EE240 – Circuits I

Mid Examination (Fall 2018)

November 6, 2018 06:00 pm–08:30 pm

Student ID _____ Name _____

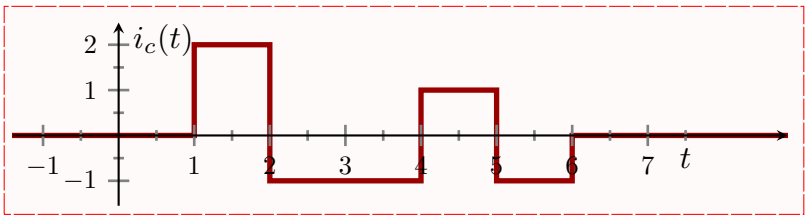
Signature _____

INSTRUCTIONS:

- Do not flip this page over until told to do so.
- **The exam needs to be solved on this book and not on blue book.**
- If you need the blue book for rough work, please ask the exam staff.
- The exam is closed book and notes. You are allowed to bring calculator and one A4 sheet with you with *hand-written* notes on both sides.
- Read all the questions before you start working on the exam.
- You cannot keep your mobile phone(s) with you (even on silent mode or switched off).

Part 1: Sources and I-V Characteristics of R, L, C

Problem 1. (**10 pts**) The current $i_c(t)$ through the capacitor of capacitance $\frac{1}{2}F$ is shown in Figure 1 below.



(a) (**1 pts**) Express $i_c(t)$ as piecewise function of time.

(b) (**8 pts**) Assuming that the voltage is zero for times $t \leq -1$ seconds, determine the voltage across the capacitor and **plot** for $0 \leq t \leq 7$ seconds.

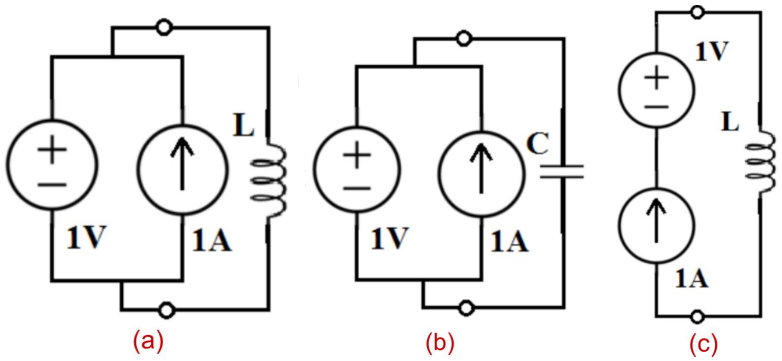
(c) (**1 pts**) Determine the energy stored in the capacitor at $t = 3.5$ seconds.

Problem 2. (**6 pts**) Consider a circuit where the DC voltage source of $5V$ is connected to a series combination of 4 Ω resistor and $1F$ capacitor through the switch. Assume that the switch is initially open and is closed at $t = 0$ and the capacitor is uncharged before the switch is closed, that is, the capacitor voltage $v_c(t) = 0$ for all $t < 0$.

(a) (**1 pts**) Draw the circuit and indicate the current $i(t)$ through the circuit and the voltages $v_R(t)$ and $v_C(t)$ across the resistor and the capacitor respectively.

(b) (**5 pts**) Plot the waveforms (not to the scale) of the voltages $v_R(t)$ and $v_C(t)$.

Problem 3. (**9 pts**) Consider the following four circuits. Assuming that the sources are switched on at $t = 0$ and the elements do not carry any current or voltage before the sources are turned-on, draw the voltage, current and energy waveform for $0 \leq t \leq 1$ seconds for each circuit (element). Total of 9 waveforms.

