LUMS
A Not-for-Profit University

Department of Electrical Engineering
School of Science and Engineering

EE240 Circuits I - Fall 2020

ASSIGNMENT 2

Due Date: 23:55, Saturday. October 31, 2020 (Submit online on LMS)
Format: 6 problems, for a total of 100 marks

Instructions:

- Solve the assignment on blank A4 sheets and either scan the document using a scanner or use CamScanner proficiently.
- Upload the solved assignment on LMS in the "Assignments" tab under Assignment 2.
- Naming convention should be as follows: "Name_RollNumber_Assignment_2.pdf".
- Feel free to contact the instructor or the teaching assistants if you have any concerns.
- You represent the most competent individuals in the country, do not let plagiarism come in between your learning. In case any instance of plagiarism is detected, the disciplinary case will be dealt with according to the university's rules and regulations.

Course Learning Outcomes Covered:

Demonstrate the understanding and use of component and network conventions and network topology.

Problem 1 [12 marks]: Source Transformation

Although you can apply Nodal or Loop analysis techniques on any given circuit to understand its parameters, writing many equations and solving very larges matrices can be often cumbersome as you will see in problems below. Therefore, circuit analyzers such as yourselves may find it beneficial to transform a given circuit into a much simpler

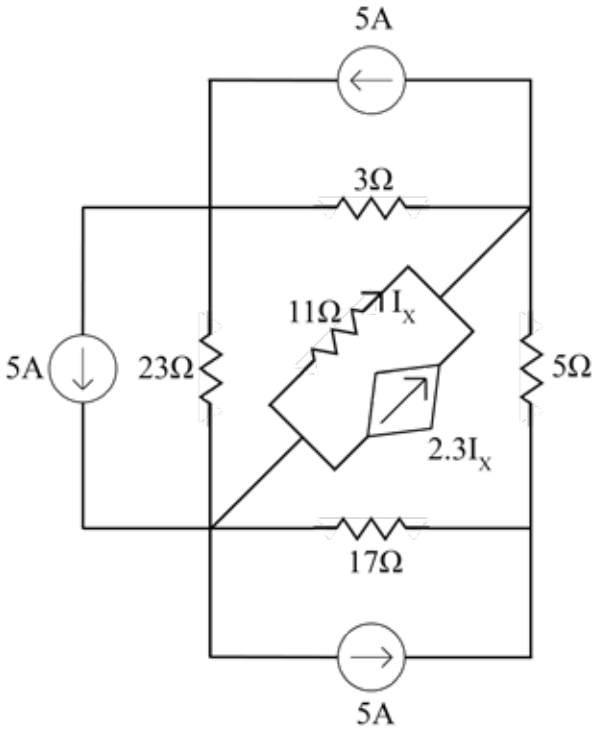
(a) **[2 marks]** For the given circuit, find:

(i) **[1 mark]** The total number of nodal equations.

(ii) **[1 mark]** Number of independent loops.

(b) **[10 marks]** Find I_X using Source Transformation.

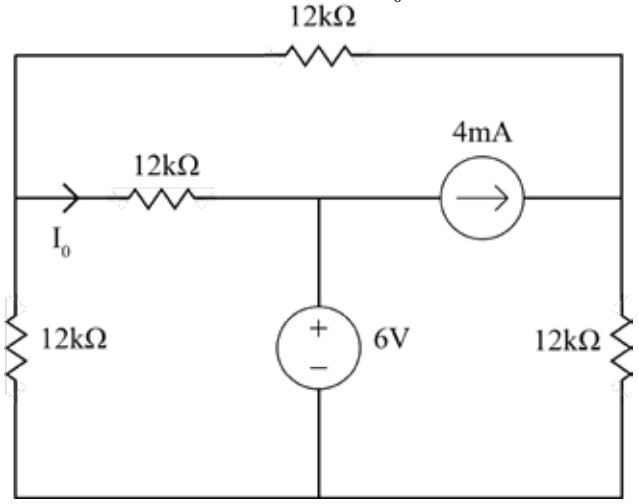
Hint: Remember Current and Voltage Source can be combined and split.



