LUMS
A Not-for-Profit University

Department of Electrical Engineering
School of Science and Engineering

EE240 Circuits I - Fall 2020

ASSIGNMENT 4

Due Date: 12 noon, Monday. December 7, 2020 (Submit online on LMS)
Format: 6 problems, for a total of 75 marks

Instructions:

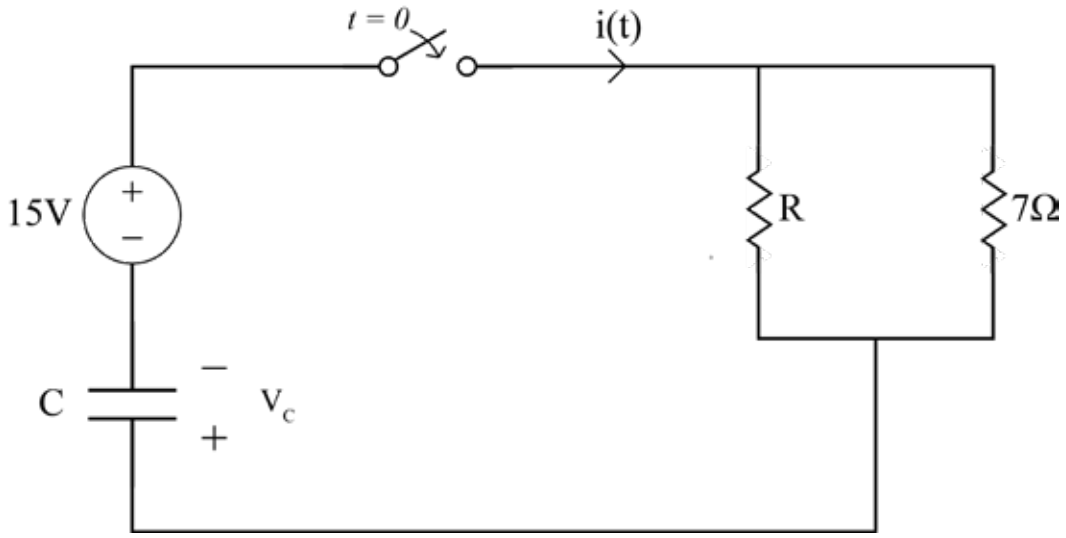
- Solve the assignment on blank A4 sheets and either scan the document using a scanner or use CamScanner proficiently.
- Upload the solved assignment on LMS in the "Assignments" tab under Assignment 4.
- Naming convention should be as follows: "Name_RollNumber_Assignment_4.pdf"
- Feel free to contact 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:

Formulate network equations based on the understanding of Kirchhoff's voltage and current laws.

Problem 1 [15 marks]: First Order Circuits

Up till now we have been discussing the characteristics of purely resistive circuits. We will now see how the addition of one energy storage element will affect the circuit behavior. The following is an RC first order circuit; it consists of one energy storage element i.e. capacitor. The switch is closed at $t = 0$. The loop current at $t = 0^+$ was measured to be 3A. The transient is observed to last only 6.25s.



(a) **[3 marks]** Analyze the circuit at initial, transient and steady state to calculate values of V_C and i at all three states.

(b) **[2 marks]** Write down the loop equation that describes the circuit.

(c) **[3 marks]** Produce the first order differential equation in standard form.

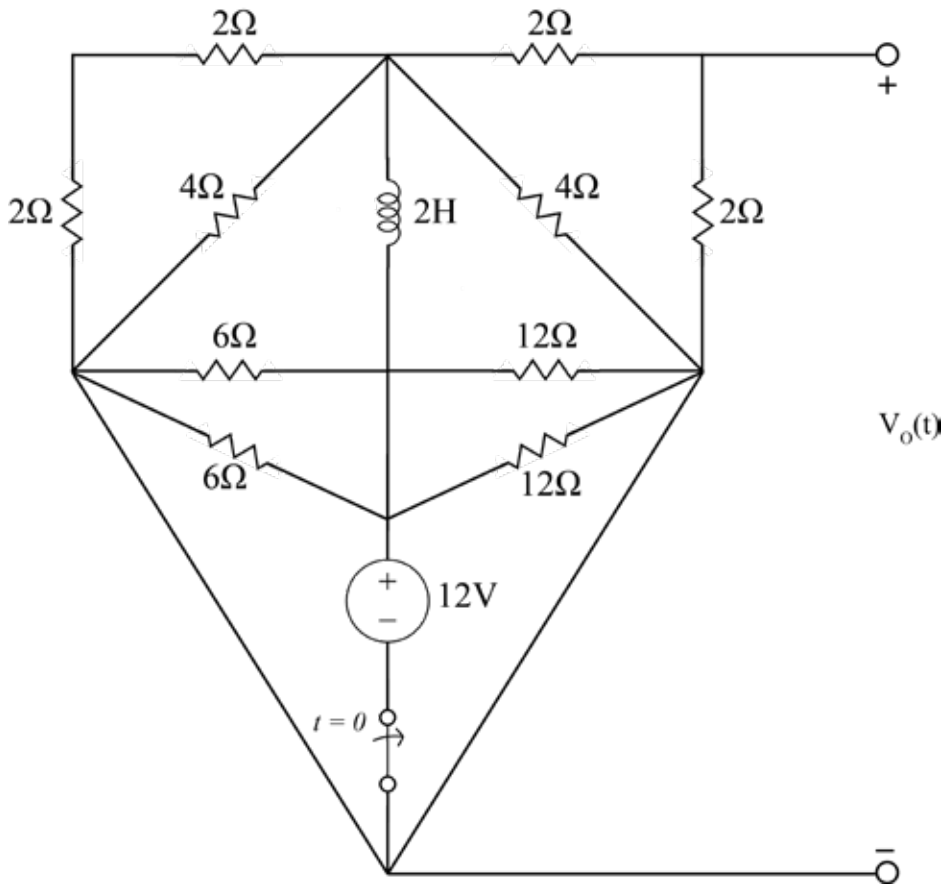
(d) **[3 marks]** Find the value of R, C and τ.

