LUMS
A Not-for-Profit University

Department of Electrical Engineering
School of Science and Engineering

EE240 Circuits I - Fall 2020

ASSIGNMENT 5

Due Date: 11:55 pm, Sunday. December 13, 2020 (Submit online on LMS)
Format: 4 problems, for a total of 60 marks

Instructions:

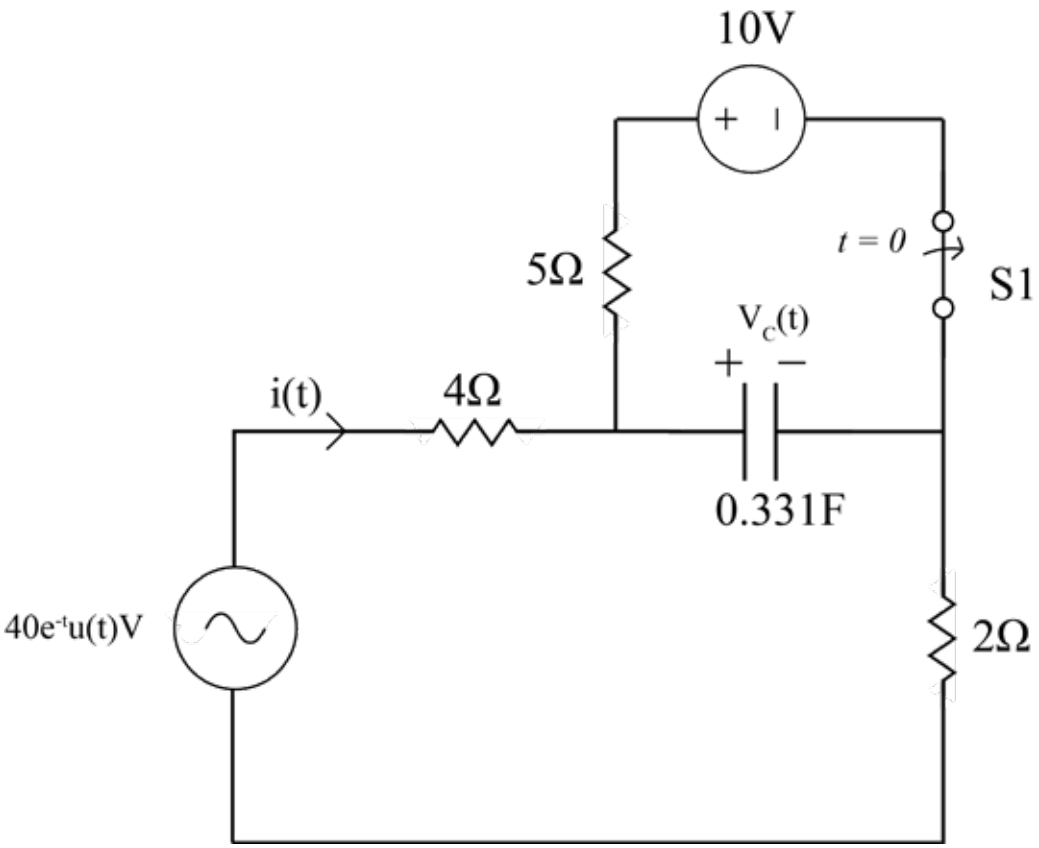
- Solve the assignment on blank A4 sheets and either scan the document using a scanner or use CamScanner proficiently.
- Upload the solved assignment on LMS in the "Assignments" tab under Assignment 5.
- Naming convention should be as follows: "Name_RollNumber_Assignment_5.pdf"
- Feel free to contact 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.