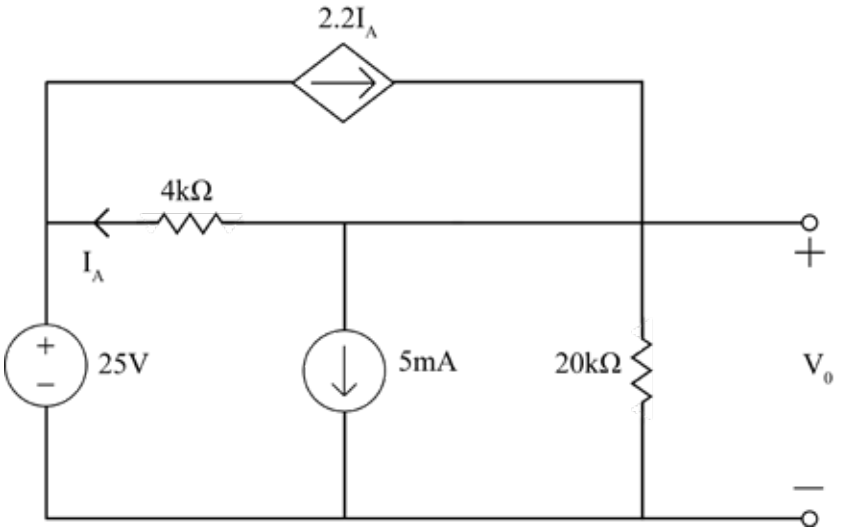
Problem 2 [24 marks]: Superposition

Superposition is applied to linear systems, whenever a system is driven by more than one independent source, the total response is the sum of the individual responses.

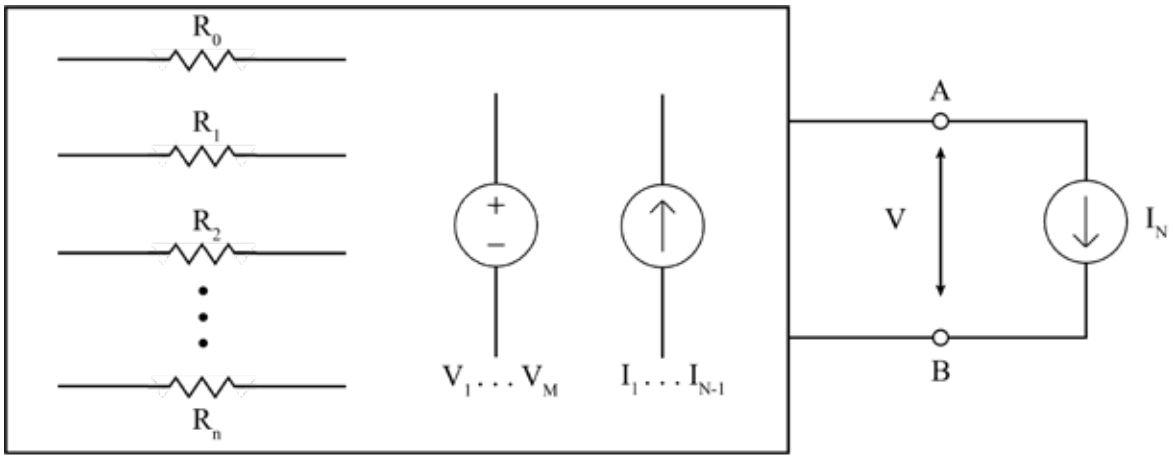
(a) **[7 marks]** In the following network find I_0 using superposition



(c) **[7 marks]** In the following network find V_0 using superposition.



(d) **[10 marks]** Let us generalize superposition, refer to the diagram below. The circuit on the left of terminal A and B has been modelled as a box containing 'M' number of voltage sources and 'N-1' number of current sources. The Nth current source is to the right of terminals A and B.



