Homework 6

ECE2004 CRN:12898

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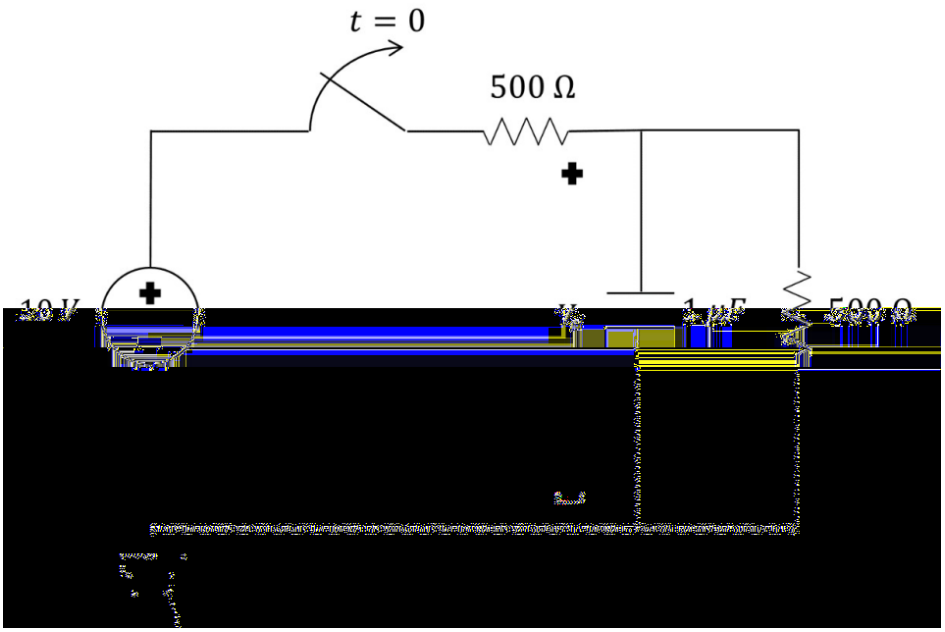
Problem 1: Assume the switch has been closed for a long time such that a steady state condition has been reached.



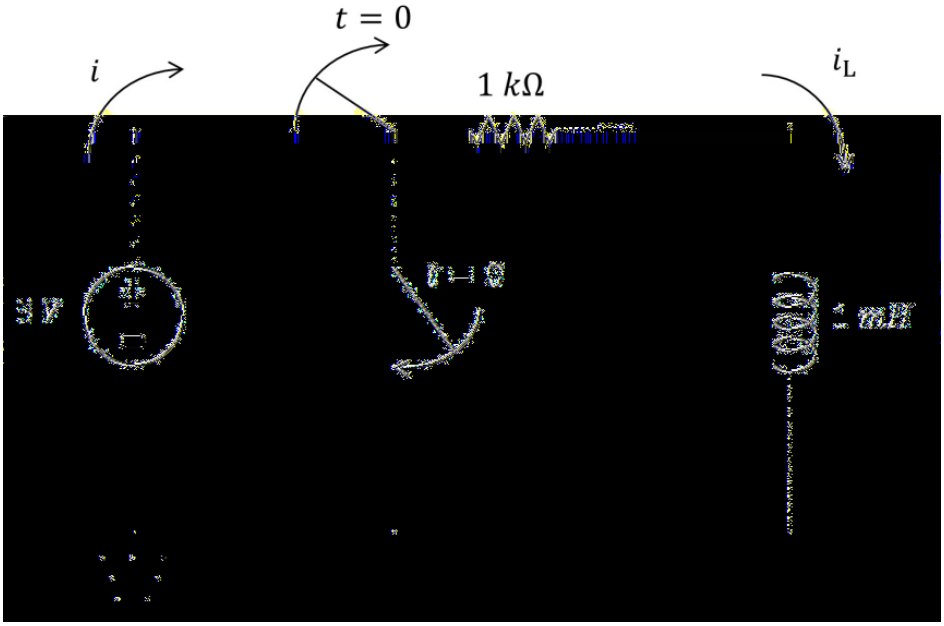
a) Find the time-domain formula for the voltage of the capacitor after the switch has been opened.

$$
\begin{aligned}
V_c &= \frac{500\Omega}{1k\Omega}10V = 5V \\
q_c &= C \times V_0(1 - e^{\frac{-t}{RC}}) \\
&= 1\mu F \times 5V(1 - e^{\frac{-t}{500\Omega \times 1\ F}}) \\
&= 5\mu C(1 - e^{\frac{-t}{0.5\,ms}})
\end{aligned}
$$

b) What is total energy absorbed by the 500Ω resistor after the switch has been opened for $(0 < t \leq \text{inf})$.

$$
\begin{aligned}
E_r &= \frac{1}{2}C \times V^2 \\
&= \frac{1}{2}1\mu F \times 25V^2 \\
&= 12.5\mu J
\end{aligned}
$$

Problem 2: Assume switches have been in their position for a long enough time such that steady state conditions have been met and then they open/close at time equals zero.



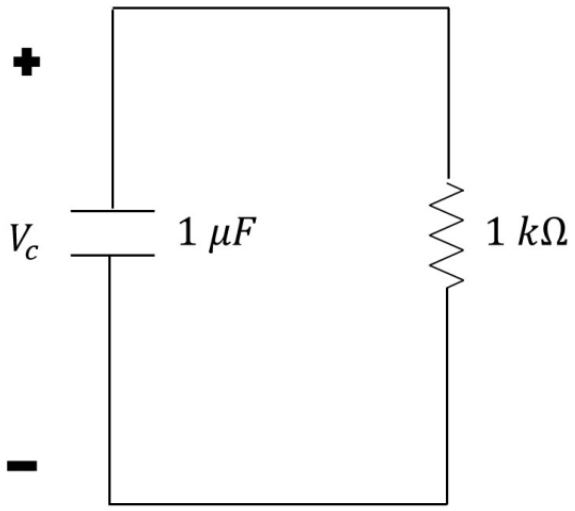
a) What is the value of $i_L(0)$?

