UNIVERSITY OF CALIFORNIA

College of Engineering
Department of Electrical Engineering
and Computer Sciences

Professor Oldham

Spring 2001

EECS 42 — MIDTERM #1

22 February 2001

Name: Einstein A
Last, First

Student ID: ____________

Signature: ____________________________

SOLUTIONS

Guidelines:

1. Closed book. A 2-page summary sheet with formulas is provided at the end of the exam.
2. Show ***all your work and reasoning on the exam*** in order to receive credit.
3. **Warning**: Some problems will be graded with no partial credit, so check your answers.
4. You may use a calculator.
5. Do not unstaple the exam.
6. This exam contains 5 problems worth 20 points each, and corresponding worksheets plus the cover page and the 2-page summary sheet.
7. **Please do not ask questions** except to point out possible errors or typographical mistakes.

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

Problem 1 (20 points)

In the circuit below we are interested in the voltage at nodes X and Y and use nodal analysis.

(a) Some possible nodal equations are given below. Circle the equation that is correct. (If none are correct, then correct one and circle it.)

(a.1) $V_1/R_1 - I_1 - V_X/R_2 = I_2 - V_Y/R_3$

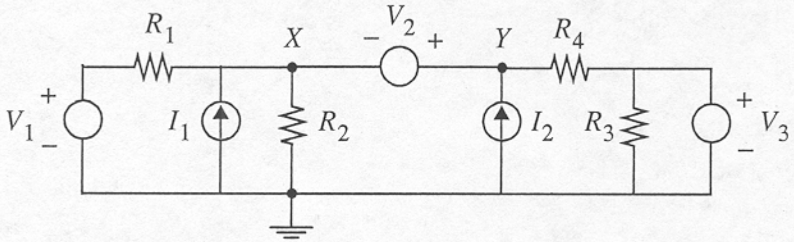
(a.2) $V_1/R_1 + V_3/R_4 = 0$

(a.3) $I_1 + I_2 + V_1/R_1 + V_3/R_4 + V_3/R_3 = 0$

(a.4) $V_1/R_1 + I_1 - V_X/R_2 + I_2 + (V_3 - V_Y)/R_4 = 0$

[✓ **(a.5)** $(V_1 - V_X)/R_1 + I_1 - V_X/R_2 = -I_2 + (V_Y - V_3)/R_4$]

(a.6) $(V_1 - V_X)/R_1 + I_1 - V_X/R_2 = (V_2 - V_3)/R_4$



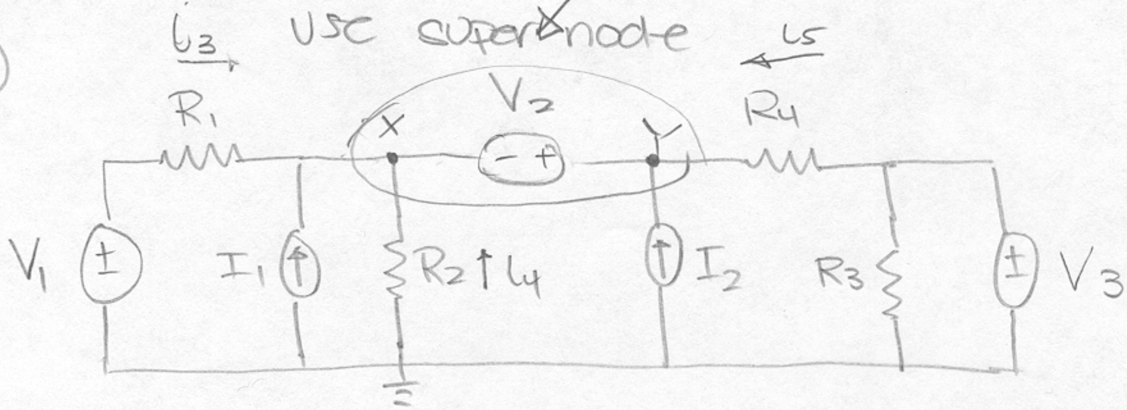
(b) What other equation, if any, is needed to solve for V_X and V_Y? Write it in the box below, BUT DO NOT SOLVE for V_X and V_Y.

