LUMS
A Not-for-Profit University

Department of Electrical Engineering
School of Science and Engineering

EE240 Circuits I - Fall 2021

ASSIGNMENT 4

Due Date: Thursday, December 9, 2021 (Submit in or before class)
Format: 7 problems, for a total of 100 marks

Instructions for submission on LMS:

- Submission of hard copy is a must but you are allowed to submit on LMS in case you are unable to attend the class in person. We require you to submit hard copy of the assignment later.
- 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:

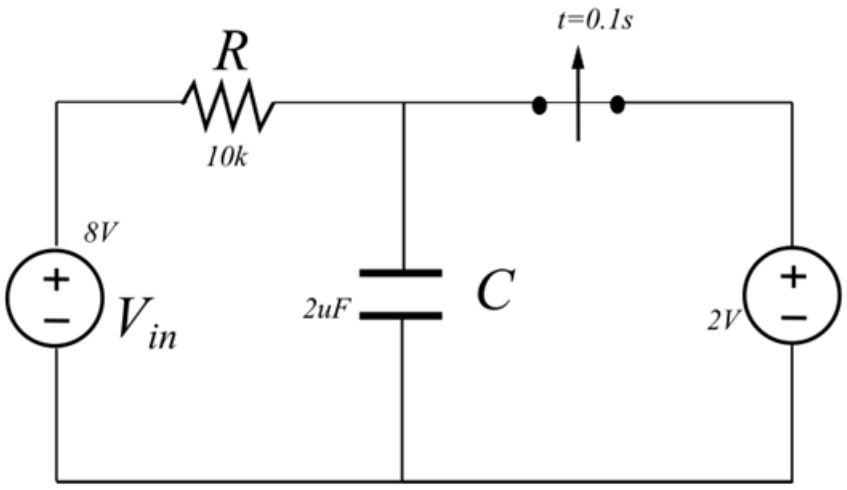
Analyze first and second order switched circuits for their initial and final condition, transient response etc.

Solve first order circuits.

Problem 1 (10 marks)

Topic: Solving First Order Circuits

The switch in the circuit below is initially closed and is opened at time $t = 0.1\,\text{s}$:



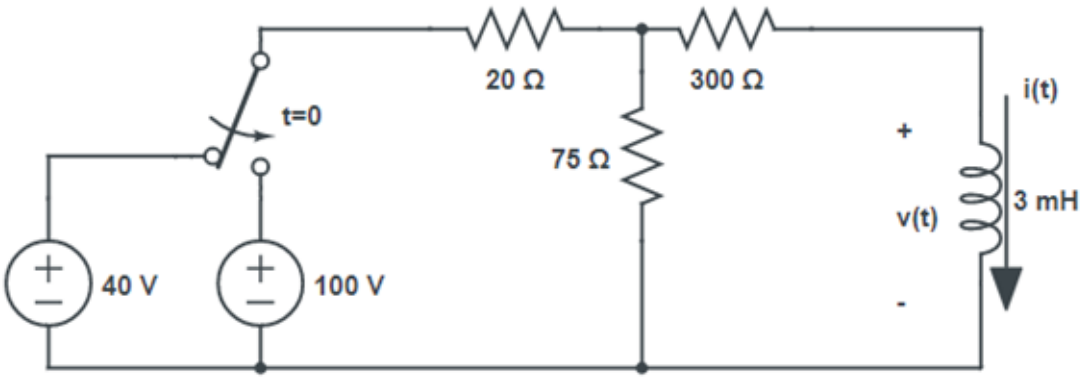
(a) Determine and plot (with appropriate labels) the voltage across capacitor for all times.

(b) Calculate the time at which the capacitor voltage reaches 5 V.

Problem 2 (10 marks)

Topic: Solving First Order Circuits

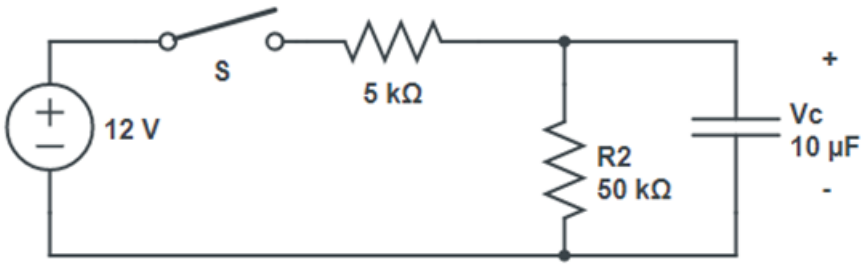
Find $v(t)$ and $i(t)$ for the following circuit for all times.



Problem 3 (10 marks)

Topic: Solving First Order Circuits

The switch S has been opened for a long time. At time $t = 0$, S is closed and is opened again at time $t = 1\,\text{s}$. Determine and plot $Vc(t)$ for all t. Label the plot and mark the intercepts.

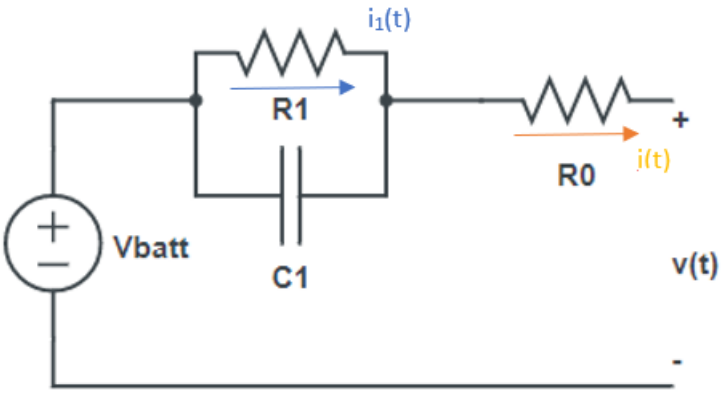


Problem 4 (10 marks)

Topic: Solving First Order Circuits

You are freshly employed in the design department of Tesla Motors. Your new job requires you to model battery packs that are to be installed in the upcoming Tesla Roadster. The circuit below is a simple model for modelling terminal voltage, $v(t)$, of a battery pack. V_{batt} represents the ideal DC voltage that can be provided by battery. R_0 models the dissipated losses.

