EE240 – Circuits I

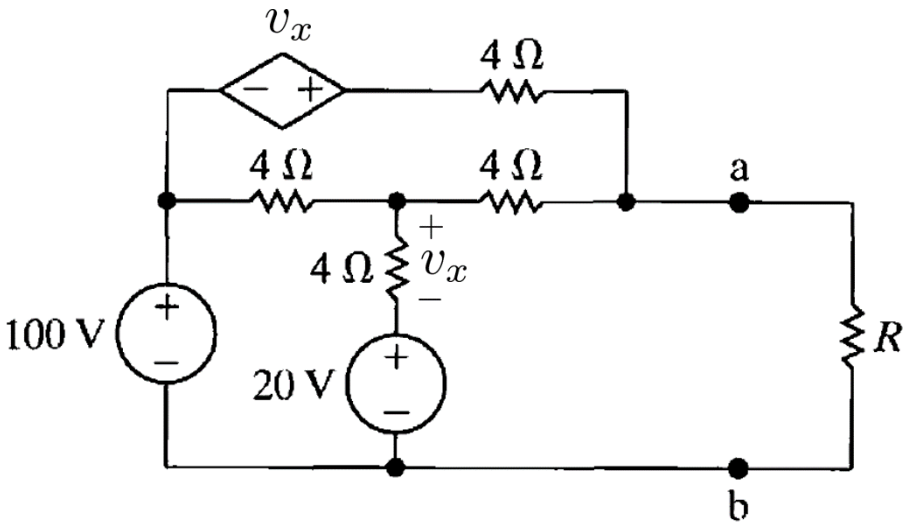
Final Examination (Fall 2020)

December 21, 2020 12:30 pm–03:30 pm

INSTRUCTIONS:

- We require you to solve the exam in a single time-slot of two hours and thirty minutes 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.
- The exam is closed book and notes. You are allowed to have two A4 sheet with you with hand-written notes on both sides. Calculators can be used.
- For the sake of completeness, we require you to write the following statement on your first page of submission: *I commit myself to uphold the highest standards of (academic) integrity.*
- Reading time: 10 minutes
- Writing time: 2 hours and 30 minutes
- Submission time: 20 minutes
- The exam consists of 6 problems worth a total of 90 points.

Problem 1. (**15 pts**) The variable resistor R in the circuit given below is adjusted until it absorbs the maximum power from the circuit.

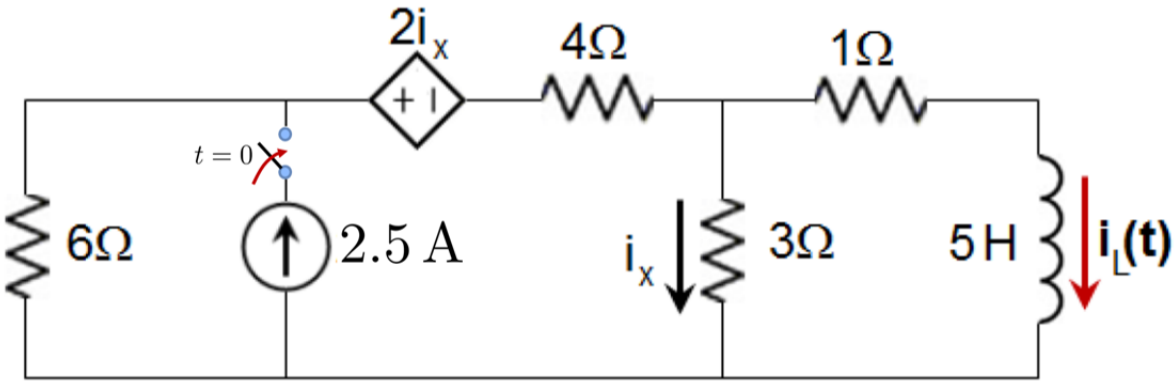


(a) (**6 pts**) Calculate the value of R for maximum power.

(b) (**6 pts**) Determine the maximum power absorbed by R.

(c) (**3 pts**) Determine the Norton equivalent of the circuit at terminals a-b.

Problem 2. (**15 pts**) The circuit given below is in steady state with switch in open state. The switch is closed at $t = 0$.



