EE 10H, Spring 2018, Midterm Exam – May 8, 2018

Instructions: This exam booklet consists of problems, blank sheets for the solutions, reference sheets with mathematical identities, and additional blank sheets. Please follow these instructions while answering your exam:

1. **Write your name and student identification number below.**
2. **Write the names of students to your left and right as well.**
3. **You have 1 hour 45 minutes to finish your exam.**
4. **Write your solutions in the provided blank sheets after each problem.**
5. **The sheets marked "Scratch…" will NOT be graded. These sheets are provided for your rough calculations only.**
6. **Write your solutions clearly. You may box in your final answer. Illegible solutions will NOT be graded.**
7. **Be brief.**
8. **Open text and open notes. NO homework or homework solutions!**

NAME: _____

STUDENT ID: _____

NAMES OF ADJACENT STUDENTS:

LEFT: none

RIGHT: none

Problem	Score
#1	25/25
#2	39/40
#3	35/35
Total	90/100

REMEMBER

The burden of making your work easy to follow (and grade) is on you. If we can't follow it, we won't grade it!

Problem 1: Consider the circuit shown in Figure 1.

(a) Draw a graph for this circuit.
(b) Identify (draw) a spanning tree that does **not** include the branches R_8 and V_B.
(c) For loop current method identify a minimum set of loop currents and mark your chosen set of chord currents on the circuit diagram.
(d) Mark the currents in every branch in terms of your chosen unknowns.
(e) Write the loop (KVL) equation for a loop that includes V_B. ONE KVL

(5 + 5 + 5 + 5 + 5 = 25 points)

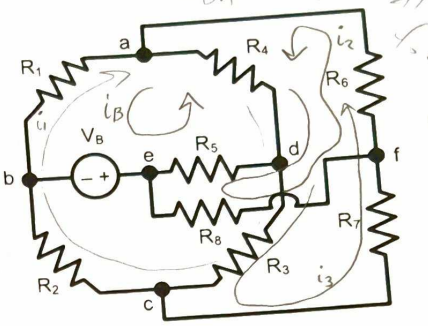
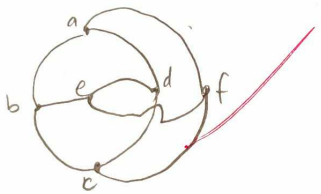


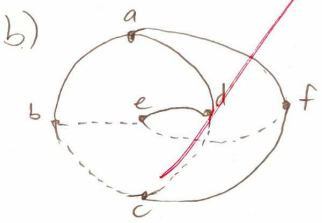
Figure 1.

Solution:

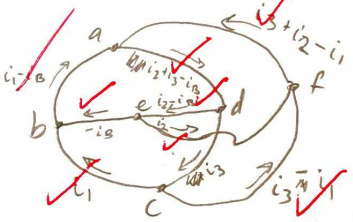
a)



b)



d)

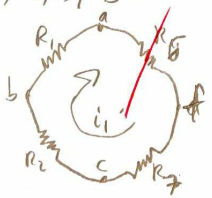


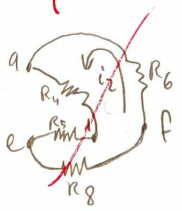
c) $b-(n-p) = 9-(6-1) = 4$ unknowns normally... $V_B = (R_5+R_4+R_1)\,i_B$, $i_B = \frac{V_B}{R_1+R_4+R_5}$

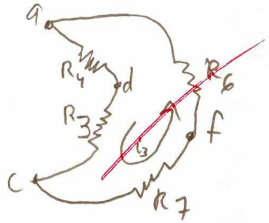
However, because V_B is a known voltage source, the current running through that Loop, i_B, is known and there are 3 unknowns.

CLARIFICATION ON i_1, i_2, i_3, i_B: a minimum of

i_B = a known value NO!





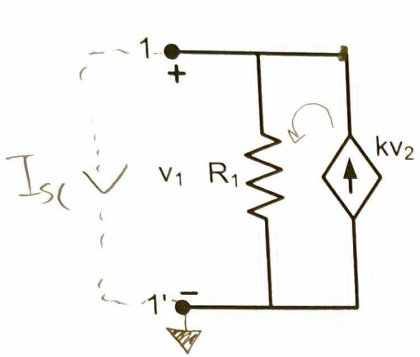


d) see graph next to part b

e) ~~$V_B = (R_5+R_4+R_1)i_B - R_5 i_2 - R_4 i_2 - (R_1+R_4)i_1 - R_4 i_3$~~

e) $V_B = R_4(i_B - i_2 - i_3) + R_5(i_B - i_2) + R_1(i_B - i_1)$

Problem 2: Refer to Figure 2 for this problem. Calculate the Thevenin's equivalent of this network looking into the terminals 1-1'. Use any method of your choice.



