EE240 – Circuits I

Final Examination (Fall 2021)

December 21, 2021 8:00 am–10:30 am

Student ID ____________________________ Name ________________________________

Signature ____________________

INSTRUCTIONS:

- Do not flip this page over until told to do so.
- Reading time: 10 minutes
- Writing time: 2 hours and 20 minutes
- The exam consists of 6 problems worth a total of 75 points.
- **The exam needs to be solved on this book and not on blue book.**
- You may use back-side of each paper to show your working.
- The exam is closed book and notes. You are allowed to bring calculator and two A4 sheets with *hand-written* notes on both sides.

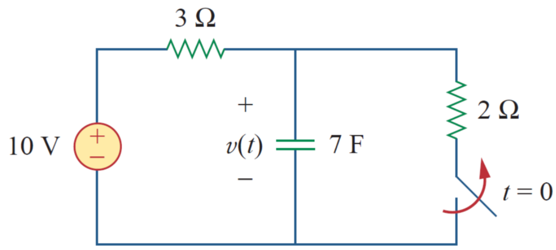
Problem	**Total Points**	**Obtained Points**
Problem 1	10	
Problem 2	15	
Problem 3	10	
Problem 4	10	
Problem 5	15	
Problem 6	15	
Total	75	

Problem 1. (10 pts) Provide brief justification or working for each of the questions in this problem.

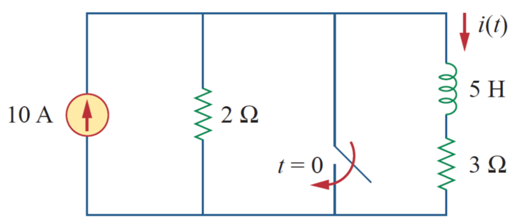
(1) (**1 pts**) For an RL circuit with $R = 2\,\Omega$ and $L = 0.5H$, determine the time constant of the circuit.

(2) (**1 pts**) In an RC circuit with $R = 2\,\Omega$ and $C = 4$ F, a capacitor is being charged. How much time does v_c (capacitor voltage) take to reach 63.2 percent of its steady state value?

(3) (**2 pts**) In the circuit given below, the switch is opened at $t = 0$. Determine $v(t)$ at $t = 0^+$ and $t = \infty$.



(4) (**2 pts**) In the circuit given below, the switch is closed at $t = 0$. Determine $i(t)$ at $t = 0^+$ and $t = \infty$.



(5) (**1 pts**) If the roots of the characteristic equation are -1 and -3, the response is

(a) $K_1e^{-t} + K_2e^{-3t}$

(b) $e^{-t}\big(K_1\cos(3t) + K_2\sin(3t)\big)$

(c) $K_1e^{-t} + K_2\,t\,e^{-3t}$

(d) $K_1\,t\,e^{-t} + K_2\,t\,e^{-3t}$

(6) (**1 pts**) In a series RLC circuit with $R = 0$, the response is

(a) overdamped

(b) undamped

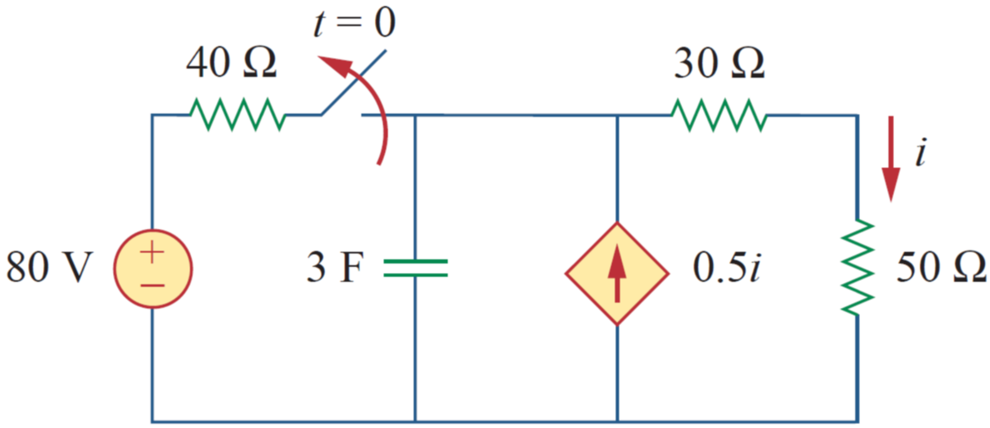
(c) underdamped

(d) critically damped

(7) (**3 pts**) Consider a series RLC circuit driven by voltage source $V_o\sin(wt)$. Draw a circuit and formulate a second order differential equation in terms of voltage across capacitor (denoted by $v_c(t)$).