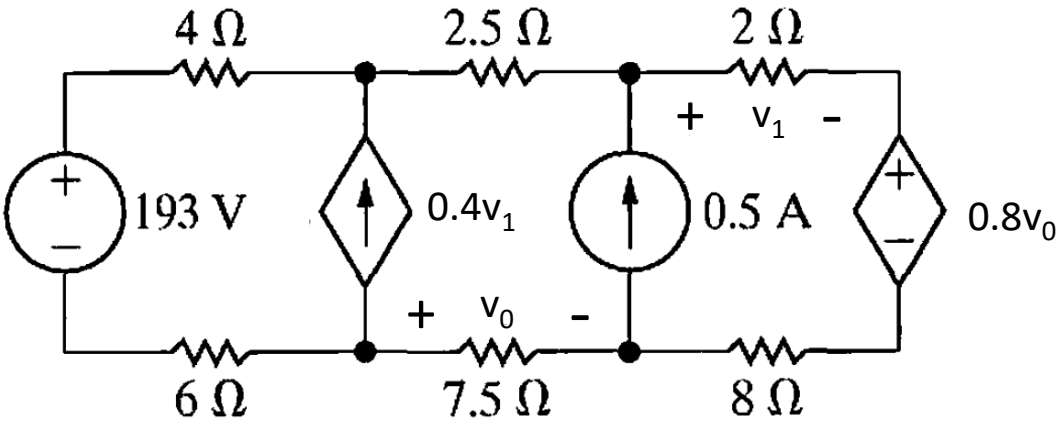


(a) (b) (c)

Part 2: Network Topology, Network Equations and Equivalent Circuits

Problem 4. (**20 pts**)

Consider the circuit given below.



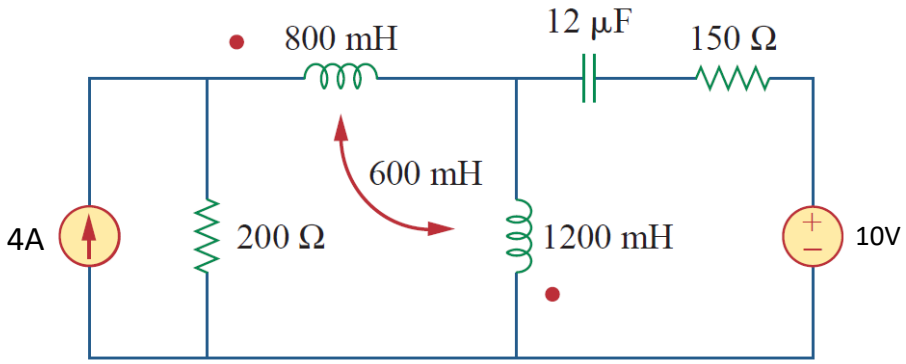
(a) (**5 pts**) Draw the graph and one tree of the circuit. Determine the number of nodes and number of branches in a circuit.

(b) (**2 pts**) Determine the number of network equations required for carrying out i) nodal analysis and ii) loop analysis.

(c) (**9 pts**) Carry out the loop analysis, that is, identify and determine the loop currents.

(d) (**4 pts**) Determine the power delivered by the independent current source.

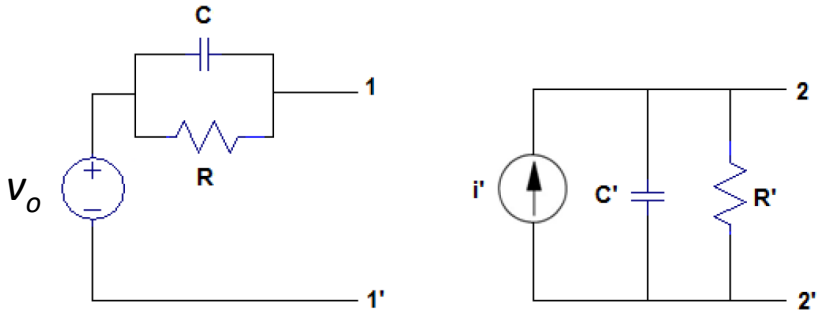
Problem 5. (**09 pts**) Consider the circuit given below.



(a) (**5 pts**) Formulate the network equations using loop analysis.

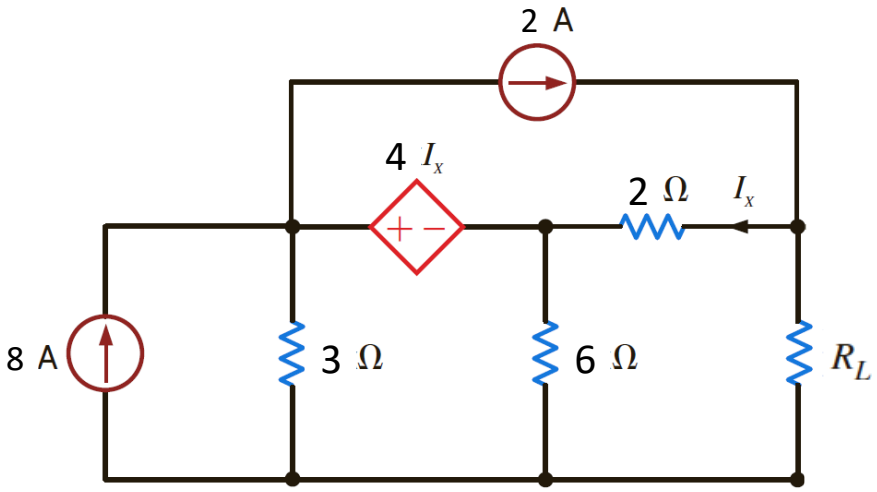
(b) (**4 pts**) Find an equivalent circuit where each coupled inductor is replaced with an uncoupled inductor and a controlled source. Draw the equivalent circuit.