The parallel R_1 - C_1 pair models, what is known as "diffusion" in batteries i.e., when a battery is allowed to rest/charge, its voltage does not immediately increases or decreases, rather builds up or decays gradually, in a capacitive fashion.

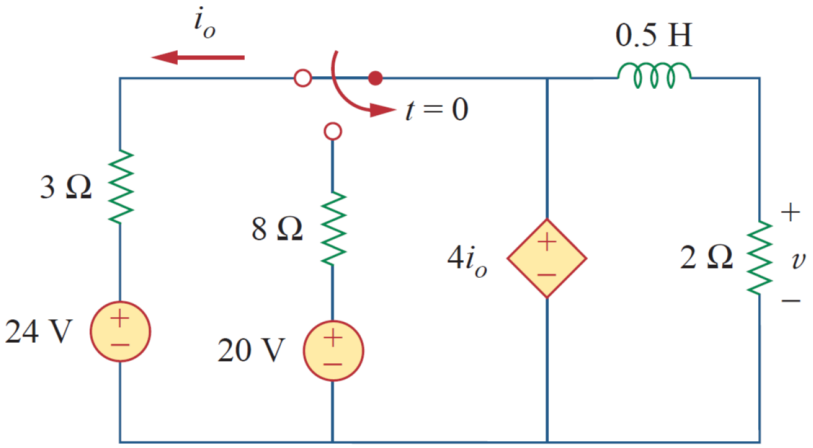


Formulate a differential equation for $i_1(t)$ in terms of $i_1(t)$ and $i(t)$.

Problem 5 (15 marks)

Topic: Solving First Order Circuits

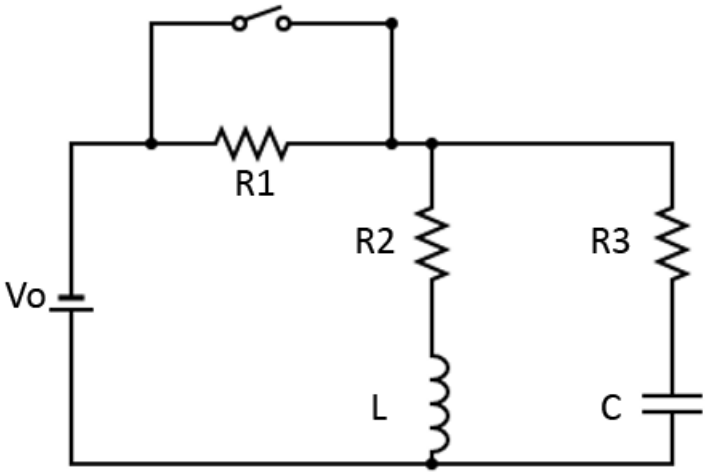
Consider a circuit given below. Find and plot $v(t)$ for all times.



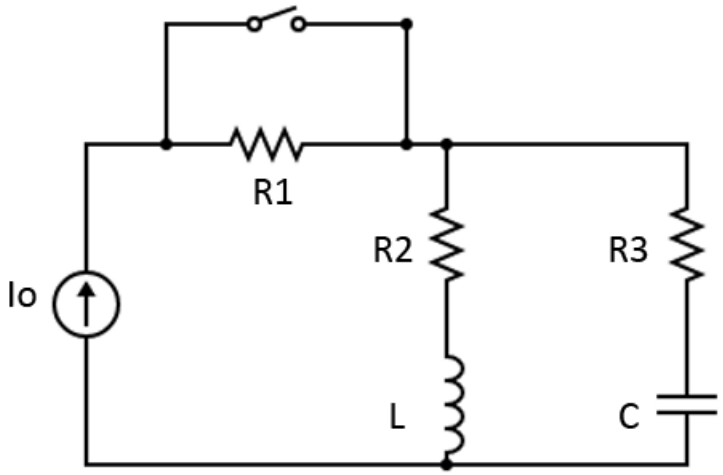
Problem 6 (20 marks)

Topic: Finding Initial Conditions

In the circuit below, we have $R_1 = 5W$, $R_2 = R_3 = 20W$, $L = 1H$ and C=1μF and $V_o = 10\,V$. Assume that the steady state is reached with switch open and the switch is closed at time $t = 0$. Assume that the currents flowing through R_2 and R_3 are denoted by i_1 and i_2 respectively. Determine $i_1(0^+)$, $i_2(0^+)$, $di_1/dt(0^+)$, $di_2/dt(0^+)$.



In the circuit below, we have replaced the voltage source with a current source $I_o = 5\,A$. Determine $i_1(0^+)$, $i_2(0^+)$, $di_1/dt(0^+)$, $di_2/dt(0^+)$.



Problem 7 (25 marks)

Topic: Finding Initial Conditions

The following is an RLC circuit in which a switch is operated as shown at $t = 0$.

(a) State the order of the circuit.

(b) Write down the three loop equations that describe the circuit for $t > 0$.

(c) Using initial conditions, find $di_1/dt(0^+)$, $di_2/dt(0^+)$, $di_2/dt(0^+)$, $d^2i_1/dt^2(0^+)$, $d^2i_2/dt^2(0^+)$ and $d^2i_3/dt^2(0^+)$.