(e) **[2 marks]** Derive the equation for i(t).

(f) **[2 marks]** Sketch the graph of i(t) for $-1s \leq t \leq 7s$

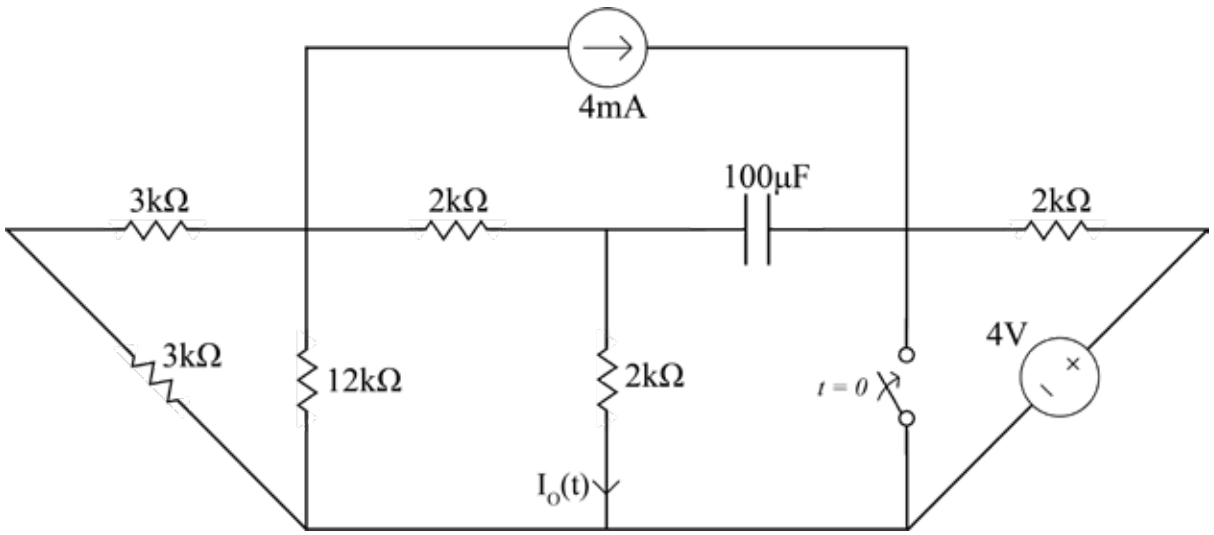
Problem 2 [10 marks]: First Order Circuits

The switch below the 12V source is opened at t = 0. Find $V_o(t)$ for all t > 0, assuming that the circuit was in steady state for t < 0.



