWITCH OPEN)

a) What is the value of v_B, just after the switch S_1 opens, i.e., at t = 0^+? (1% accuracy is sufficent.)

PRECHARGE VOLTAGE DIVIDER:

$$V_{BB} \times \frac{R_B}{R_B + R_S + R_W} \cong V_{BB}$$

v_B = 2VOLTS V

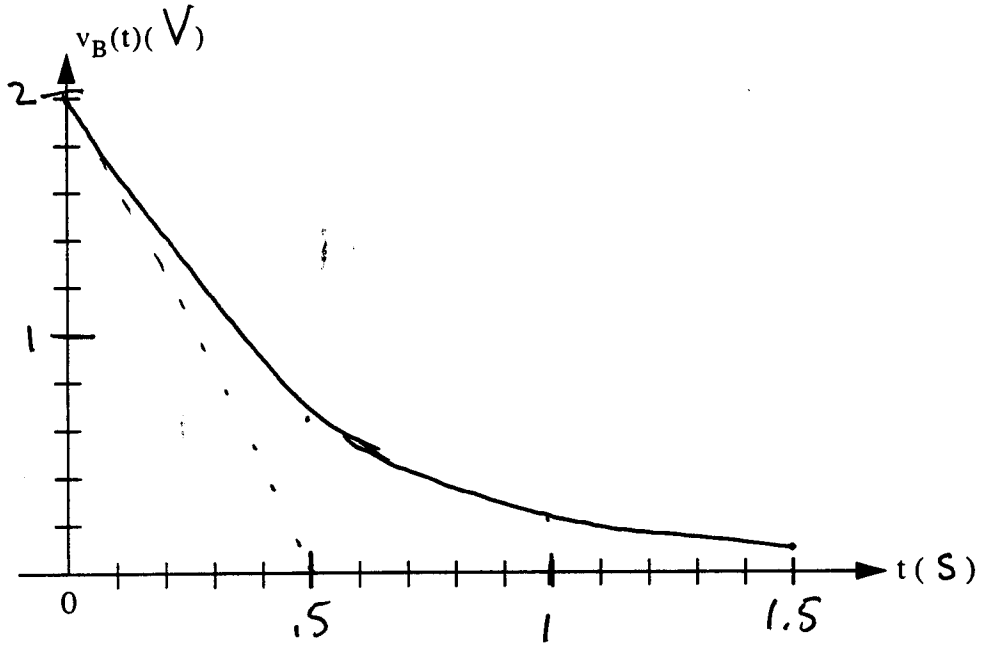
b) What is the value of v_B much later (e.g., 1 hour later)?

v_B = 0 V

c) On the axes provided on the facing page, **neatly** sketch the graph of $v_B(t)$ versus time. **You must label axes with units**.

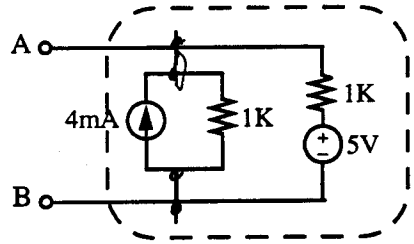
d) Write an equation for v_B as a function of time.

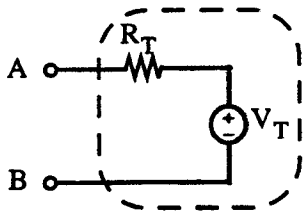
$v_B(t) = 2e^{-t/.5}$


$v_B(t)$(V)
2
1
0
.5
1
1.5
t (S)

Problem 6 (15 points)

a) Find the Thévenin Equivalent Circuit of the following:





SUPERPOSITION

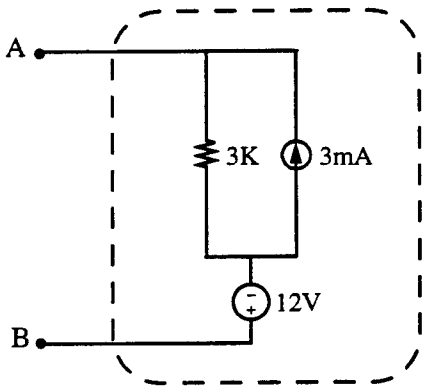
$V_{OC} = 4mA \times \frac{1}{2}K + \frac{1}{2}5V = 4.5V$

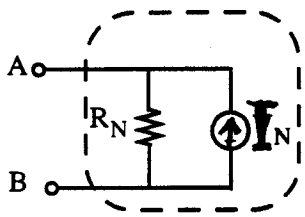
$R_{TH} = 1K//1K = 0.5K$

$V_T =$ 4.5 V

$R_T =$ 0.5 K

b) Find the Norton Equivalent of the following linear circuit:





$V_{OC} = 9V - 12V$

$I_{SC} = \frac{-3V}{3K}$

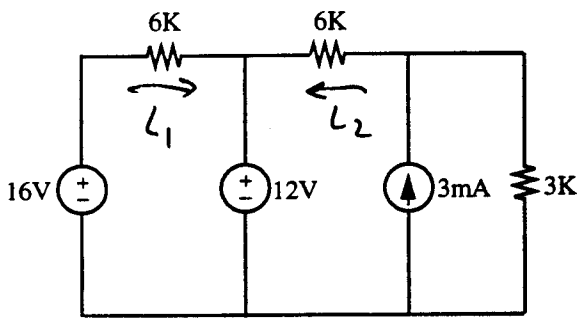
$R_N = R_{TH} = 3K$

$I_N =$ −1 mA

$R_N =$ 3 K

12V

c) Find the power supplied by the voltage source in the following circuit.



$I_1 = \frac{4V}{6K} = \frac{2}{3}mA$

$I_2 = \frac{9V - 12V}{9K} = -\frac{1}{3}mA$

$I_{out} = -\left(\frac{2}{3} - \frac{1}{3}\right) = -\frac{1}{3}mA$

$P_{out} = -\frac{1}{3}mA \times 12V$

Power out = −4 m W