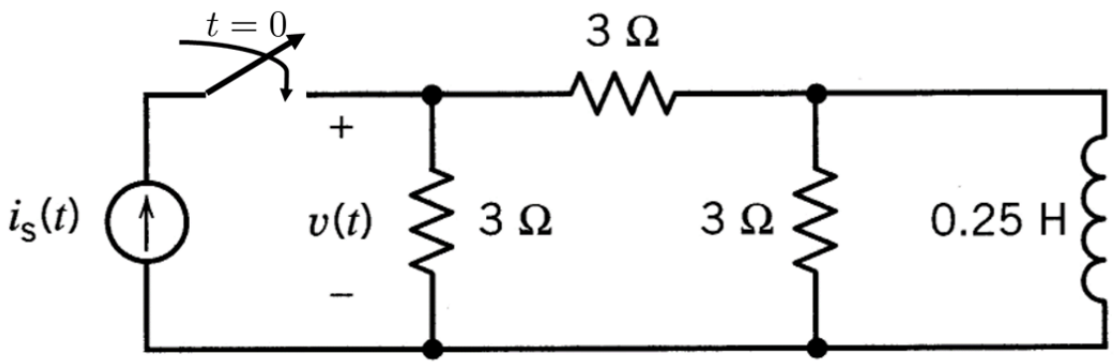
(a) (**2 pts**) Determine the current $i_L(t)$ at $t = 0^-$.

(b) (**1 pts**) Determine the current $i_L(t)$ at $t = 0^+$.

(c) (**5 pts**) Determine the current $i_L(t)$ at $t = \infty$

(d) (**7 pts**) Using the results of the previous parts, or otherwise, determine the current $i_L(t)$ for all times and plot it.

Problem 3. (**15 pts**) Consider the circuit given below. The circuit is in steady state and the the switch is closed at $t = 0$.



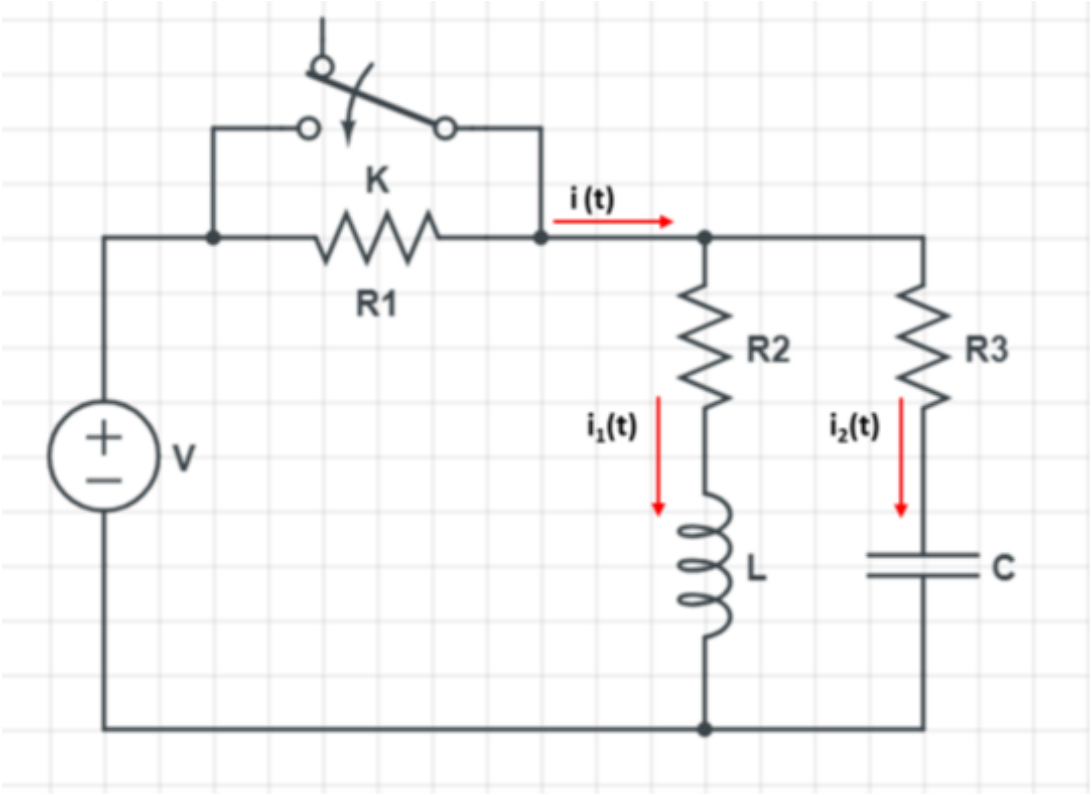
(a) (**4 pts**) For a circuit for $t > 0$, form an equivalent series RL circuit containing one source, one resistor and one inductor. Ignore $v(t)$ indicated in the circuit. (Hint: You may use source transformation or Thevenin equivalent approach.)

(b) (**8 pts**) For $i_s(t) = e^{-t}\cos t$, determine the current through the inductor for $t \geq 0$. Ignore $v(t)$ indicated in the circuit.

(c) (**3 pts**) Using the result of previous part or otherwise, determine the voltage $v(t)$ indicated in the circuit for $t \geq 0$.

