EE240 – Circuits I

Final Examination (Fall 2018)

December 19, 2018 06:30 pm–09:00 pm

Student ID _____ Name _____

Signature _____

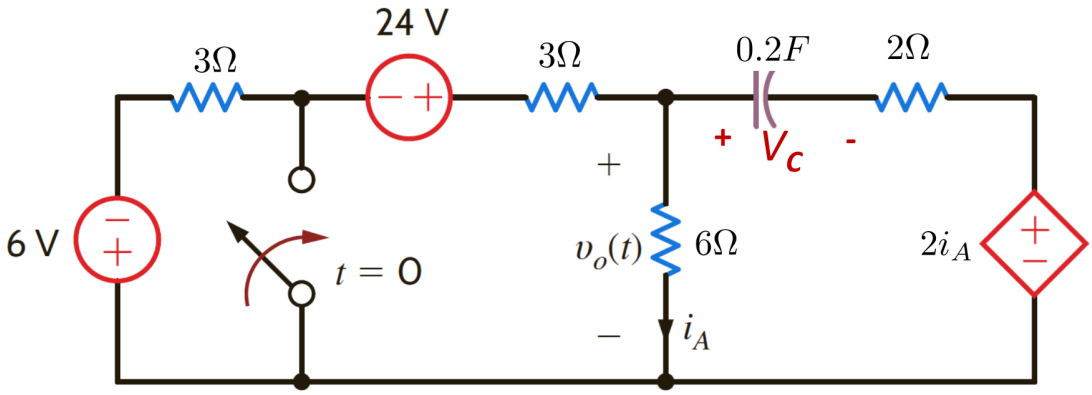
INSTRUCTIONS:

- Do not flip this page over until told to do so.
- The exam consists of 6 problems worth a total of 85 points.
- **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 two 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).

Problem	**Total Points**	**Obtained Points**
Problem 1	20	
Problem 2	10	
Problem 3	10	
Problem 4	10	
Problem 5	15	
Problem 6	20	
Total	85	

Part 1: First Order Circuits

Problem 1. (**20 pts**) The circuit given below is in steady state with switch open. The switch is closed at $t = 0$.



(a) (**4 pts**) Determine the voltage $V_c(t)$ at $t = 0^-$, that is, just before the switch is operated.

(b) (**1 pts**) Determine the voltage $V_c(t)$ at $t = 0^+$, that is, just after the switch is operated.

(c) (**4 pts**) Determine the current $i_A(t)$ at $t = 0^+$, that is, just after the switch is operated.

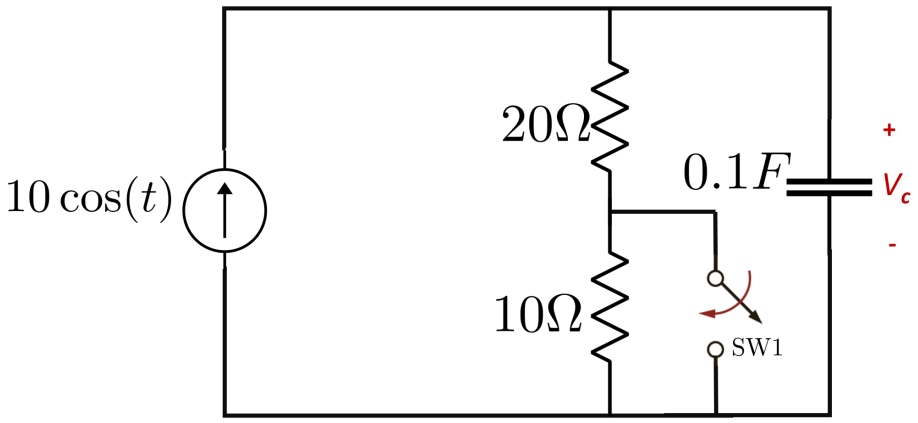
(d) (**5 pts**) Find the R_{th} across the capacitor terminals for the circuit obtained after the switch is operated. (Hint: Use test voltage or current source to find R_{th})

(e) (**4 pts**) Using the results of the parts (c) and (d), or otherwise, determine the current $i_A(t)$ for all times $t > 0$.