Part 1: First Order Circuits

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



(a) (**4 pts**) Determine the current $i(t)$ at $t = 0^-$, that is, just before the switch is operated. Also determine the current through the inductor.

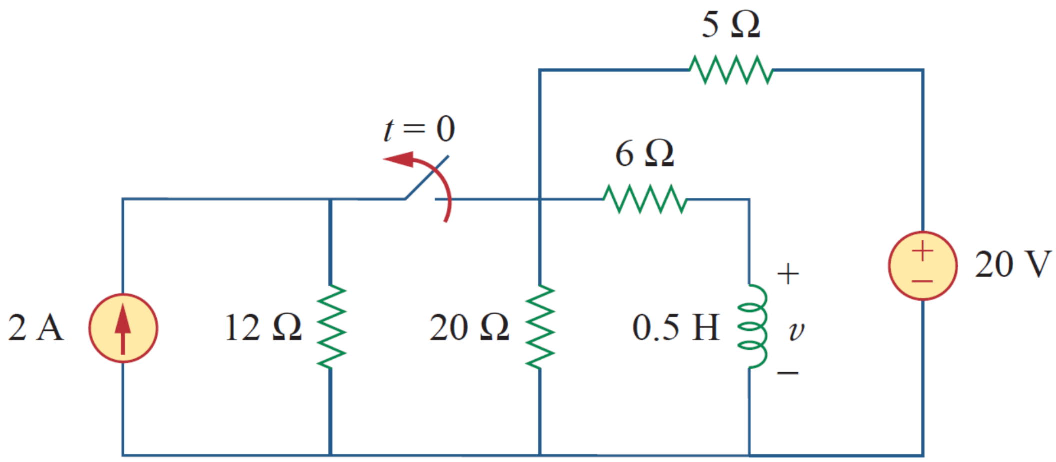
(b) (**2 pts**) Determine the current $i(t)$ at $t = 0^+$, that is, just after the switch is operated.

(c) (**1 pts**) Determine the current $i(t)$ at $t = \infty$.

(d) (**6 pts**) Using the results of the previous parts, or otherwise, determine the current $i(t)$ for all times $t > 0$.

(e) (**2 pts**) Plot the current $i(t)$ for $-\tau \leq t \leq 6\tau$ (where τ denotes the time constant of the circuit).

Problem 3. (**10 pts**) The circuit given below is in steady state with **switch in closed state**. The switch is opened at $t = 0$.



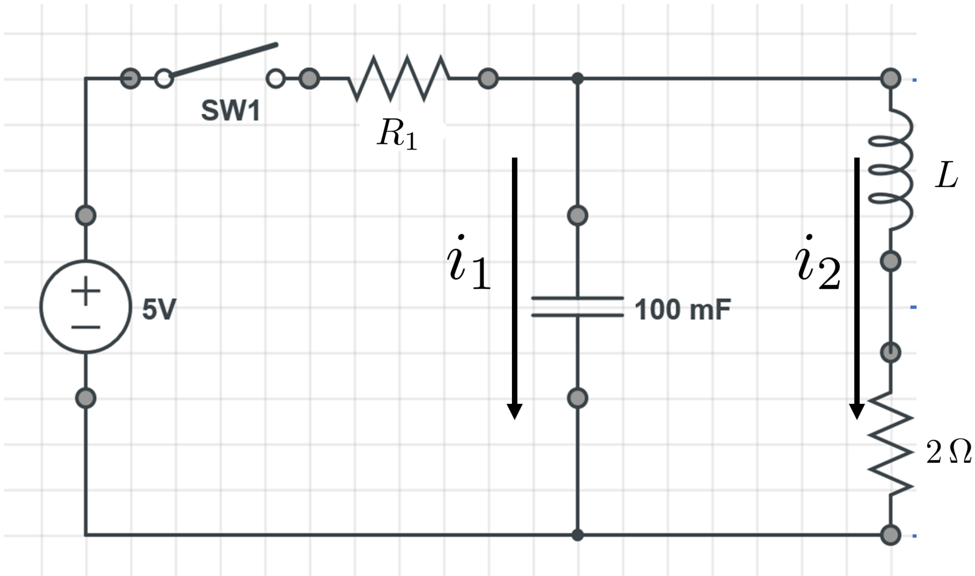
(a) (**3 pts**) Determine the current through inductor at $t = 0^-$.

