EE240 – Circuits I

Mid Examination (Fall 2021)

November 13, 2021 12:30 pm–02:45 pm

INSTRUCTIONS:

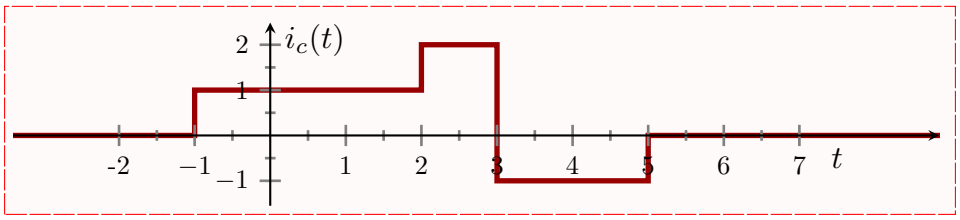
- Reading time: 15 minutes
- Writing time: 2 hours
- We require you to solve the exam in a single time-slot of two hours without any external or electronic assistance.
- We encourage you to solve the exam on A4 paper, use new sheet for each question and write sheet number on every sheet.
- Clearly outline all your steps in order to obtain any partial credit.
- The exam is closed book and notes. You are allowed to have one A4 sheet with you with hand-written notes on both sides. Calculators can be used.
- If you are ready, please proceed to the next page.

Mapping between exam parts and course learning outcomes (CLOs)

- Part 1: R, L, C Basics, Sources and I-V Characteristics (CLO1)
- Part 2: Network Topology, Network Equations and Kirchhoff's Laws (CLO2)
- Part 3: Additional Analysis Techniques (CLO3)

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

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



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

(b) (**7 pts**) Assuming that the current is zero for times $t \leq -1$ seconds, determine the voltage across the capacitor and **plot** for $-2 \leq t \leq 7$ seconds.

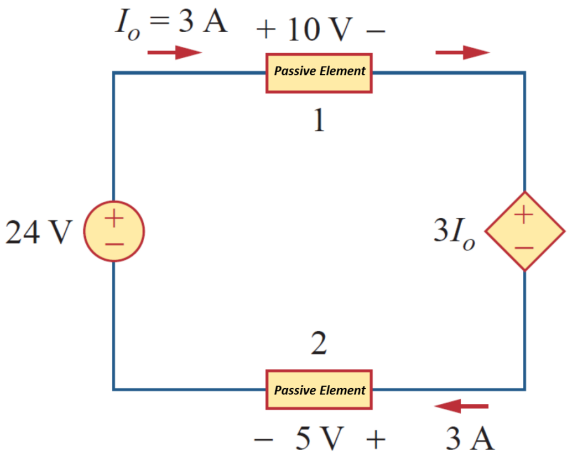
(c) (**2 pts**) Determine the energy stored in the capacitor at $t = 3$ seconds.

Problem 2. (**8 pts**) Consider a circuit where the DC current source of $2A$ is connected to a parallel combination of 2 Ω resistor and $0.5H$ inductor through the switch. **Assume that the switch is initially closed and is opened at** $t = 0$.

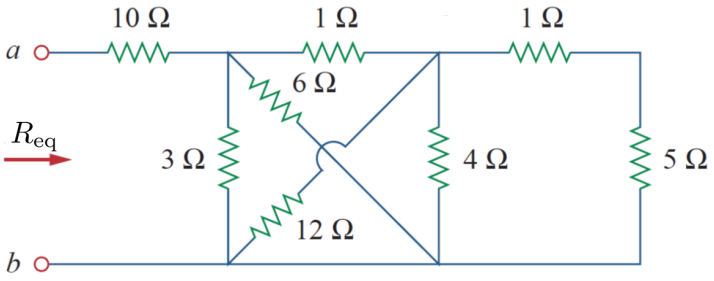
(a) (**2 pts**) Draw the circuit and indicate the voltage $v(t)$ across the resistor and the current $i_R(t)$ and $i_L(t)$ through the resistor and the inductor respectively.

(b) (**6 pts**) Plot the waveforms (not to the scale but label the axes and indicate intercepts) of the currents $i_R(t)$ and $i_L(t)$.

Problem 3. (**4 pts**) Calculate the power **supplied** by each element in the circuit given below.