$i_L(0) = \frac{5V}{1k\Omega} = 5mA$

b) What is the value of $i_L(t)$ after $t = 0$?

$$\begin{aligned} i_L(t) &= i_L(0)e^{\frac{-Rt}{L}} \\ &= 5mA \times e^{\frac{-1k\Omega \times t}{1\,m\,H}} \\ &= 5mA \times e^{\frac{-t}{1\ s}} \end{aligned}$$

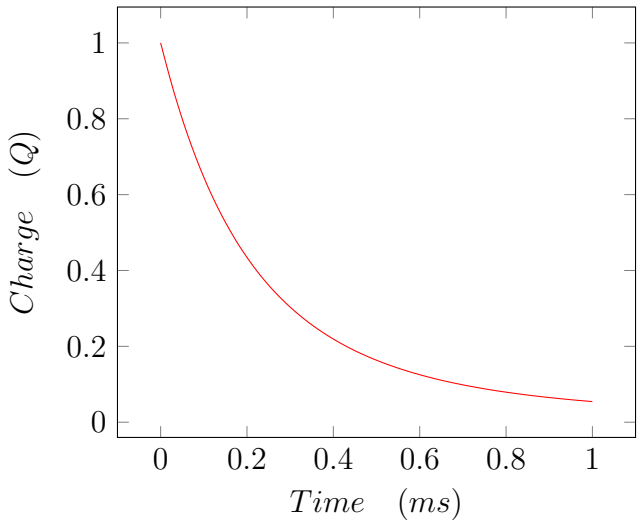
Problem 3: Assume that the capacitor has been charged to $10V$ before a switch isolated the circuit below at time $t = 0$.



a) Plot the charge over time of the capacitor for this circuit, q_c.

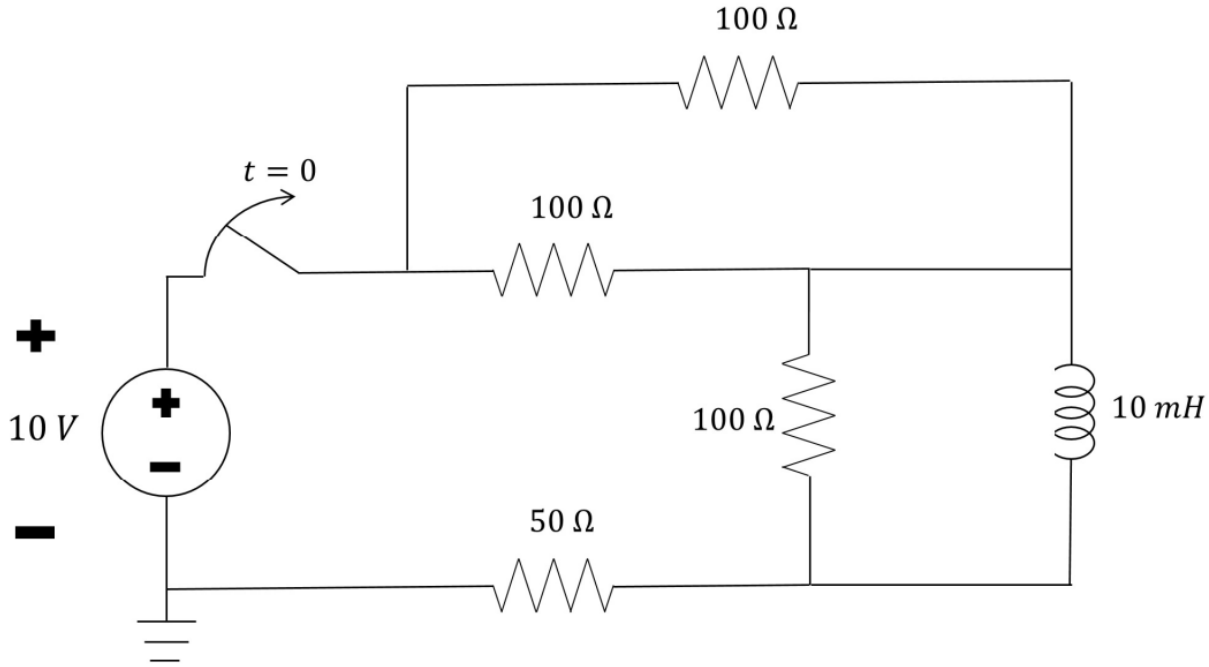
$$q_c = C \times V_0(1 - e^{\frac{-t}{RC}})$$
$$= \times V_0(1 - e^{\frac{-t}{RC}})$$

Problem 3 RC Circuit Charge axis lines



b) What is the time constant for this circuit? $\tau = 1ms$

Problem 4: Assume the switch has been closed for a long time and is opened at $t = 0$. Find the current through the inductor after $t = 0$.



$$V_0 = 10V \times \frac{50\Omega}{(100\Omega \parallel 100\Omega) + 50\Omega} = 10V\frac{50\Omega}{100\Omega} = 5V$$

$$i_L(0) = \frac{5V}{50\Omega} = 0.1A$$

$$i_L(t) = i_L(0)e^{\frac{-Rt}{L}}$$

$$= 0.1A \times e^{\frac{-100\Omega \times t}{10\,mH}}$$

$$= 0.1A \times e^{\frac{-t}{100\ s}}$$