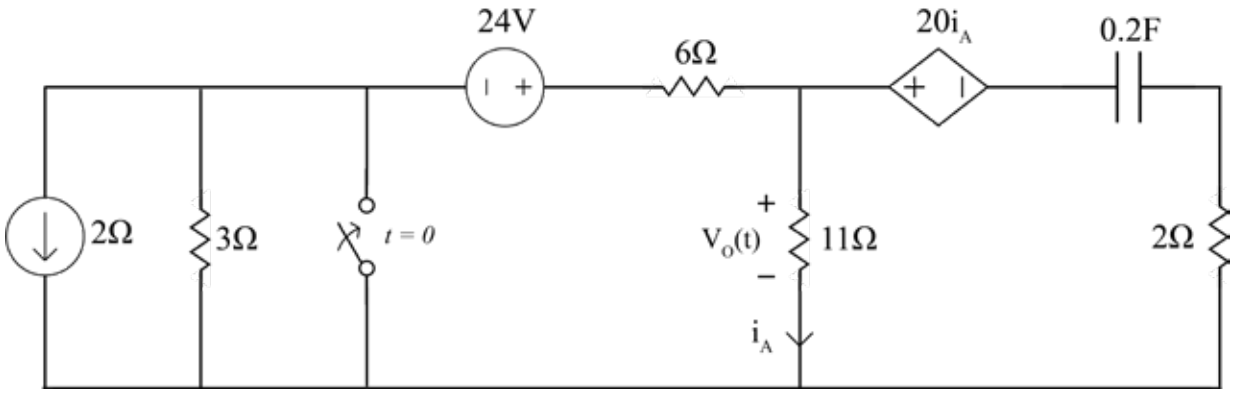
Problem 3 [10 marks]: First Order Circuits

Find $I_o(t)$ for all t > 0 in the circuit shown, assuming that the circuit was in steady state before t = 0.



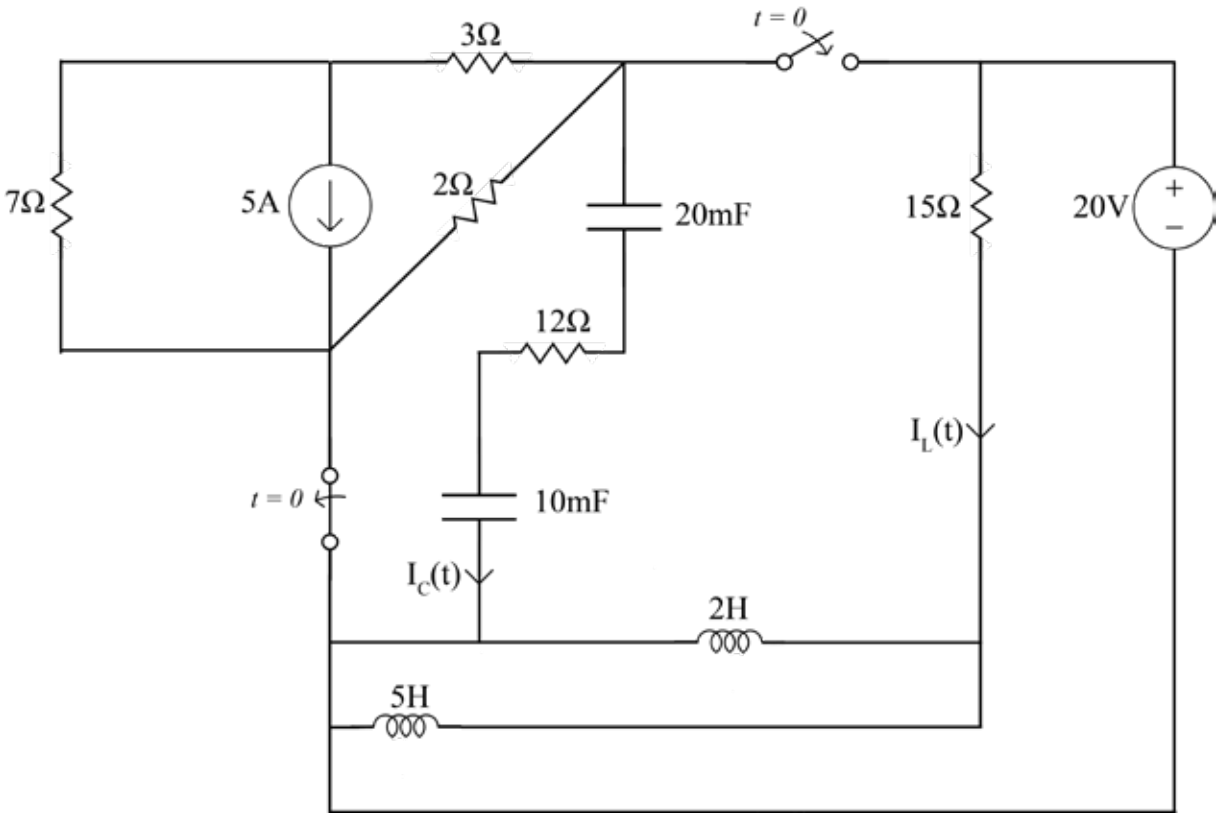
Problem 4 [20 marks]: First Order Circuits

(a) Find the expression for $V_O(t)$ in the following network (for all time) given that the switch is closed at t = 0.