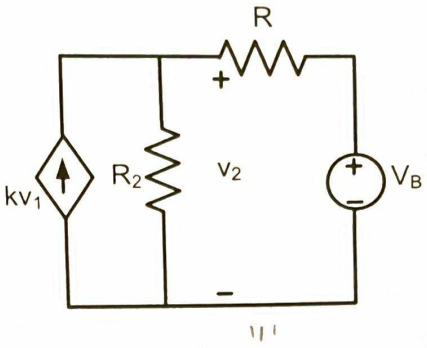
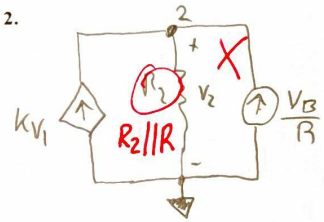


Figure 2.

(20 + 20 = 40 points)

Solution:

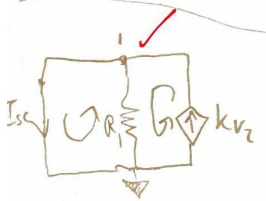


-5

For V_{Th}:

$$kv_2 = \frac{v_1}{R_1} \checkmark$$

$$v_2 = \frac{v_1}{kR_1} \checkmark$$



$$R_1(I_{sc} - kv_2) = 0$$

$$v_2 = \frac{I_{sc}}{k} \checkmark$$

$$\frac{v_1}{R_1} = -I_{sc} + kv_2 = -I_{sc} + I_{sc} = 0$$

$$v_1 = 0 \checkmark$$

$$kv_1 + \frac{(V_B - v_2)}{R} = \frac{v_2}{R_2} \quad X \; -5$$

$$0 + \frac{V_B - v_2}{R} = \frac{I_{sc}}{kR_2}$$

$$I_{sc} = \frac{V_B k R_2}{R} \quad X$$

$$kv_1 + \frac{V_B}{R} = \frac{v_2}{R_2 \| R} \quad X$$

$$kv_1 + \frac{V_B}{R} = \frac{1}{R_2} \cdot \frac{v_1}{kR_1}$$

$$\frac{V_B}{R} = v_1 \left(\frac{1}{kR_1R_2} - \frac{k^2R_1R_2}{kR_1R_2} \right)$$

$$V_{Th} = v_1 = \frac{V_B}{R} \left(\frac{kR_1R_2}{1 - k^2R_1R_2} \right) \quad X$$

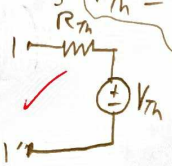
V-ZR

$$R_{Th} = \frac{V_{Th}}{I_{sc}} = \frac{\frac{V_B k R_1 R_2}{R(1 - k^2 R_1 R_2)}}{\frac{V_B k R_2}{R}}$$

$$R_{Th} = \frac{R_1(1 - 2k^2R_1R_2)}{1 - k^2R_1R_2}$$

$$R_{Th} = \frac{V_{Th}}{I_{sc}} = \frac{V_B k R_1 R_2}{R(1 - k^2 R_1 R_2)} \cdot \frac{R}{V_B k R_2}$$

$$R_{Th} = \frac{R_1}{1 - k^2 R_1 R_2} \quad X$$



30

$I_o(t)$

Problem 3: Refer to Figure 3 for this problem. Find $I_o(t)$ for all $t \geq 0$. Assume $k < R$.

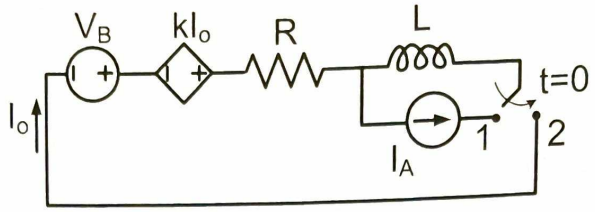


Figure 3

(35 points)

Solution:

for $t < 0$

for inductors, $I_L(0+) = I_L(0-) = -I_A$

initial cond. $I_o(0+) = -I_A$ ✓

for $t > 0$

$$V_B + kI_o = I_o R + L\frac{dI_o}{dt}$$

$$I_o(R-k) + L\frac{dI_o}{dt} = V_B$$

$$\left(\frac{dI_o}{dt} + \frac{R-k}{L} I_o = \frac{V_B}{L}\right) e^{\frac{R-k}{L}t}$$

$$\left(I_o e^{\frac{R-k}{L}t}\right) = \int \frac{V_B}{L} e^{\frac{R-k}{L}t}\, dt$$

$$= \frac{V_B}{L} \cdot \frac{L}{R-k} e^{\frac{R-k}{L}t} + B$$

$$I_o = \frac{V_B}{R-k} + Be^{\frac{k-R}{L}t}$$

$I_o(\infty)$: $V_B + kI_o = I_o R$

$I_o(R-k) = V_B$

$I_o = \frac{V_B}{R-k}$ ✓

$I_o(0) = -I_A = \frac{V_B}{R-k} + B$

$B = -I_A - \frac{V_B}{R-k}$

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$$I_o(t) = \frac{V_B}{R-k} - \left(I_A + \frac{V_B}{R-k}\right) e^{\frac{k-R}{L}t} \quad t \geq 0$$