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

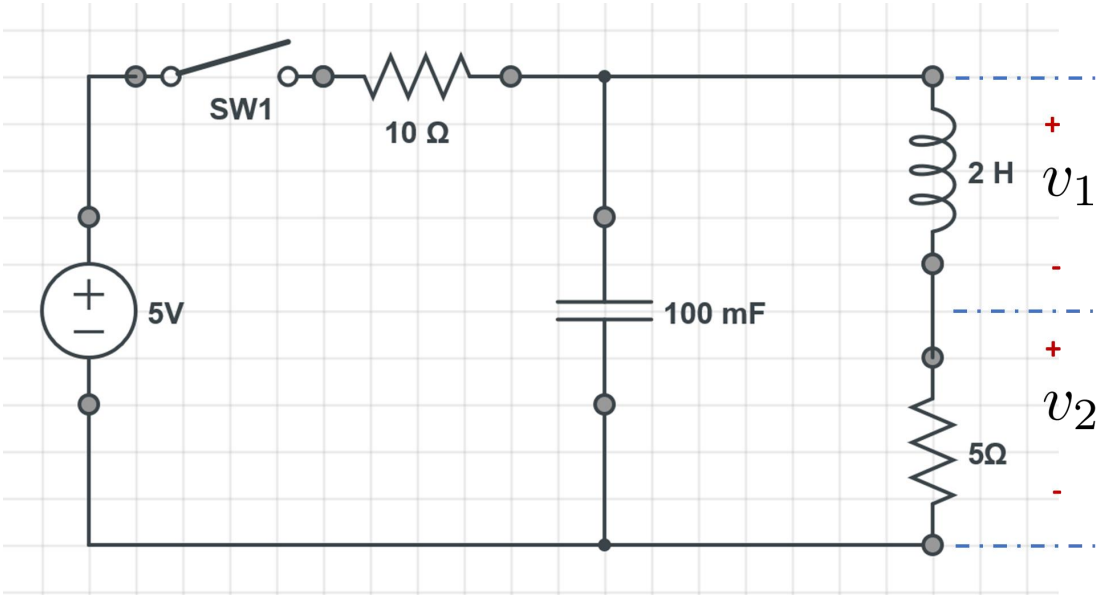
Problem 2. (**10 pts**) The circuit given below is operating in the steady state with the switch SW1 open. At $t = 0$, the switch is closed. Find an expression for the voltage $V_c(t)$ for $t \geq 0$.

(**Hint:** Analyse the circuit for $V_c(t)$ at $t = 0^-$, that is determine $V_c(t)$ before operating the switch. Use the fact that the circuit is in steady state.)



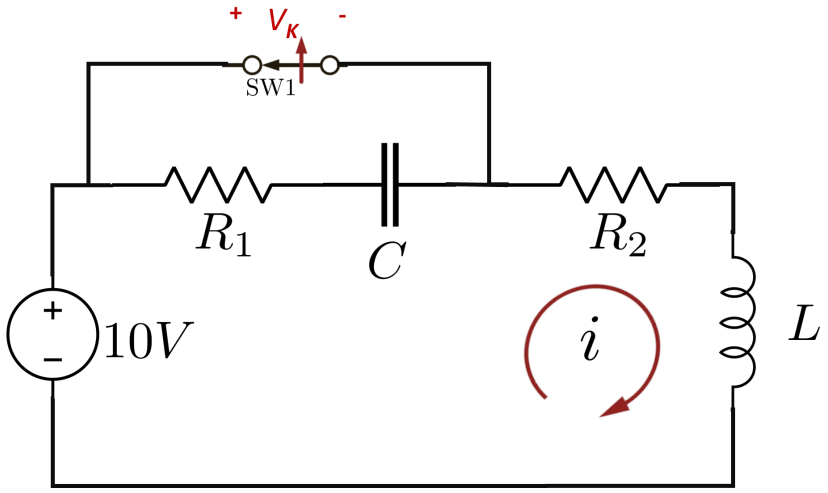
Part 2: Evaluation of Initial Conditions

Problem 3. (**10 pts**) In the circuit given below, assume that the switch SW1 is initially open and is closed at $t = 0$. Determine $v_1(t)$, $v_2(t)$, $dv_1(t)/dt$, $dv_2(t)/dt$ and $dv_1^2(t)/dt^2$ at $t = 0^+$.