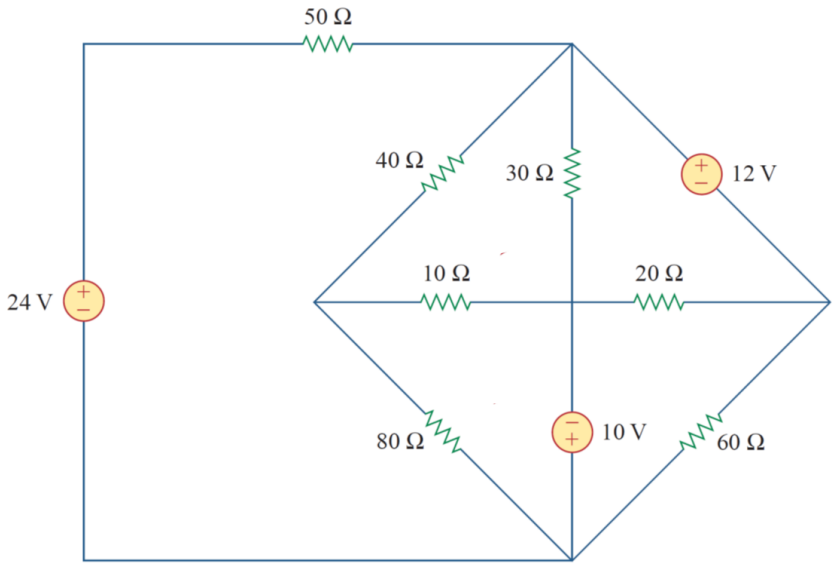


Problem 4. (**4 pts**) For a network of resistors, calculate the equivalent resistance R_eq across terminals a and b.



Part 2: Network Topology, Network Equations and Kirchhoff's Laws

Problem 5. (**18 pts**) Consider the circuit given below.



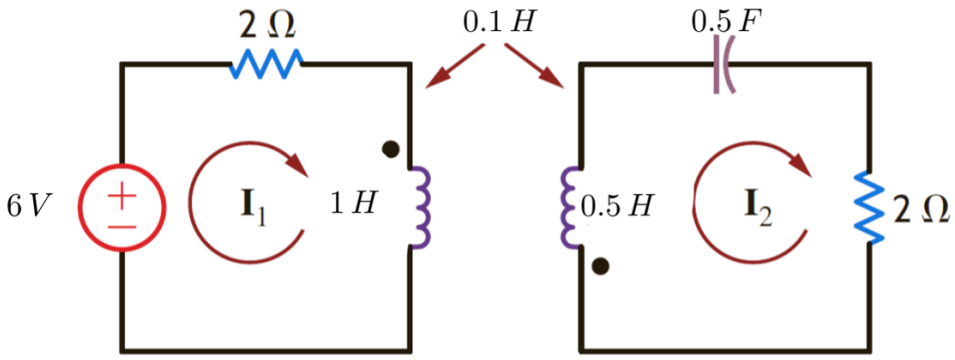
(a) (**4 pts**) Draw the graph and one tree of the circuit. Determine the number of nodes and number of branches in the circuit (or graph).

(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 nodal analysis, that is, identify and determine the nodal voltages.

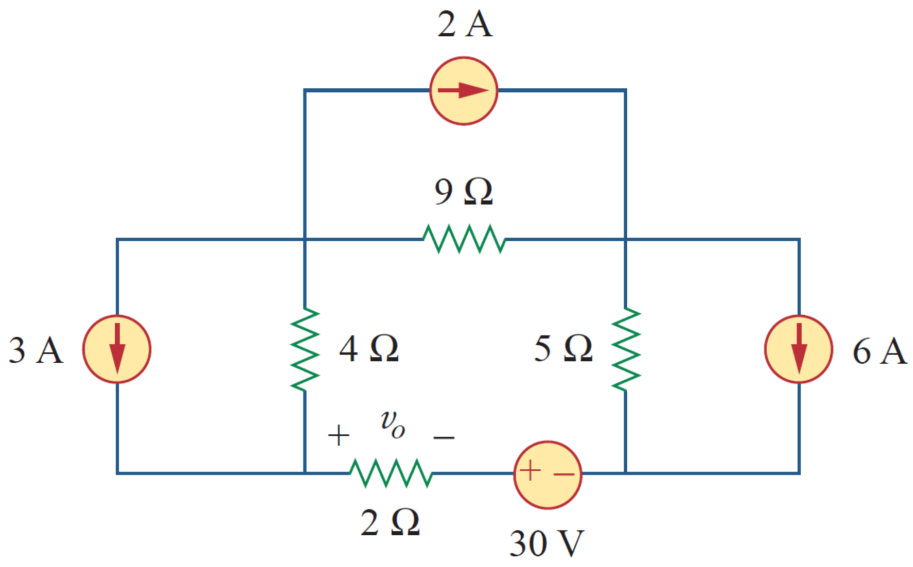
(d) (**3 pts**) Determine the power delivered by the 10 V voltage source.

