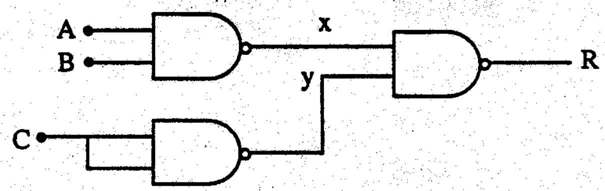
Problem 1 (15 points)

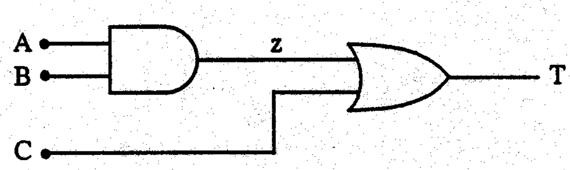
What is the value of the unknown node voltage in each of the following circuits? Assume diodes are perfect rectifiers.

(a)



A	B	C	x	y	R
0	0	0	1	1	0
0	0	1	1	0	1
0	1	0	1	1	0
0	1	1	1	0	1
1	0	0	1	1	0
1	0	1	1	0	1
1	1	0	0	1	1
1	1	1	0	0	1

(b)



A	B	C	z	T
0	0	0	0	0
0	0	1	0	1
0	1	0	0	0
0	1	1	0	1
1	0	0	0	0
1	0	1	0	1
1	1	0	1	1
1	1	1	1	1

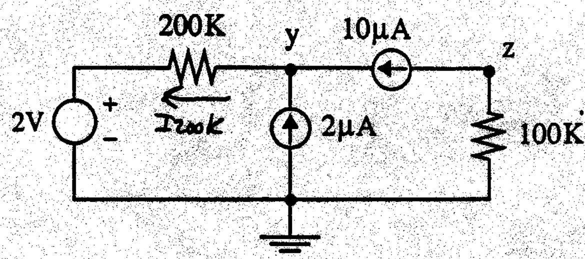
(c) Is R = T for all possible inputs?

☑ YES

☐ NO

(WARNING: You must fill out truth tables in this problem to receive credit.)

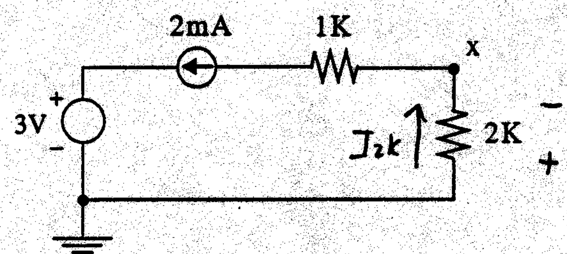
Problem 2 (15 points)



(a) Find V_y. $V_y = 2V + I_{200k} \cdot 200k = 4.4V$

$\Uparrow$ 12µA

$V_y = 4.4V$



$I_{2K} = 2mA$

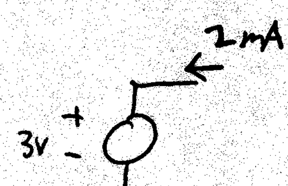
(b) Find V_x.

$V_x = -4V$

$V_x = 0 - 2k \cdot I_{2k} = -4V$

(c) Find power delivered by the voltage source.

$P_3 = -6mW$



$P = V \cdot I$

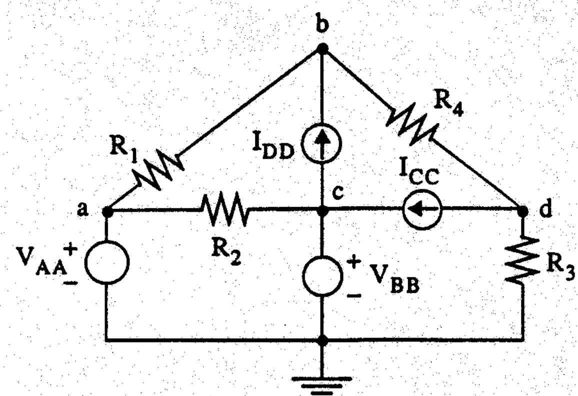
$P = -2mA \cdot 3V = -6mW$

Problem 3 (12 points)

For the circuit below:

(a) Identify known and unknown node voltages, and

(b) Write sufficient nodal equations to solve for the unknown node voltages (do not solve).