Contains 'M' Voltage Sources, 'N-1' Current Sources and an arbitrary number of Resistors.

(i) **[3 marks]** The number of resisters in the box is arbitrary. Each combination of resistors will have a certain scaling effect on the voltage across A and B due to every one of the M voltage sources. Use this information to write the voltage V_M across A and B due to one of the voltage sources in the box.

(ii) **[2 marks]** Repeat the same for one of the current sources.

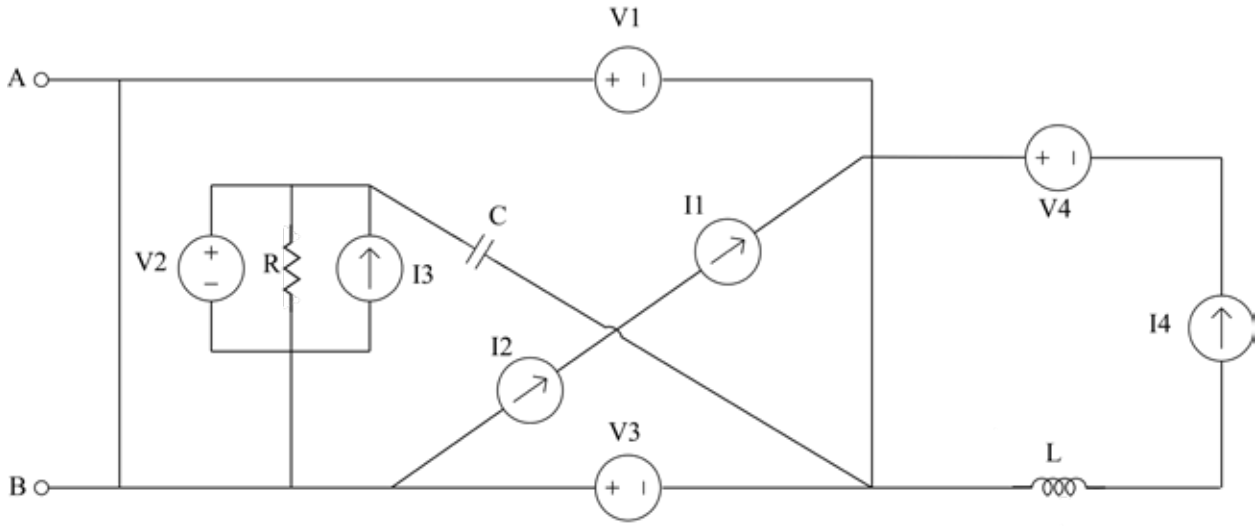
(iii) **[2 marks]** Now write the effect of the current source on the right on the voltage across terminal A and B.

(iv) **[3 marks]** Superpose all three by writing them in form of summations. The effect due to the sources inside the box can be named V_{OC} (open circuit voltage).

Aha! You have just set the basis for Thevenin theorem using your knowledge of superposition theorem. You will cover this in much greater detail in lectures to come.

Problem 3 [6 marks]: Power Sources

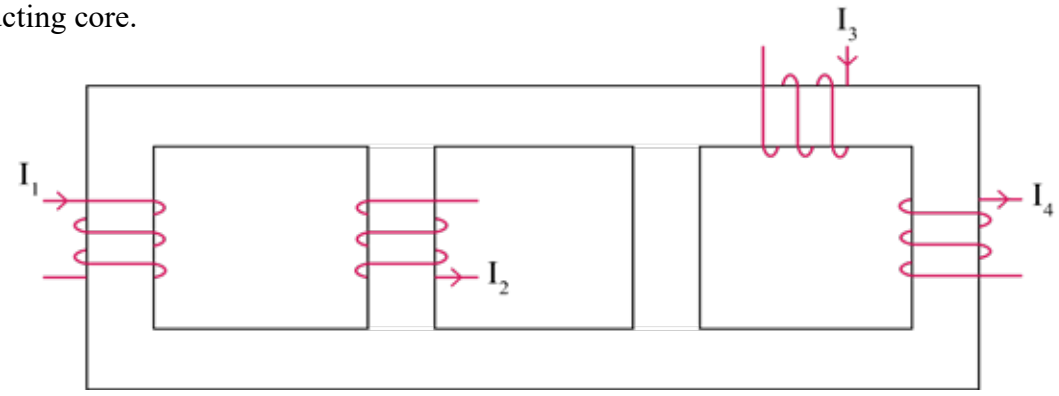
Your project partner is responsible for making the circuit which powers your LED Cube. They have come up with the following circuit:



