School of Electrical Engineering & Telecommunications

ELEC1111

Topic 5: Inductors and RL Circuits

1. The circuits shown in Fig. 1 and 2 are considered to be under DC conditions

   a) Find v_c, i_L, and the energy stored in the capacitor and inductor.

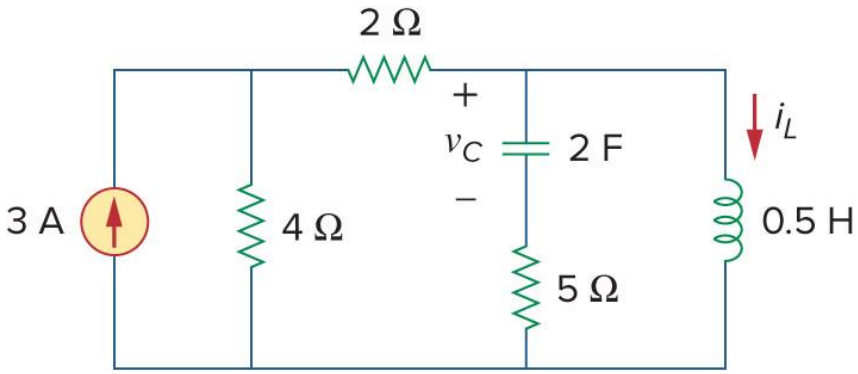


Fig. 1.

   b) Find v_c, i_L, i, and the energy stored in the capacitor and inductor.

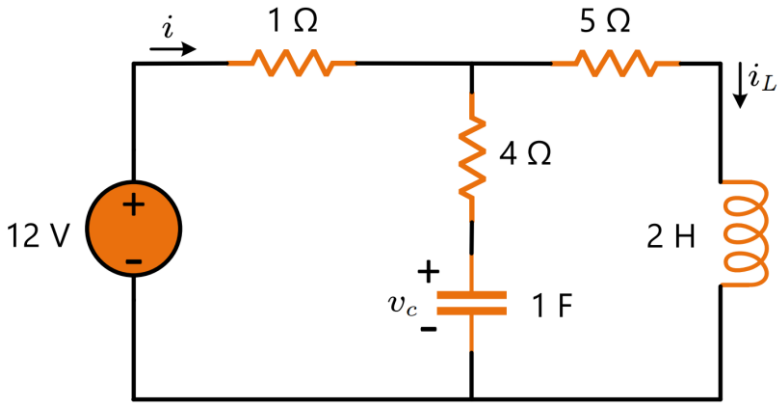


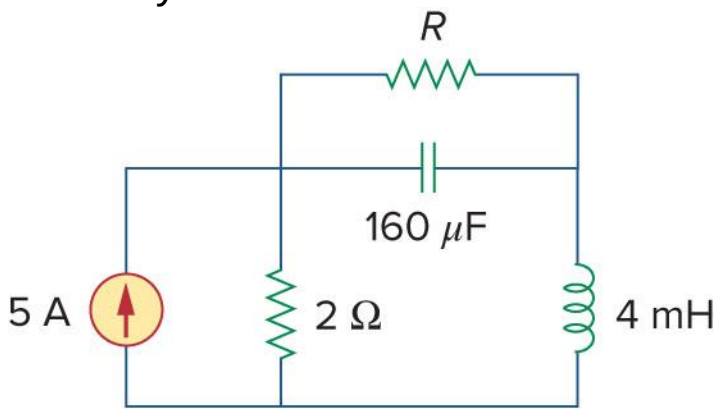
Fig. 2.

Answer:

a) $v_c = 0$ V, $i_L = 2$ A, $w_c = 0$ J, and $w_L = 1$ J

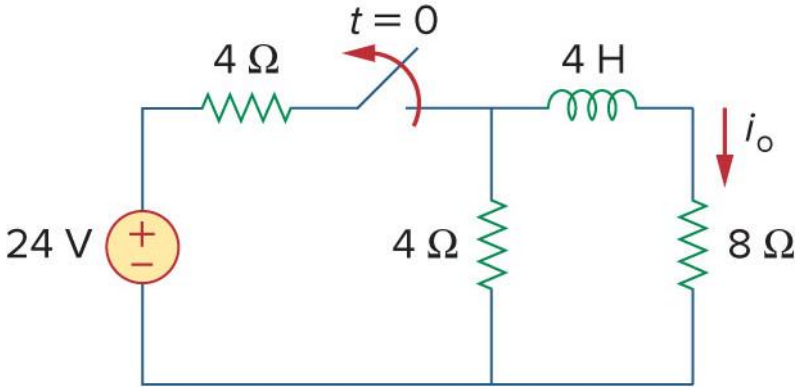
b) $v_c = 10$ V, $i_L = i = 2$ A, $w_c = 50$ J, and $w_L = 4$ J

2. In the following circuit, Calculate the value of R that will make the energy stored in the capacitor the same as that stored in the inductor under steady-state conditions.