Problem 6. (**06 pts**) Formulate the network equations in terms of loop currents indicated in the circuit given below.

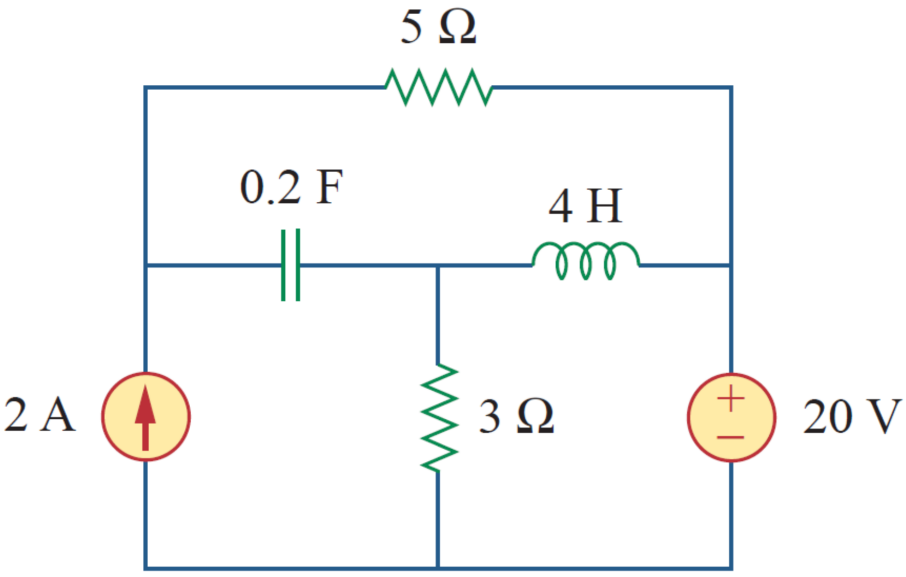


Part 3: Additional Analysis Techniques

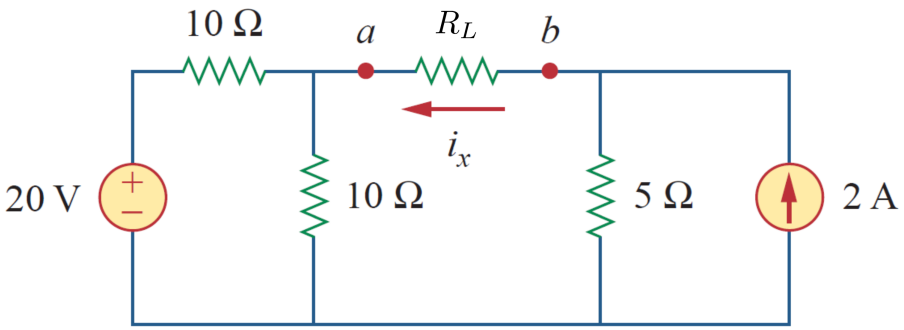
Problem 7. (**06 pts**) Use source transformation to find v_o in the circuit given below.



Problem 8. (**06 pts**) Obtain a dual circuit for the circuit given below.



Problem 9. (**10 pts**) Consider a circuit given below.



(a) (**4 pts**) Determine the value of R_L for maximum power transfer to R_L using Thevenin's Theorem.

(b) (**4 pts**) Obtain Thevenin equivalent of the circuit across terminals a and b.

(c) (**2 pts**) Determine the power absorbed by R_L

Problem 10. (**08 pts**) Find the Norton equivalent circuit of the circuit given below