After remembering your project partner had missed the circuits lecture on series/ parallel connections of power sources, you become sure the circuit will not work. Identify as many errors or redundant elements in the following circuit.

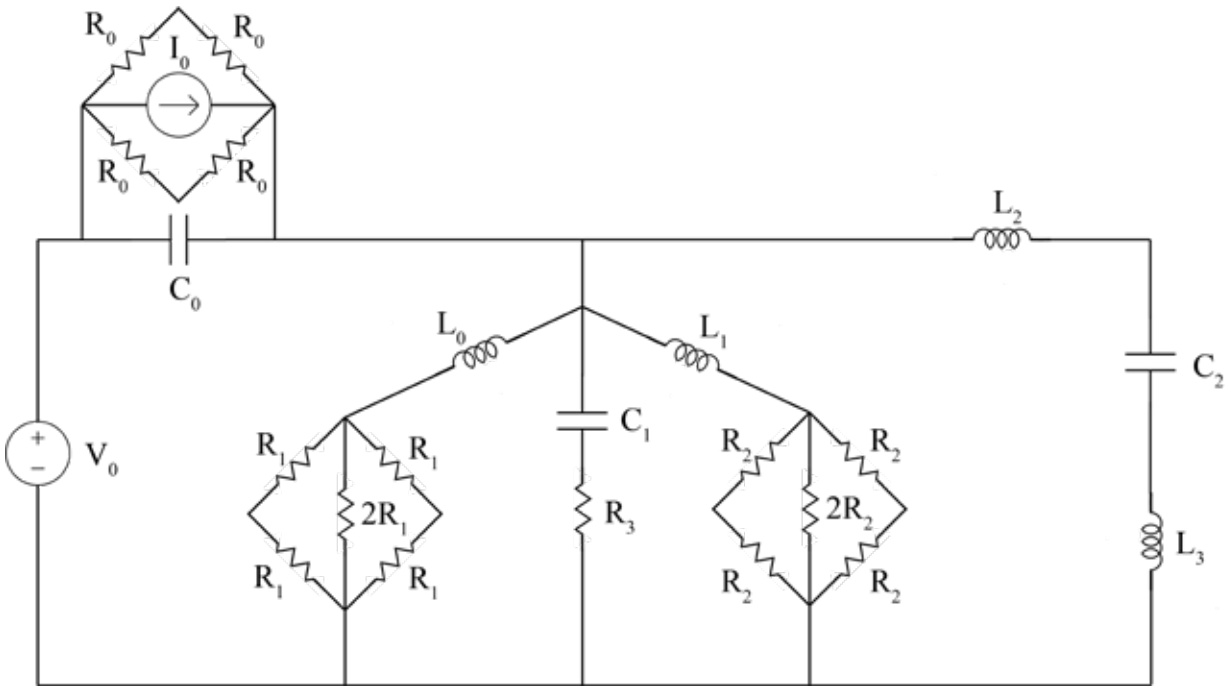
Problem 4 [10 marks]: Dot Convention

Use different symbols to specify the polarity of the following coils on the flux conducting core.



Problem 5 [15 marks]: Nodal Analysis

Nodal analysis is a circuit analysis is a circuit analysis based on defining node voltages as the variable. The application of nodal analysis extends to circuits that are not necessarily resistive. The next few lectures will prove to you the importance of circuit analysis in greater detail. For now, consider the network below.