Answer here ⟶ $V_x + V_2 = V_y$

Problem 1 Worksheet

floating voltage source

a)



Super node equation (sum currents in = 0)

$$I_1 + I_2 + i_3 + i_4 + i_5 = 0$$

=>

$$I_1 + I_2 + \frac{V_1 - V_x}{R_1} + \frac{0 - V_x}{R_2} + \frac{V_3 - V_u}{R_4} = 0$$

by process of elimination, only

a.5: $$\underbrace{\frac{V_1 - V_x}{R_1}}_{i_3} + \underbrace{I_1}_{I_1} - \underbrace{\frac{V_x}{R_2}}_{i_4} = \underbrace{-I_2}_{-I_2} + \underbrace{\frac{V_y - V_3}{R_4}}_{-i_5}$$

matches with nodal equation.

b) Auxiliary equation

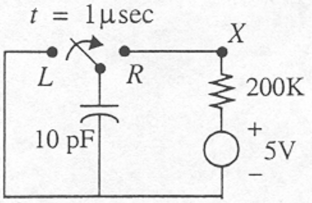
find relationship between V_x and V_y

V_x goes up V_2 to get to V_y

$$\therefore \quad V_x + V_2 = V_y$$

Problem 2 (20 points)

In the circuit below, the switch is operated at $t = 1\mu\text{sec}$ (in other words, the capacitor is switched from node L to node R).



(a) Find V_X, the voltage at node X, for $t < 1\mu\text{sec}$.

(**Note**: Answer must be in the box.)

a) $\boxed{V_X = 5\ V}$

(b) Find V_X for $t = 1\mu\text{sec}$ (just after switch moves).

(**Note**: Answer must be in the box.)

b) $\boxed{V_X = 0\ V}$

(c) Find V_X for $t \to \infty$.

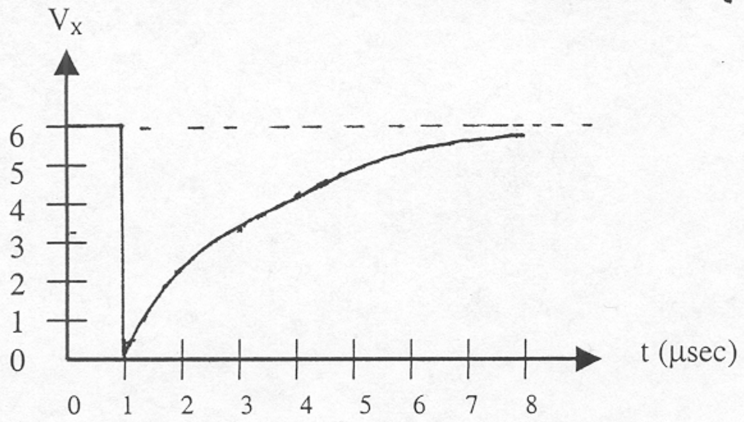
(**Note**: Answer must be in the box.)

c) $\boxed{V_X = 5\ V}$

(d) Sketch neatly on the axes below a plot of V_X versus time.

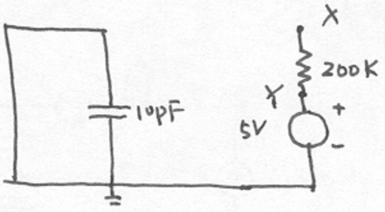
(**Warning**: Neatness and accuracy will be rewarded.)

$\tau = RC = 2\mu S$



(a). When switch is on the left

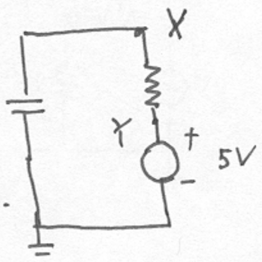
Circuit is shown on the right:



$V_Y = 5V$. since no current goes through the resistor, $V_{XY} = 0$.

$\boxed{V_X = 5V.}$

(b). The voltage across the capacitor is now 0. Just after the switch is turned to the right. Notice now V_X is the voltage across the capacitor. We know voltage across capacitor can't jump.