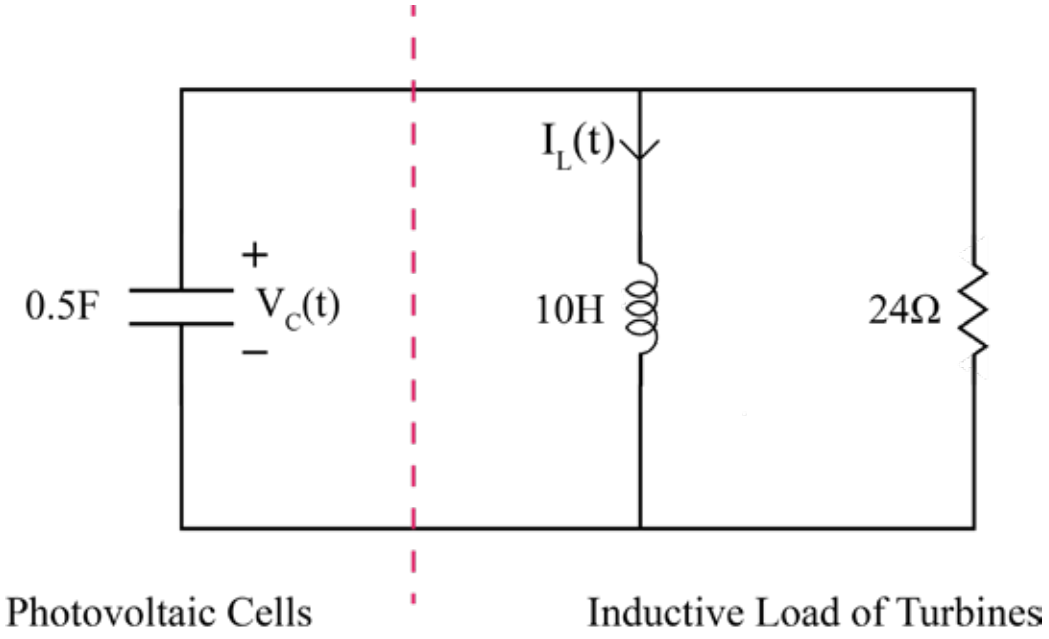
Problem 1 [8 marks]: First Order Circuits

For the network below, find and sketch an expression of i(t) for all times. The switch S1 is opened at $t = 0$, assume that the circuit is in a steady state at $t=0^-$.



Problem 2 [18 marks]: Second Order Circuits

Solar energy is predominantly the go to choice for meeting the power requirements for most space probes. In particular, you must have seen huge solar arrays mounted on the International Space Station. This question will address a simplified model of photocells given below. In a revolution segment where the space station moves into the Earth's shadow at $t = 0$, V_C = 12.9V and I_L = 250mA



(a) **[3 marks]** Find $\frac{dV_C(0^+)}{dt}$.

(b) **[3 marks]** Produce the second order equation governing the circuit.

(c) **[3 marks]** By solving the characteristic equation find the roots and plot them on the complex plane.

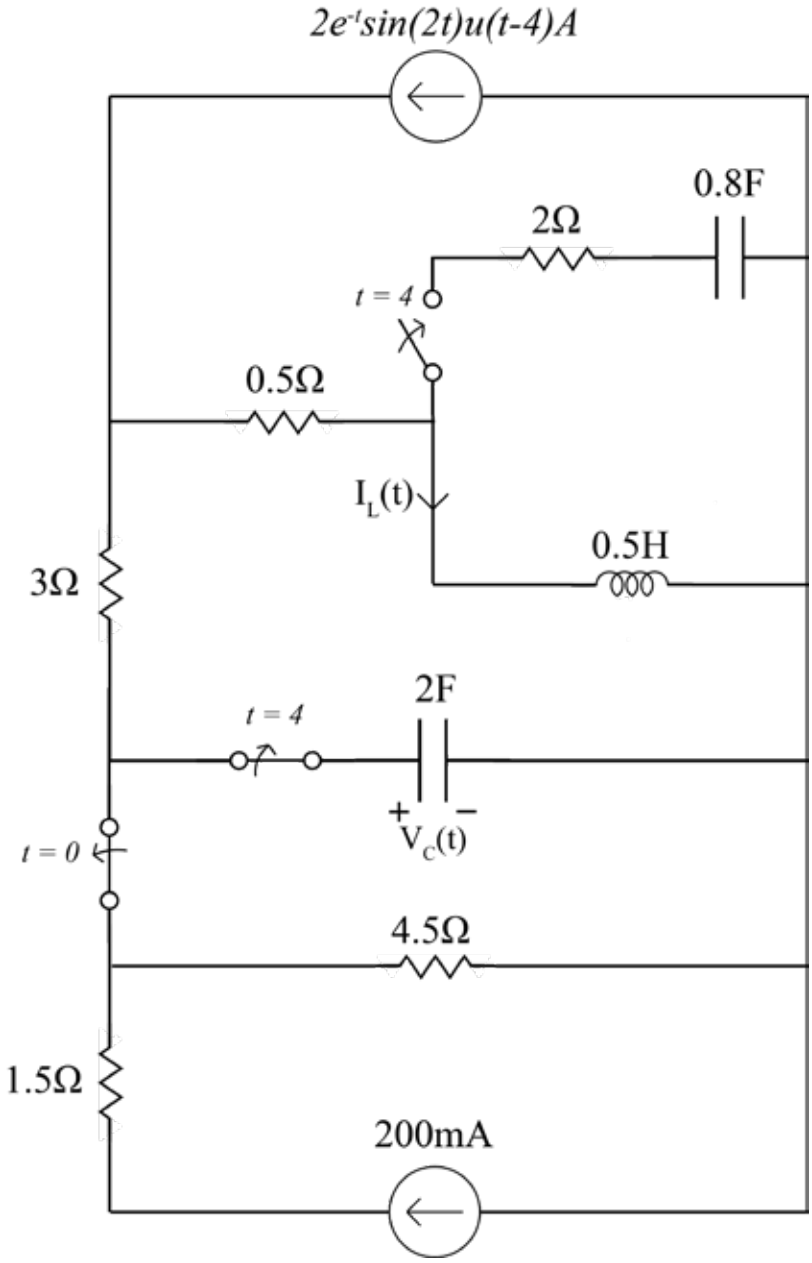
(d) **[2 marks]** If present, what do the real and imaginary parts signify in terms of the response of the circuit.