Problem 6. (**6 pts**) Find the values of i', R' and C' in terms of R, C and v_o such that the networks shown below are equivalent at terminals 11 and 22.

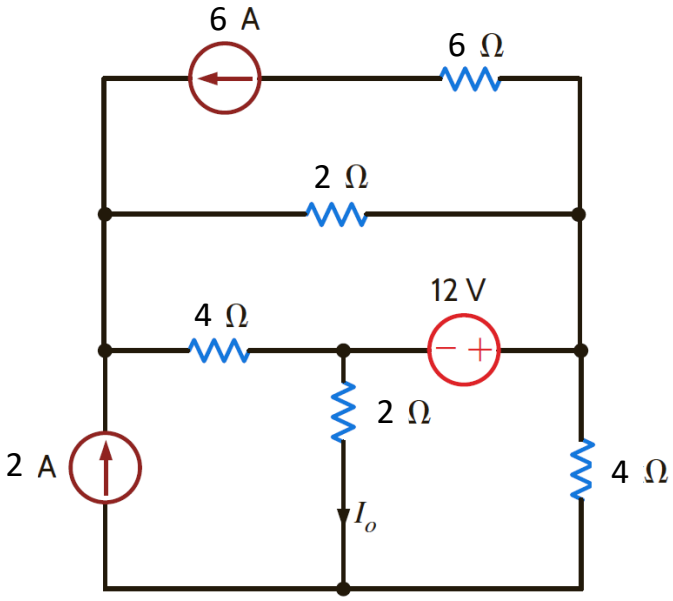


Part 3: Additional Analysis Techniques

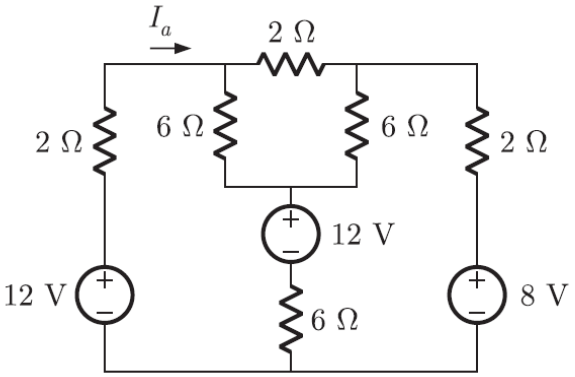
Problem 7. (**12 pts**) For the circuit given below, determine the value of R_L for maximum power transfer to R_L using Thevenin's Theorem.



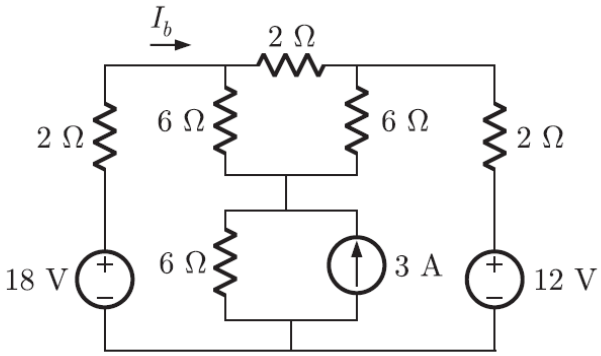
Problem 8. (**9 pts**) Determine I_o using the superposition theorem (principle) for the circuit given below.



Problem 9. (**4 pts**) Given the following two circuits, determine the relation between I_a and I_b. You must provide justification to support your answer.
(Hint: Use the concept of linearity.)



(a)



(b)

Problem 10. (**5 pts**) Consider the network shown below, where the rest of the circuit is pure resistive in nature. The voltage $V_R = 6V$ for $R = 4\Omega$ and the current $i_R = 2.4A$ for $R = 0\Omega$. Determine the voltage V_R in volts when $R = \infty$.