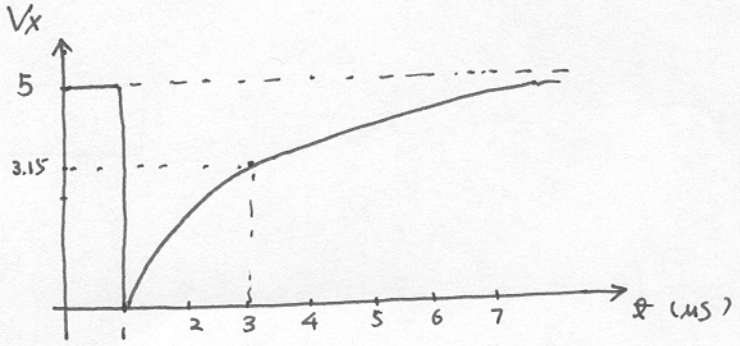
$\boxed{V_X = 0}$

(c). For $t \to \infty$, no current goes through the loop. So again $V_X = V_Y = 5\ v$.

(d). Time Constant $\tau = 2\ \mu S$.

$0 < t < 1\ \mu s$. $V_X = 5\ V$.

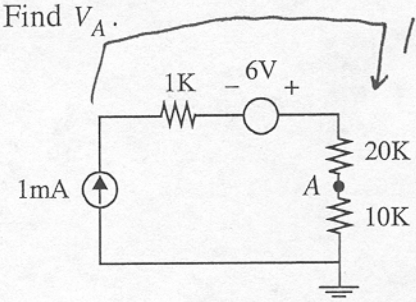
$1 < t < \infty\ \mu s$, $V_X = 5(1 - e^{-(t-1)/\tau})$, $\tau = 2 \mu S$.



Problem 3 (20 points)

Find the voltage indicated for each of the following circuits. (The answer MUST be in the box provided.)

(a) Find V_A.



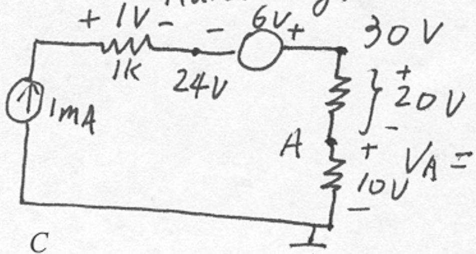
1mA The same current going around the loop.

Easy way:

$V = iR = 10^{-3} \times 10 \times 10^{3} = 10V$

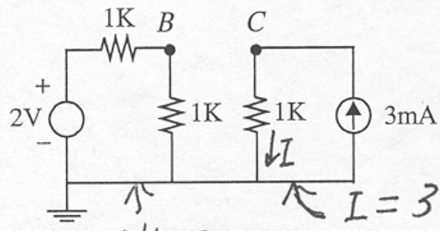
V_A = 10V

Hard way:



$V_A = 30 - 20 = 10V$

(b) Find V_{BC}.



V_{BC} = −2V

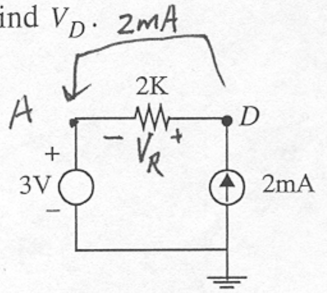
$I = 3mA$,

$V_C = IR = 3mA \times 1K = 3V$

Voltage Divider:

$V_B = \left(\frac{1}{1+1}\right) \cdot 2V = 1V$ $V_{BC} = V_B - V_C = -2V$

(c) Find V_D.



$V_A = 3V$,

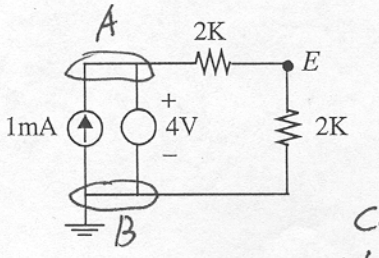
$V_R = IR = 2mA \times 2k = 4V$

V_D = 7V

Current flowing from high Voltage to low Voltage

$V_D = V_A + V_R = 3 + 4 = 7V$

(d) Find V_E.



Voltage drop between A and B is determined by the Voltage Source. $V_{AB} = 4V$

V_E = 2V

Current source does not change this.

Voltage divider: $V_E = \left(\frac{2k}{2k+2k}\right) \cdot V_{AB} = \frac{1}{2} \cdot 4V = 2V$

V_E is the Voltage across the 2k Resistor on the right

Problem 4 (20 points)

For the circuit below, calculate the following quantities. (Note that the sign is important and the answer must appear in the box.) This is a DC, not a transient, problem.