(e) **[5 marks]** Find the expression for $V_C(t)$ for all times.

(f) **[2 marks]** Sketch a properly labeled diagram for $V_C(t)$.

Problem 3 [25 marks]: Second Order Circuits

In the following circuit,



(a) **[3 marks]** Analyze the circuit at $t = 0^-$, to find $V_C(0^-)$ and $I_L(0^-)$.

(b) **[2 marks]** Analyze the circuit at $t = 0^+$ to find $\frac{dI_L(0^+)}{dt}$.

(c) **[4 marks]** Find $I_L(t)$ for $0 \le t \le 4$.

(d) **[3 marks]** Find $I_L(4)$ and $\frac{dI_L(4^+)}{dt}$.

(e) **[3 marks]** Write the second order differential equation governing the circuit.

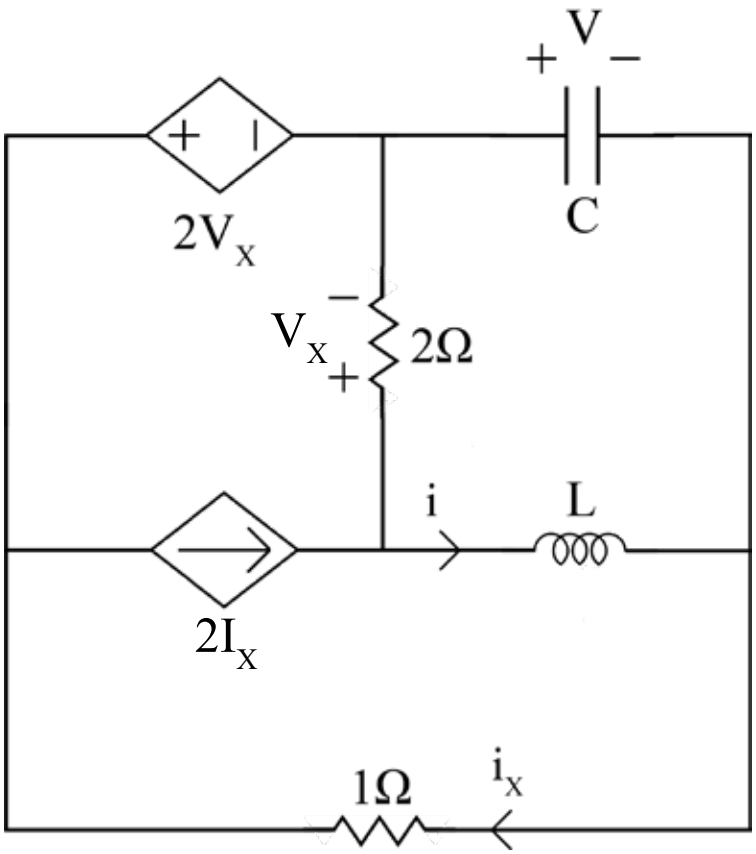
(f) **[4 marks]** Evaluate the particular solution .

(g) **[3 marks]** Evaluate the complemantary solution .

(h) **[3 marks]** Find $I_L(t)$ for all times and sketch a rough graph of how you would expect the response to look like.

Problem 4 [9 marks]: Second Order Circuits

With the ongoing environmental crisis, electric vehicles are being developed at an unprecedented pace. Pakistan too has passed legislative bills to introduce electric vehicles in the country to boon industry as well as curb environmental hazards caused by burning fossil fuels in conventional engines. One such model of an electric vehicle uses an AC motor, and the motor-controller circuit is show in the figure below.



Given that L = 100mH, C = 10mF, V(0) = 10V and i(0) = 0, determine

(a) **[1 mark]** i(t), the motor controlled current.

(b) **[8 marks]** v(t).

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