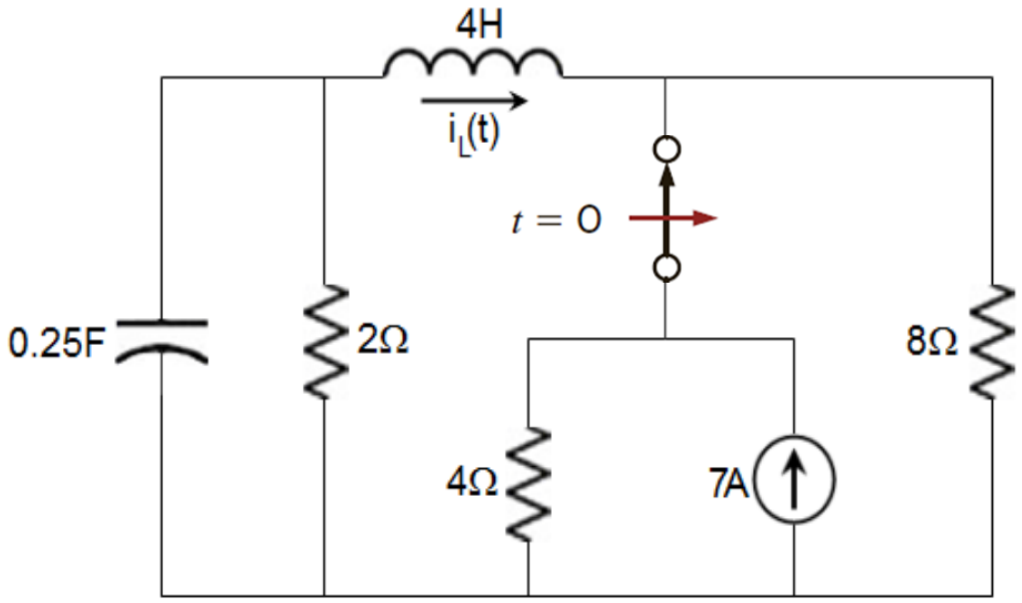
Problem 4. (**10 pts**) In the circuit below, we have $R_2 = R_3 = 20\Omega$. We assume that the steady state is reached with switch K open. At time $t = 0$, the switch is closed. Determine values of resistance R_1, inductance L, capacitance C and voltage V of the voltage source using the following information.

- $i_1(0^+) = 2\,\text{A}$
- $i_2(0^+) = 1\,\text{A}$
- $\frac{di_1}{dt}(0^+) = 40\,\text{A/s}$
- $\frac{di_2}{dt}(0^+) = -\frac{1}{2}\,\text{A/s}$



Problem 5. (**20 pts**)

Consider the circuit shown below. The circuit is in steady state with switch in closed state. The switch is opened at $t = 0$.



(a) (**6 pts**) Determine $i_L(t)$ and $\frac{di_L}{dt}$ at $t = 0^+$.

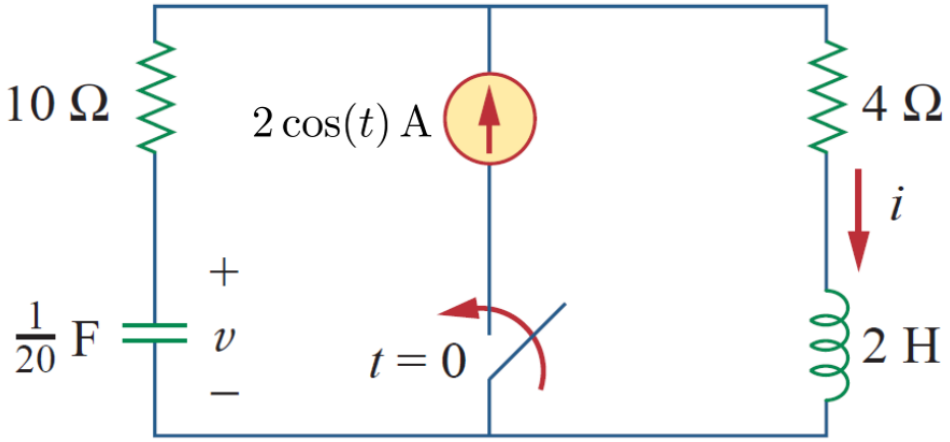
(b) (**5 pts**) Formulate the second-order differential equation describing the current $i_L(t)$ for $t \geq 0$.

(c) (**2 pts**) Determine the damping ratio ζ and natural frequency ω_n of the circuit after the switch is closed.

(d) (**7 pts**) Determine and plot (with labels) $i_L(t)$ for all times.

Problem 6. (**15 pts**)

The switch in the following circuit is closed at $t = 0$.



(a) (**5 pts**) Formulate the second order differential equation describing the voltage $v(t)$ after the switch is closed.

(b) (**8 pts**) Determine $v(t)$ for all times.

(c) (**2 pts**) Using the result of previous part or otherwise, determine $i(t)$ for all times.