Problem 5 [15 marks]: Initial Conditions

RLC Circuits have wide applications in Electrical Engineering which you will come across in future courses. These circuits are used in communication systems, signal processing power transmission etc. In Circuits I we will just analyze their properties and circuit behavior. The following is an example of such circuit in which two switches are operated as shown at *t = 0*.



(a) **[1 mark]** State the order of the circuit.

(b) **[3 marks]** Draw the simplified/ reduced form of the circuit.

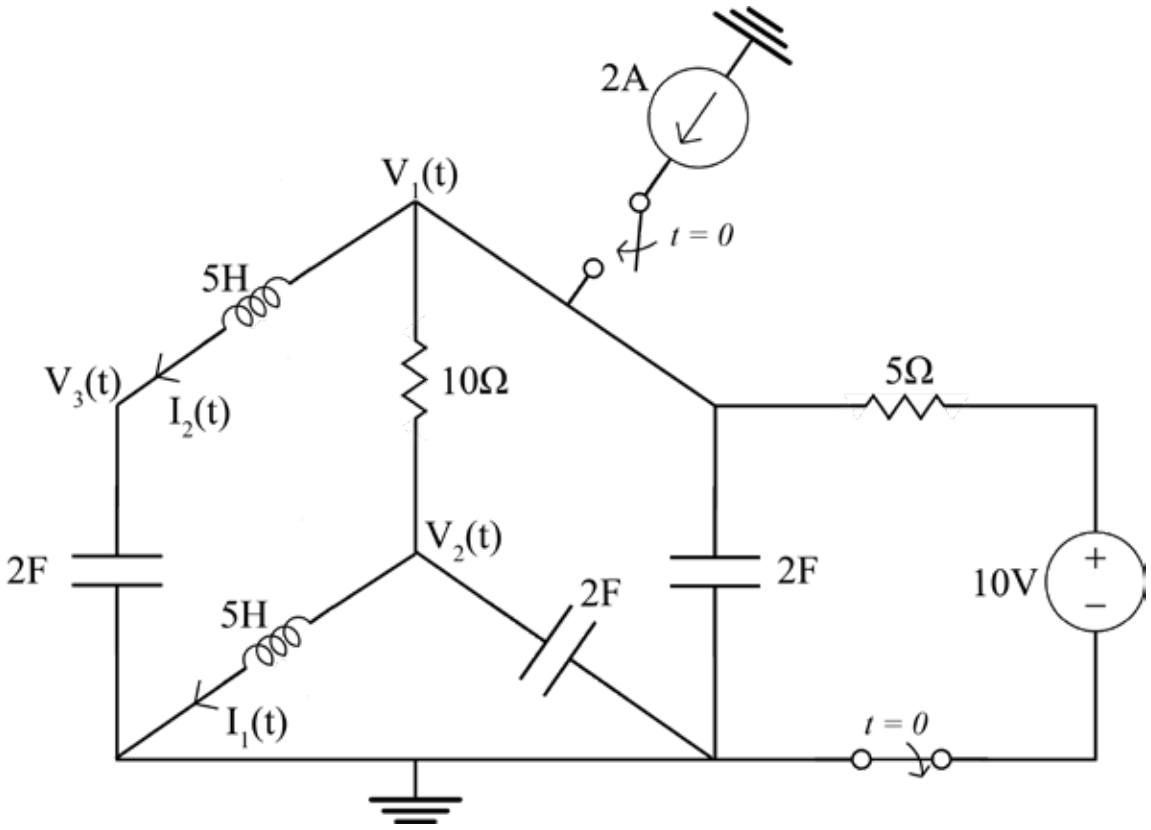
(c) **[1 mark]** At $t = 0^-$, at what value are the capacitors charged?

(d) **[2 marks]** Produce the set of 2 loop equations that describe the circuit after t = 0.

(e) **[6 marks]** By evaluating the loop equations at $t = 0^+$, find $\frac{dI_C(0^+)}{dt}, \frac{dI_L(0^+)}{dt}, \frac{dI_L(\infty)}{dt}, \frac{dI_C(\infty)}{dt}$

Problem 6 [15 marks]: Initial Conditions

The following is an RLC circuit in which two switches are operated as shown at $t = 0$.



(a) **[1 mark]** State the order of the circuit.

(b) **[6 marks]** State and explain the values for $V_3(t)$, $V_2(t)$, $V_1(t)$, $I_2(t)$, $I_1(t)$ at $t = 0^-$ and $t = 0^+$.

(c) **[3 marks]** Write down the three nodal equations that describe the circuit at $t > 0$.

(d) **[5 marks]** Using answers from (b) or otherwise find $\frac{dV_1(0^+)}{dt}$, $\frac{d^2V_2(0^+)}{dt^2}$, $\frac{d^2V_3(\infty)}{dt^2}$.

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