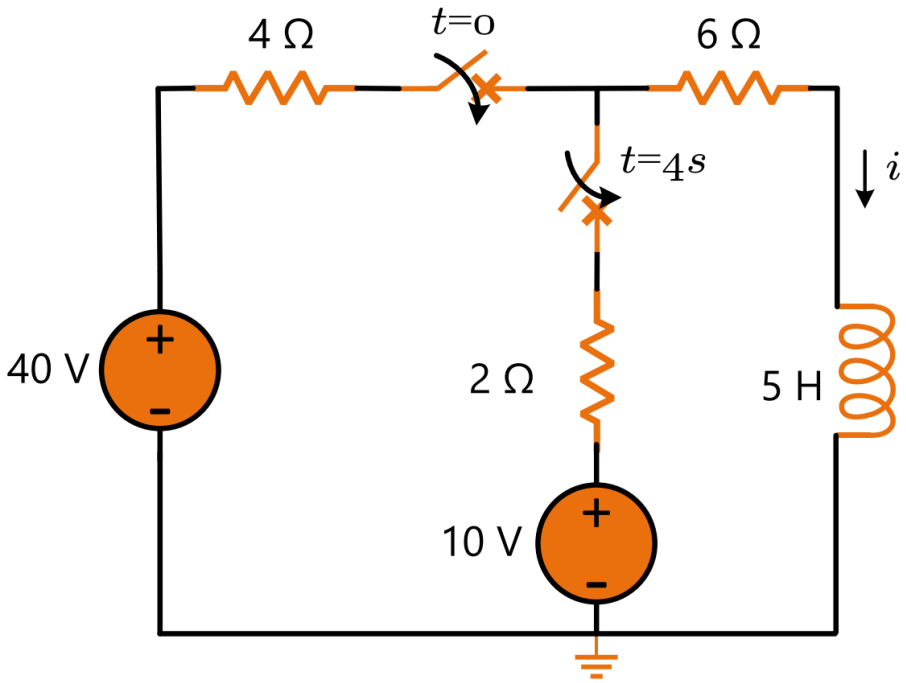
Answer: $R = 5\ \Omega$,
Hint: Find the capacitor and inductor energies in term of R.

3. The switch in the following circuit has been closed for a long time. At $t = 0$, the switch is opened. Calculate $i_o(t)$ for all time (i.e., for both $t < 0$ and $t > 0$), and sketch the current $i_o(t)$ as a function of time showing all critical points in the sketch.



Answer: $i_o(t) = \begin{cases} 1.2\ \text{A} & t \le 0 \\ 1.2e^{-3t}\ \text{A} & t \ge 0 \end{cases}$

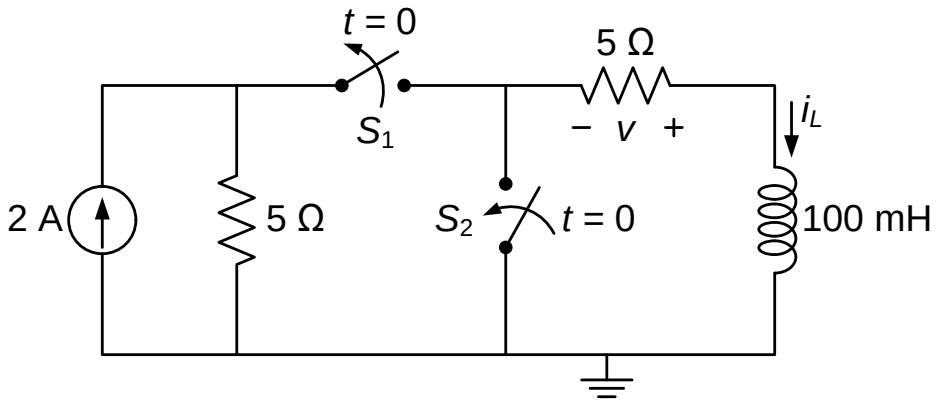
4. In the following circuit, at $t = 0$, switch 1 is closed (next to 4-Ω resistor), and switch 2 is closed 4 seconds later. Find $i(t)$ for all time (i.e., for both $t < 0$ and $t > 0$), and calculate $i(t)$ at $t = 2\ s$ and $t = 5\ s$. Sketch $i(t)$ waveform showing all critical points in the sketch.