(a) P_1, the power into (dissipated in) resistor R_1. 3 methods

$\boxed{P_1 = 3.6mW}$

#1 $P = \frac{V^2}{R} = \frac{(6)^2}{10K} = \boxed{3.6 mW}$

#3 $P = iV = (.6mA)(6V) = \boxed{3.6 mW}$

#2 $+$ $i\downarrow R_1$ $-$ $i = \frac{6V}{10K} = .6mA$ $P = i^2R = (.6mA)^2(10K) = \boxed{3.6 mW}$

(b) P_2, the power into (dissipated in) resistor R_2. 3 methods

$\boxed{P_2 = 10^{-7} W}$ $= .1 \mu W$ $= 100nW$

#1 $P = i^2R = (1\mu A)^2(100K) = \boxed{1\times10^{-7} W}$

$- V_{R2} +$ R_2 $V_{R2} = (1\mu A)(100K) = .1V$

#3 $P = \frac{V^2}{R} = \frac{(.1V)^2}{100K} = \boxed{1\times10^{-7} W}$

#2 $P = IV = (1\mu A)(.1V) = \boxed{1\times10^{-7} W}$

(c) P_3, the power into capacitor C_3.

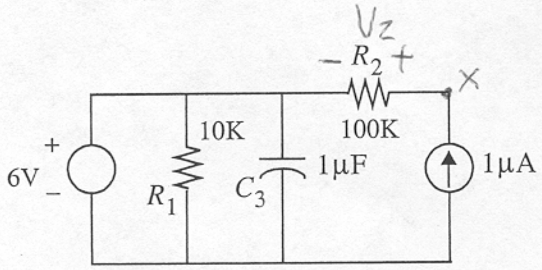
$\boxed{P_3 = 0 W}$

This is a DC, not a transient problem.
Steady State! No current through capacitor
$P = IV = \boxed{0 W}$

(d) P_4, the power into the current source.

$\boxed{P_4 = -6.1\mu W}$

① First, Find V_2, voltage drop across R_2.
② Second, find V_x
③ third, use $P = IV$