(a.1) known node voltages:

$V_a = V_{AA}$, $V_c = V_{BB}$

(a.2) unknown node voltages:

V_b, V_d

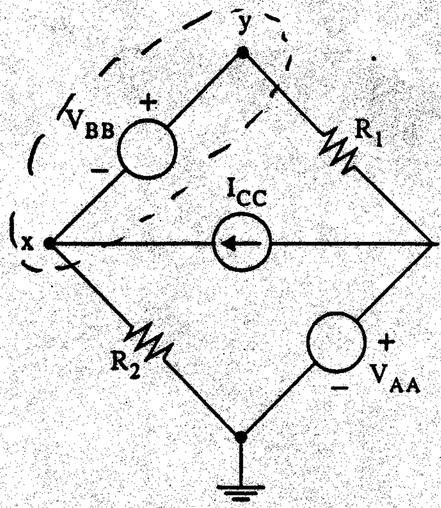
Nodal Equations:

at (b) $(V_{AA} - V_b)/R_1 + I_{DD} + (V_d - V_b)/R_4 = 0$

at (d) $(V_b - V_d)/R_4 - I_{CC} - V_d/R_3 = 0$

Problem 4 (10 points)

For the circuit below, using nodal analysis write sufficient equations to find V_x and V_y. Do not solve.



Write KCL at the supernode

$$\frac{V_x}{R_2} + \frac{V_y - V_{AA}}{R_1} = I_{cc}$$

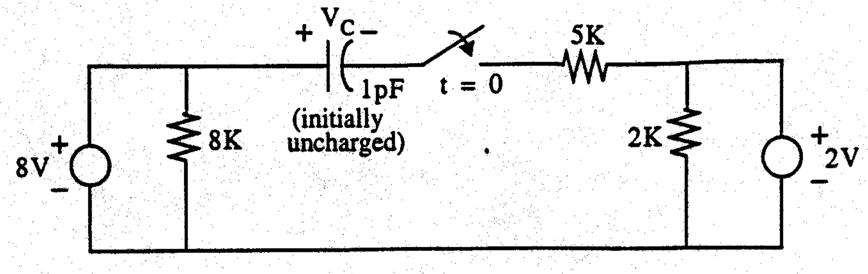
$$V_y - V_x = V_{BB}$$

Equations:

$$\frac{V_x}{R_2} + \frac{V_y - V_{AA}}{R_1} = I_{cc}$$

$$V_y - V_x = V_{BB}$$

Problem 5 (15 points)



For the circuit above, the capacitor is initially uncharged. The switch closes at $t = 0$.

(a) Find V_C for $t = 0^+$ and $t \to \infty$.

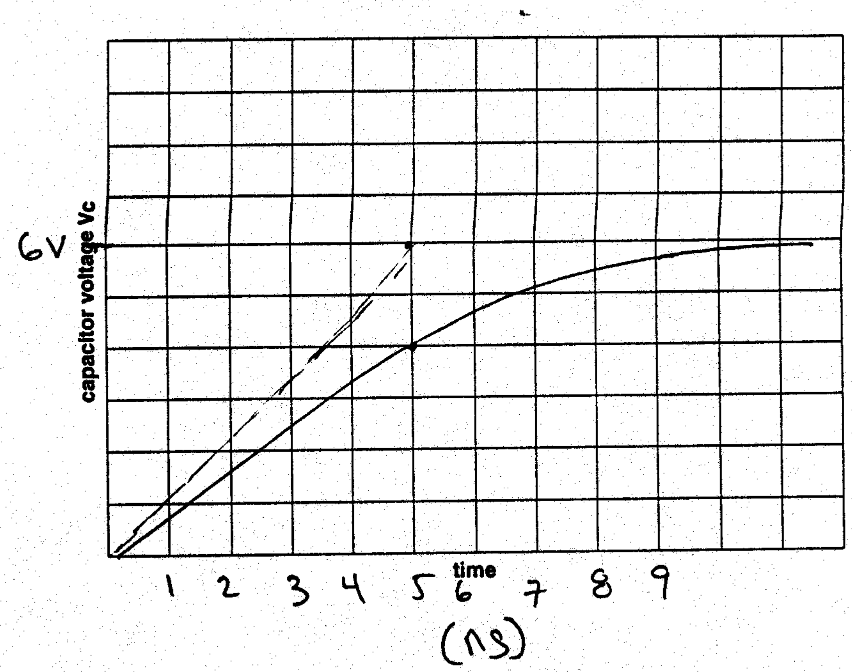
Since initially the capacitor is uncharged, $V_c(0^+) = 0V$
at ∞ the voltage at the (+) side is 8V, at the (–) side of the capacitor the voltage is 2V, $\Rightarrow V_c = 8-2 = 6V$

$V_C(t = 0^+) =$ 0V

$V_C(t \to \infty) =$ 6V

(b) Sketch (very neatly and accurately!) V_C vs. t on the graph below. You **must** label the axes.

slope at $t=0 = \frac{6V}{5ns}$



(c) Write an equation for $V_C(t)$.