(b) (**4 pts**) Determine the the voltage $v(t)$ at $t = 0^+$.

(c) (**3 pts**) Determine the voltage $v(t)$ for all times.

Part 2: Evaluation of Initial Conditions

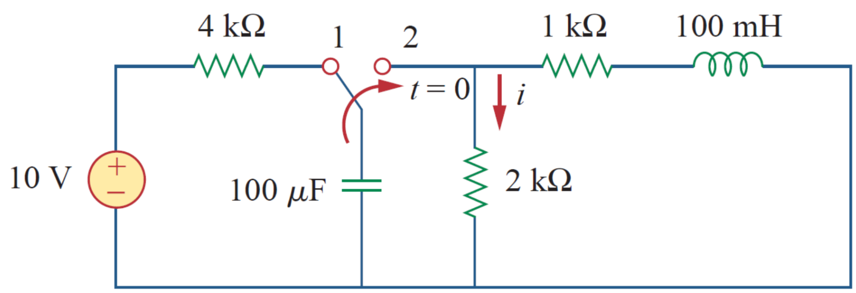
Problem 4. (**10 pts**) In the circuit given below, assume that the switch SW1 is initially open and is closed at $t = 0$. If $i_1(0^+) = 1\,A$ and $\frac{d^2 i_2}{dt^2}(0^+) = 40\,A/s^2$, find values of resistance R_1 and inductance L.



Part 3: Second-Order Circuits

Problem 5. (**15 pts**)

Consider the circuit shown below. The circuit is in steady state with switch at position 1. At $t = 0$, the switch is moved from position 1 to position 2.



(a) (**1 pts**) Draw the snapshot of the circuit at $t = 0^+$.

(b) (**1 pts**) Determine $i(t)$ at $t = 0^+$.

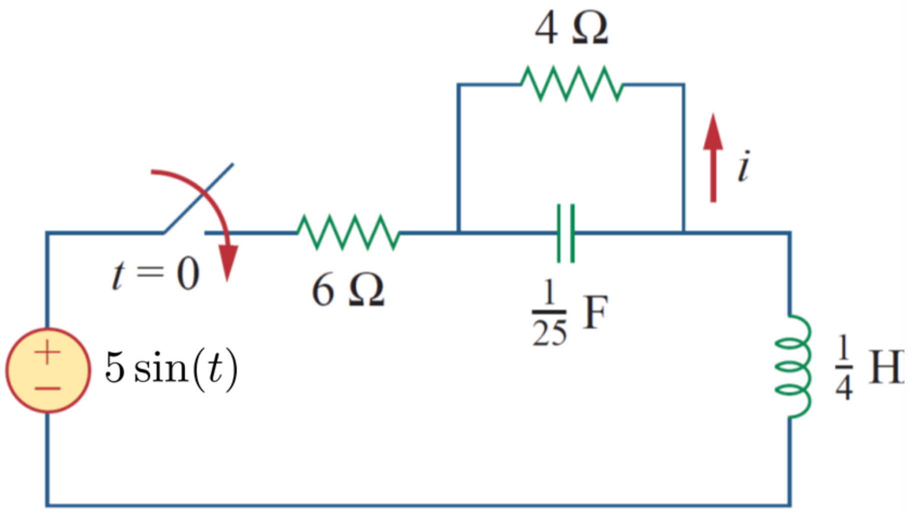
(c) (**3 pts**) Formulate a second-order differential equation in terms of i describing circuit for $t \geq 0$.

(d) (**2 pts**) Determine the damping ratio ζ and undamped natural frequency ω_n for the circuit after the switch is operated.

(e) (**2 pts**) Determine $\frac{di}{dt}$ at $t = 0^+$.

(f) (**6 pts**) Determine $i(t)$ for all times $t \geq 0$.

Problem 6. (**15 pts**) In the circuit given below, assume that the switch is initially in open state and is closed at $t = 0$.



(a) (**1 pts**) Draw the snapshot of the circuit at $t = 0^+$.

(b) (**5 pts**) Formulate a second-order differential equation in $i(t)$ describing circuit for $t \geq 0$.

(c) (**9 pts**) Determine $i(t)$ for all times $t \geq 0$.