Problem 4. (**10 pts**)

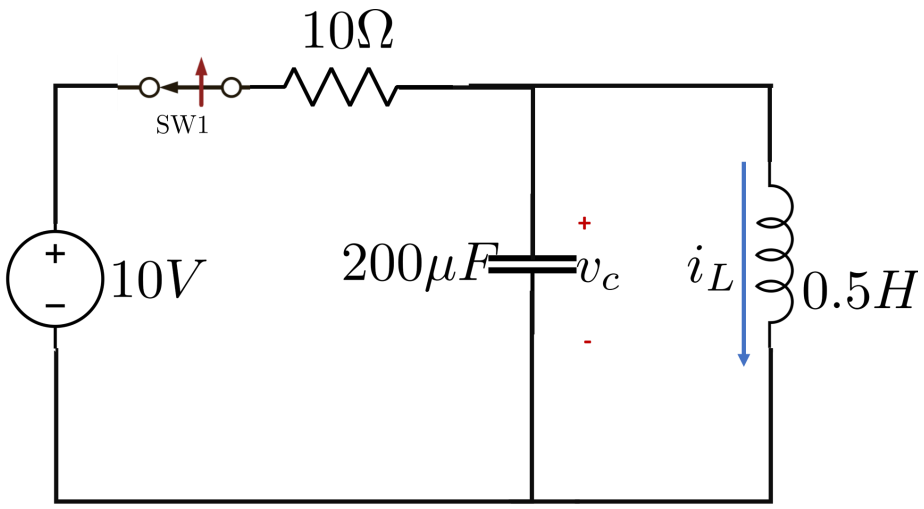
Consider the circuit shown below with $C = 1F$. The switch SW1 is initially closed for long time and is opened at $t = 0$. Given $i(0^+) = 1\ A$, $di/dt(0^+) = -10A/s$ and $v_k(0^+) = 20V$, determine R_1, R_2 and L.



Part 3: Second-Order Circuits

Problem 5. (**15 pts**)

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



(a) (**1 pts**) Determine $i_L(t)$ at $t = 0^-$.

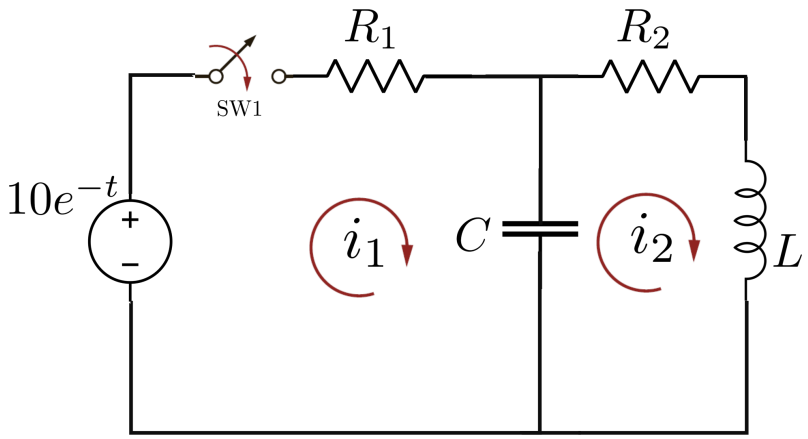
(b) (**7 pts**) Determine $i_L(t)$ for all times $t \geq 0$.

(c) (**3 pts**) Determine $v_c(t)$ for $t \geq 0$.

(d) (**2 pts**) Plot $i_L(t)$ and $v_c(t)$ for $t \geq -1\ s$.

(e) (**2 pts**) Determine the damping ratio ζ and the natural frequency ω_n of the circuit (after operating the switch).

Problem 6. (**20 pts**) In the circuit given below, assume that the switch SW1 is initially open and is closed at $t = 0$. Assume $L = 0.5H$, $C = 0.1F$, $R_1 = 10\Omega$ and $R_2 = 5\Omega$.



(a) (**8 pts**) Formulate the loop equations and eliminate $i_1(t)$ to obtain a second-order differential equation for $i_2(t)$.

(b) (**4 pts**) Determine $i_1(0^-)$, $i_2(0^-)$, $i_2(0^+)$ and $di_2/dt(0^+)$.

(c) (**8 pts**) Determine $i_2(t)$ for all times $t \geq 0$