Answer: $i(t) = \begin{cases} 0\ \text{A}, & t \le 0 \\ 4(1 - e^{-2t})\ \text{A}, & 0 \le t \le 4 \\ 2.727 + 1.273e^{-1.466(t-4)}, \text{A} & t \ge 4 \end{cases}$

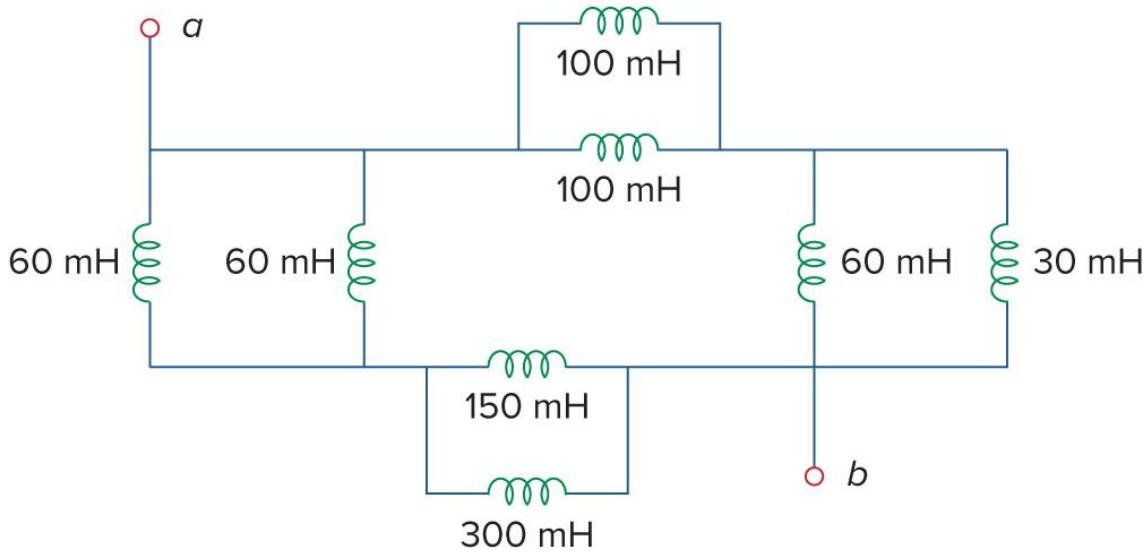
Hint: Use time shift property explained at the end of Topic 4.

5. (**Final Exam – S1, 2016**) Consider the circuit shown below, where switch S_1 has been closed for a long time and switch S_2 has been open for a long time. At $t = 0$, switch S_1 opens and switch S_2 closes. Derive an expression for the inductor current $i_L(t)$ and $v(t)$ for $t > 0$.



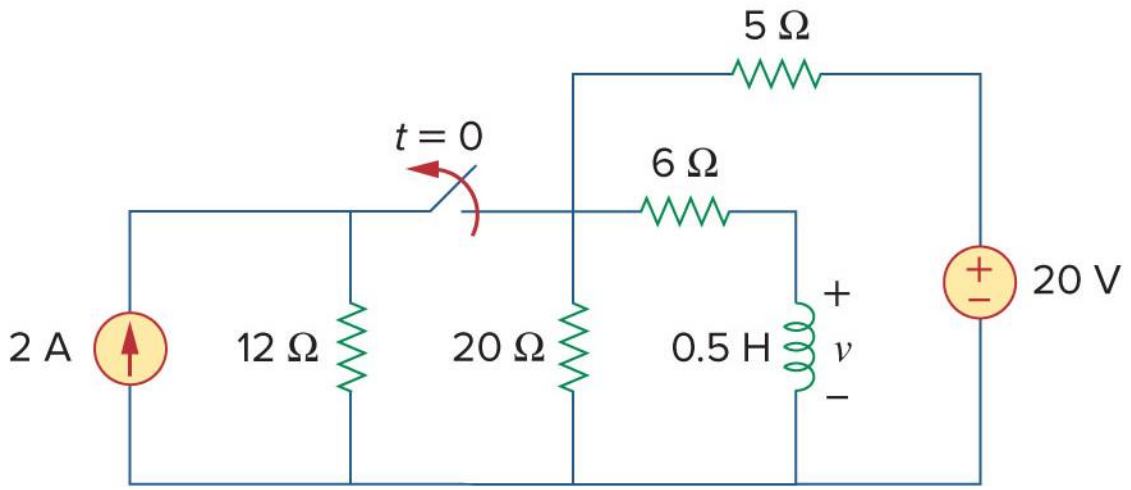
Answer: $i_L(t) = 1e^{-50t}u(t)$ A, $v(t) = -5e^{-50t}u(t)$ V