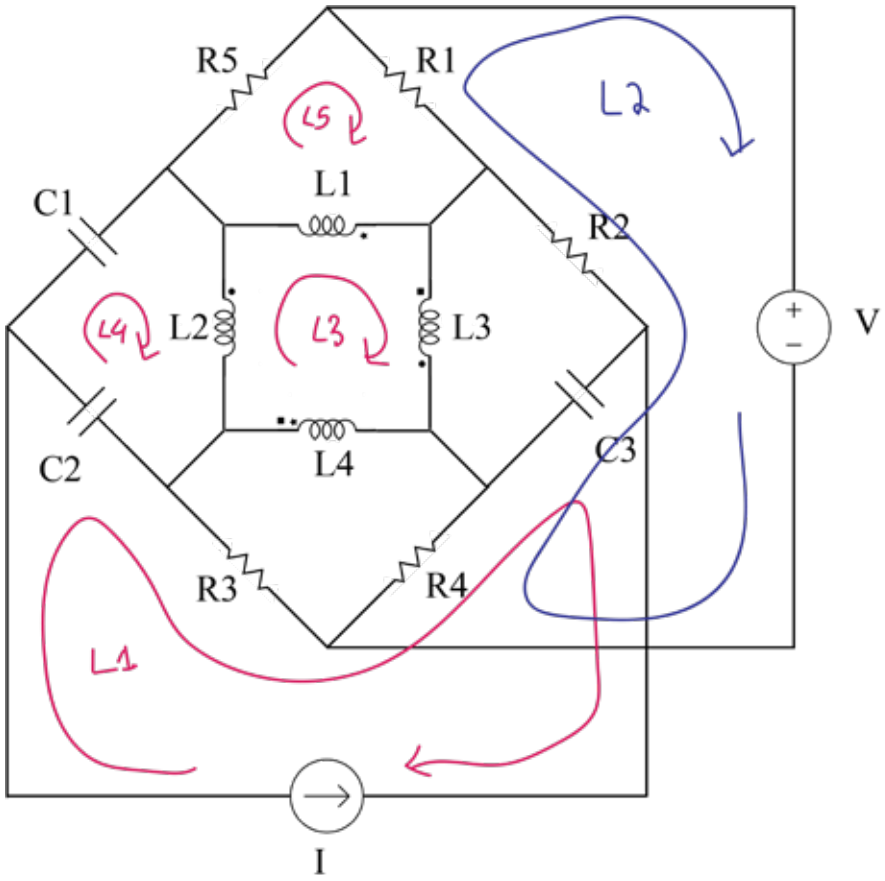


(i) **[3 marks]** State the number of nodes in the circuit and the number of nodal equations needed to specify the network.

(ii) **[12 marks]** Obtain the nodal equations for the network.

Problem 6 [33 marks]: Loop Analysis

For the following circuit



(a) **[2 marks]** Label all the nodes on the circuit.

(b) **[1 mark]** Although you can use Loop and Nodal analysis, it is important to understand which technique to use. For the provided circuit, explain which method would be most appropriate and why.

(c) **[2 marks]** How many branches are present in the circuit.

(d) **[3 marks]** Analyzing network topology is useful when dealing with a certain network's properties disregarding the distorted size and shape of the network. Draw the graph of the circuit.

(e) **[1 mark]** Calculate the number of chords in the tree of the graph.

(f) **[2 marks]** Draw one particular variation of the tree from your graph.

(g) **[15 marks]** Use the Kirchhoff Voltage Law to write the complete set of loop equations using the indicated loops.

(h) **[7 marks]** By using your loop equations, formulate a matrix of the form AI = V that describes the circuit.

Note: You do not need to solve further for the scope of this assignment, but we do suggest to brush up on your knowledge on Cramer's Rule from Linear Algebra for the subsequent assignments.

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