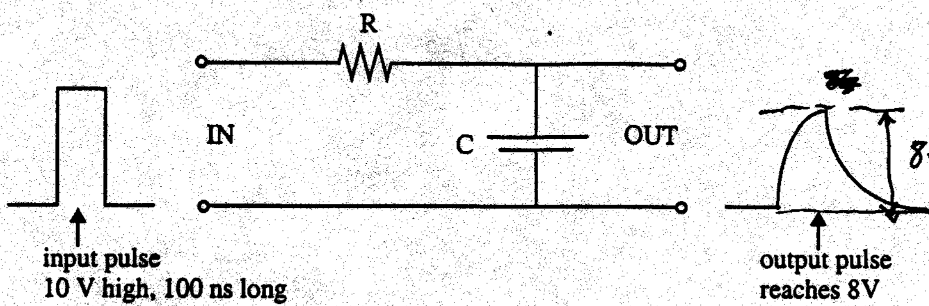
$V_C(t) = 6 - 6e^{-t/\tau}$ V

$\tau = 5ns$

For $\tau = R_{eq} C_{eq}$
$C_{eq} = 1pF$
$R_{eq} = 5K\Omega$ since voltage sources "short out" the 8K and the 2K resistors.

Problem 6 (10 points)

In the lab on RC circuits, you measure the pulse response of the circuit below.



You know R is 2KΩ. What is the value of C?

C = 31 pF

For the rising portion of of the output pulse

$$V(t) = 10(1 - e^{-t/RC}).$$

At $t = 100$ ns, $V(100\text{ns}) = 8$v. $R = 2\text{K}\Omega$.

Therefore,

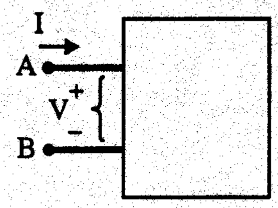
$$\frac{8}{10} = (1 - e^{-100\times10^{-9}/2000C}).$$

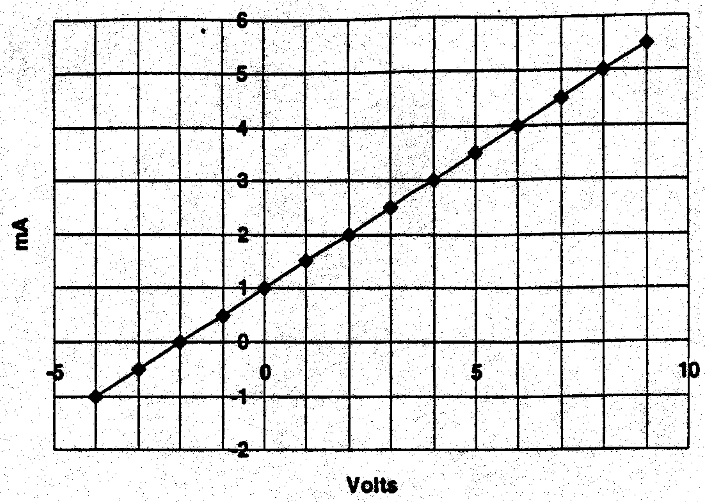
Solving for C,

$$C = \frac{10^{-10}}{2 \log 5} = 31.07 \text{pf}$$

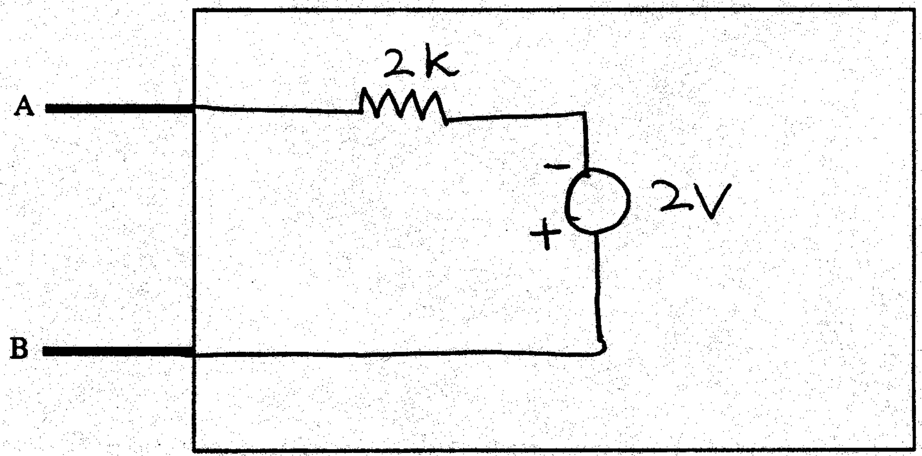
Problem 7 (11 points)

You measure the I-V graph of a circuit in a "black box" in the lab.





What is a possible circuit that is in the box? Draw here ↓.



Since the graph doesn't go through (0,0), there's an active source inside the box.

$$\text{Slope} = \frac{I}{V} = \frac{1}{R} = \frac{2 \times 10^{-3}}{4}.$$

$\Rightarrow R = 2\ k\Omega$.