① $V_2 = IR = (1\mu A)(100K) = .1V$

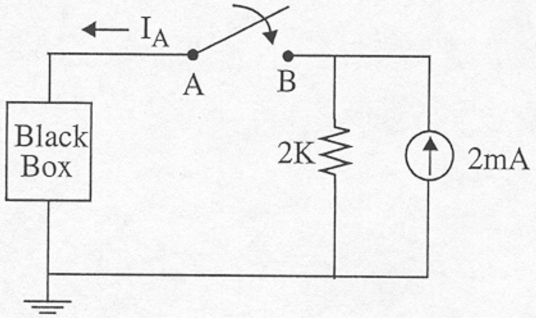
② $V_x = 6V + V_2$
$= 6V + .1V = 6.1V$

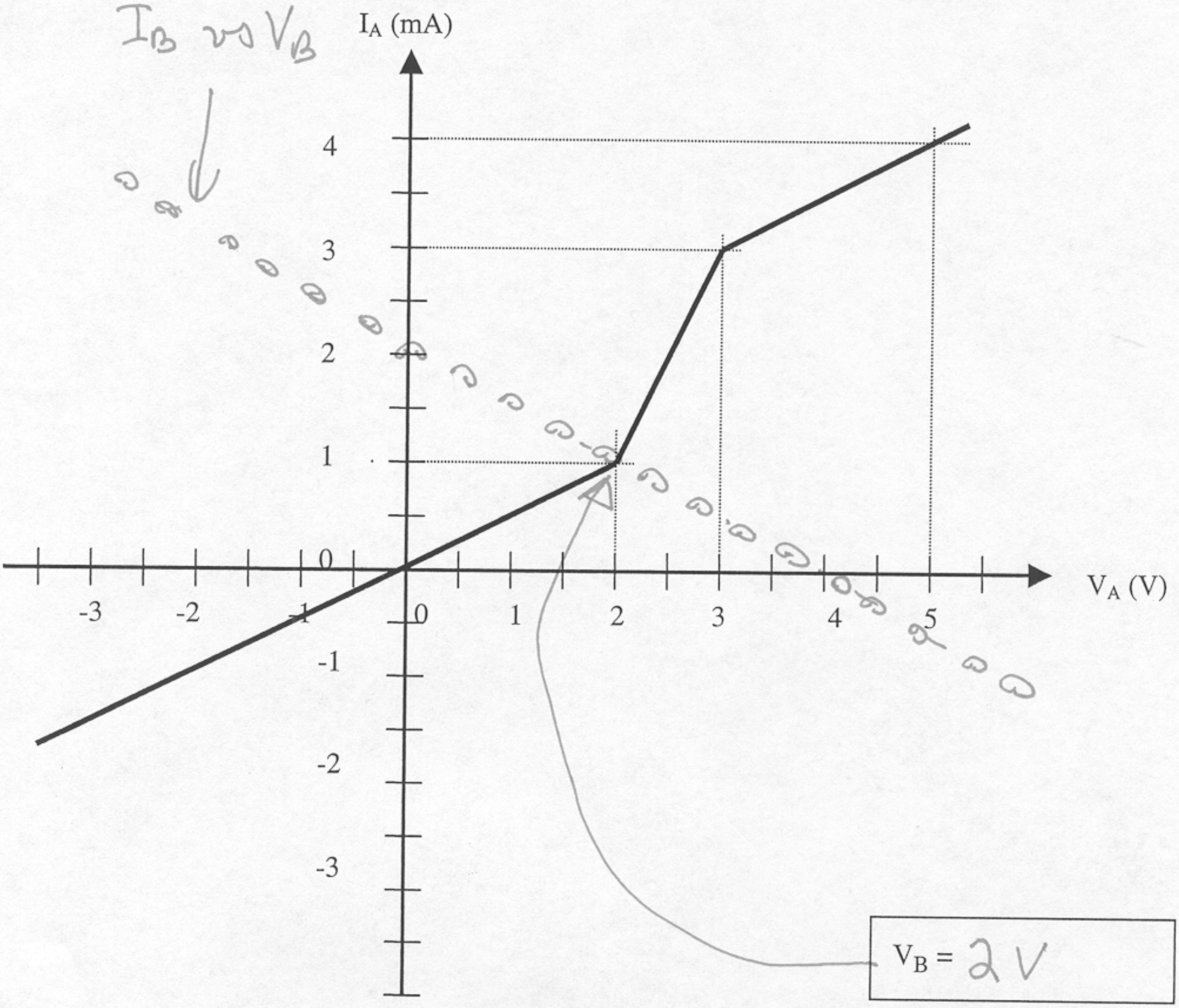
③ $P = IV = -(1\mu A)(6.1V) = \boxed{-6.1\mu W}$

Problem 5 (20 points)

The circuit below consists of two parts: 1) a "black box" that has the nonlinear I-V characteristics shown on graph I_A versus V_A, and 2) a simple resistor in parallel with a current source. When the switch is open, it is obvious that $V_A = 0$ and $V_B = 4V$.

Use the load-line method to find the approximate value of V_B when the switch is closed. (IMPORTANT: You must show your work to receive credit.) (Also note: This is a DC problem, not a transient problem.)

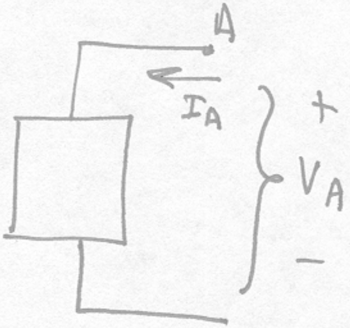


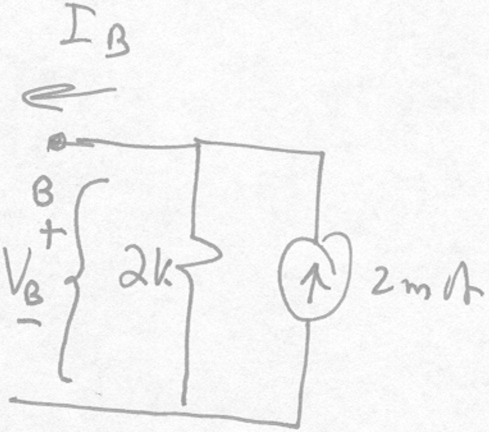


V_B = 2V

Problem 5 Worksheet

Solution:





I_A vs V_A shown on graph

I_B vs V_B is linear
and $I_B = 2mA$ when $V_B = 0$
and $I_B = 0$ when $V_B = 4V$
WE PLOT THIS ON
SAME AXES ○○○○○

BUT $I_B = I_A$
& $V_B = V_A$

SO INTERSECTION IS SOLUTION