6. Find the equivalent inductance as seen from the terminals a-b in the circuit below.



Answer: $L_{\text{eq}} = 45.5$ mH

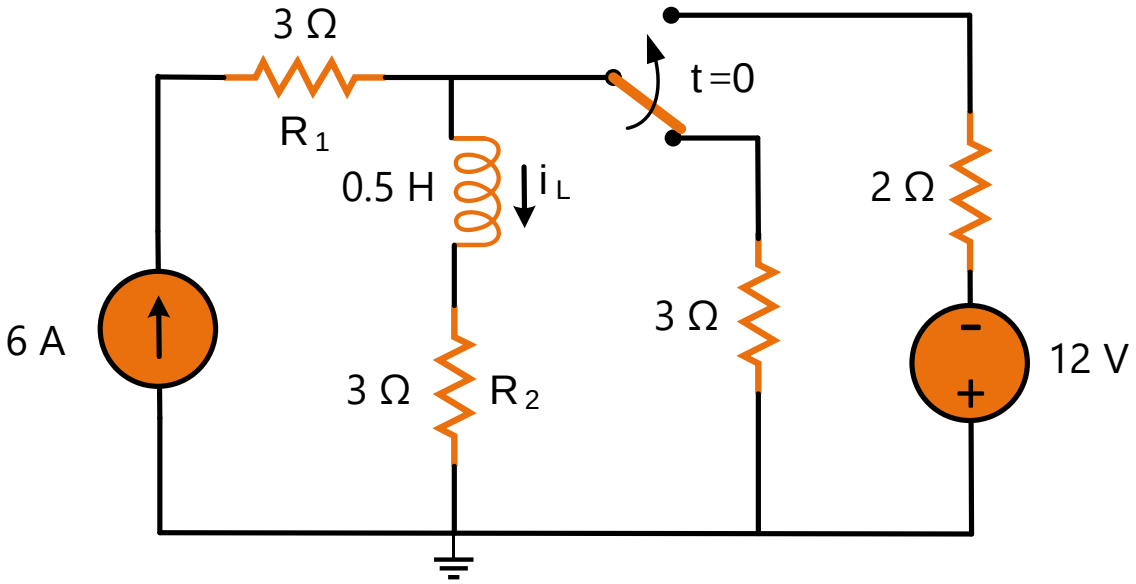
7. Find the voltage across inductor $v(t)$ for $t > 0$.



Answer: $v(t) = -4e^{-20t}u(t)$ V

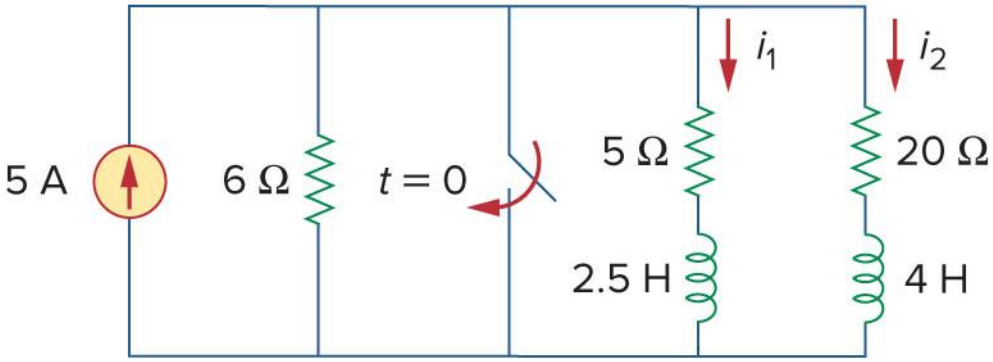
8. (**Final Exam – S1 2017**) In the circuit below,

a) Find the energy stored in the inductor under steady-state when the switch is in the open position (connected to 3-Ω resistor).
b) If the switch has been in the open position for a long time and closes at $t = 0$, derive an analytical expression for the current $i_L(t)$ through the inductor for $t > 0$.
c) Plot the current through the inductor as a function of time.
d) Derive an analytical expression for the voltages across resistors R_1 and R_2 (v_{R_1} and v_{R_2}) as a function of time for $t > 0$.



Answer:
a) $w_L(0) = 2.25$ J
b) $i_L(t) = 3e^{-10t}u(t)$ A
c) $v_{R_1}(t) = 18$ V, $v_{R_2}(t) = 9e^{-10t}u(t)$ V

9. Derive an expression for $i_1(t)$ and $i_1(t)$ for $t > 0$.



Answer: $i_1(t) = 2.4e^{-2t}u(t)$ A, $\quad i_2(t) = 0.6e^{-5t}u(t)$ A