Let's assume there is a voltage source in series with R. Let this be V_s ~~when I = 0~~

when $I = 0$, $V = -2$ volts

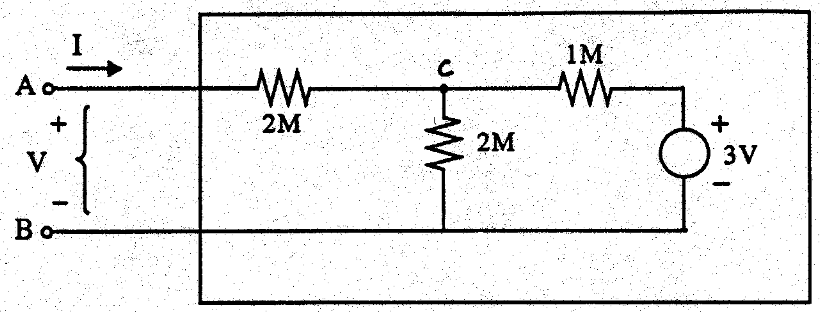
$V = IR + V_s \Rightarrow -2 = 0 + V_s$

$\Rightarrow V_s = -2$ Volts.

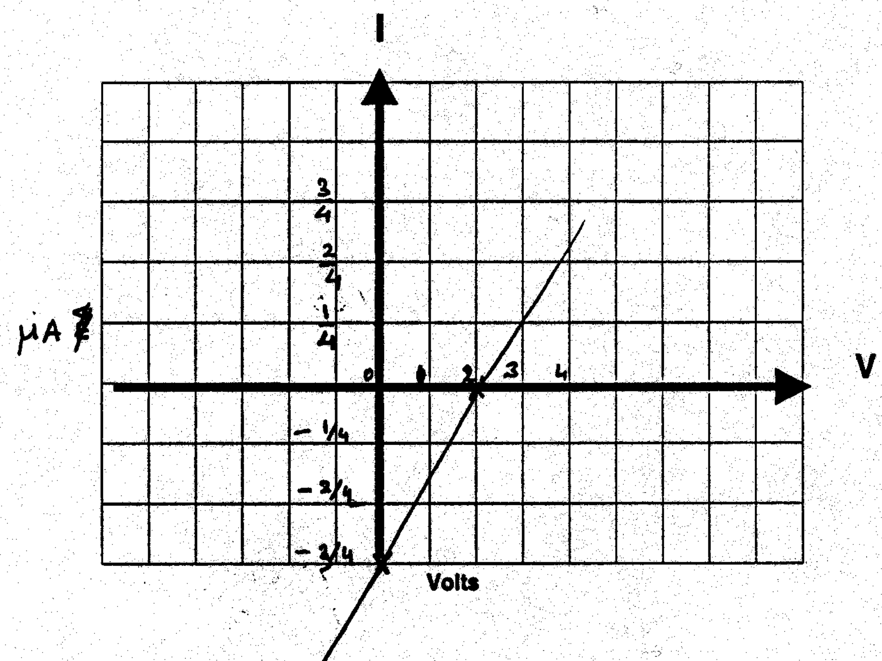
Thus, a possible circuit is as the one given in fig. a.

Problem 8 (12 points)

In this experiment you "peek," i.e., you open the box before testing it. You see the following circuit:



What will be the I-V graph you will measure for this circuit? (You must label axes for credit.)



The easiest way to draw the I-V curve is to find V_{oc} and I_{sc}

V_{oc} (Open Circuit Voltage)

Since $I = 0$, $V_A = V_c$.

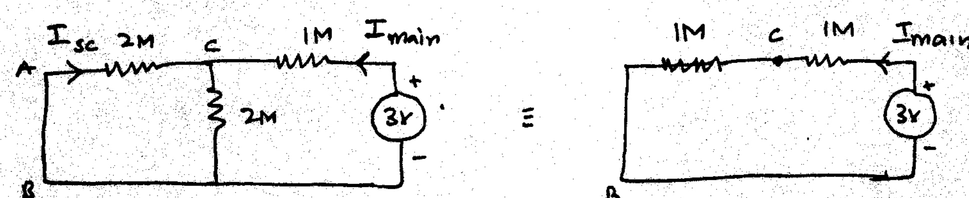
$$V_c = \left(\frac{2M}{2M+1M}\right) 3V = 2 \text{ Volts}.$$

$$= V_{oc}.$$

I_{sc} (Short Circuit Current)

Since $V_A = 0$ (ie $V_A = V_B$)

equivalent circuit can be drawn as



$$I_{main} = \frac{3V}{2M} = 1.5\,\mu A.$$

Therefore $I_{sc} = -\frac{1}{2} I_{main} = -\frac{3}{4}\,\mu A$

So we get $V_{oc} = 2$ Volts, $I_{sc} = -0.75 \times 10^{-6}$ A

This gives us the required I–V graph !!