ECE 2210 / 00 homework # 10

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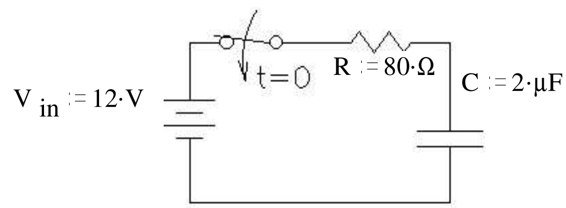
If you have the textbook, read pages 128 to 147. If not, find the section in your book that covers first-order transient reponses of RC and RL circuits and read that.

1. An FE style problem
   A 10-microfarad capacitor has been charged to a potential of 150 volts. A resistor of 25 Ω is then connected across the capacitor through a switch. When the switch has been closed for 10 time constants the total energy dissipated by the resistor is most nearly

   (A) 1.0×10^{-7} joules
   (B) 1.1×10^{-1} joules
   (C) 9.0×10^{1} joules
   (D) 9.0×10^{3} joules

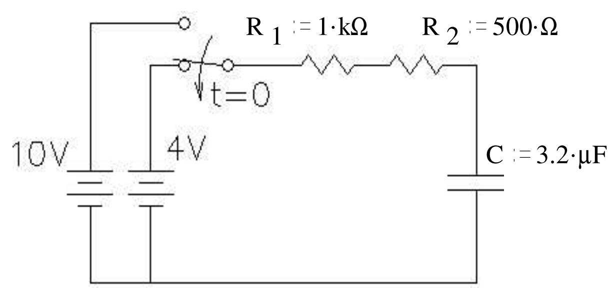
2. a) The switch is closed at time $t = 0$ and $v_C(0) = 0V$, find $v_C(t)$.

   b) What is the value of the voltage across C at $t := 40 \cdot \mu s$

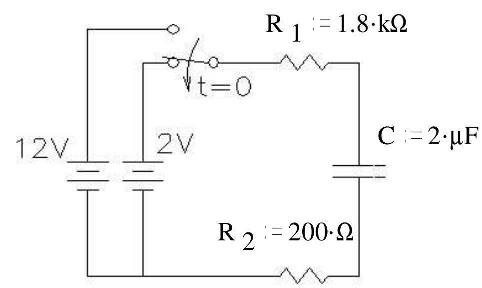


3. In the circuit below, the switch has been in the upper position for a long time and is switched down at time $t = 0$.

   What is the capacitor voltage (V_C) at $t := 4 \cdot ms$

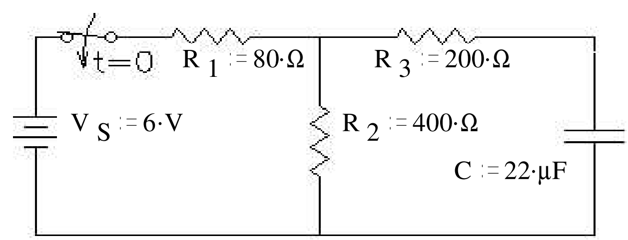


4. The switch below has been in the upper position for a long time and is switched down at time $t = 0$.
   At what time is $v_C = 4$ V?



5. a) What is the time constant of this circuit?
   Hint: Use a Thevenin equivalent circuit.

   b) What will be the final value of v_C?
   (After the switch has been closed for a long time)

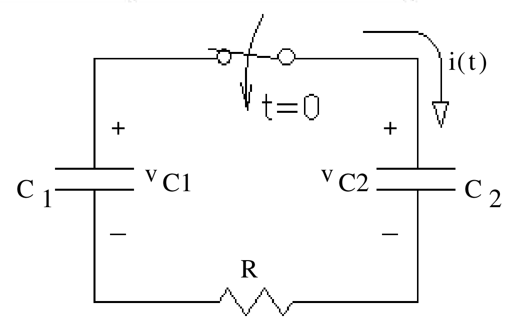


6. In a circuit with two capacitors, the left capacitor (C_1) has an initial charge and the right capacitor (C_2) does not. When the switch is closed at time $t = 0$, current $i(t)$ flows, discharging C_1 and charging C_2.

   a) Derive the differential equation for $i(t)$. Hint: write an equation in terms of i and integrals of i, then differentiate the whole equation.

   Write your DE in this form: $\text{Constant} = x(t) + \tau \cdot \frac{d}{dt} x(t)$

   What is the time constant (τ)?



   b) Find i(t) given $C_1 := 24 \cdot \mu F$ $C_2 := 12 \cdot \mu F$ $R := 400 \cdot \Omega$ $v_{C1}(0) = 18 \cdot V$ $v_{C2}(0) = 0 \cdot V$

   c) Find $v_{C2}(t)$ for the same values. Hint: The trick here will be finding the final condition. Realize that charge will be conserved. If C_1 discharges x coulombs, then C_2 will charge x coulombs. Charges will stop flowing when $v_{C1} = v_{C2}$. It may help to think of two water tanks, one with half the cross-sectional area of the other. $V = \frac{Q}{C}$

   d) Find the initial and final stored energy of the system ($W_{C1} + W_{C2}$) to find the total "loss". What happened to that energy?

Answers 1. B 2.a) $12 \cdot V - 12 \cdot V \cdot e^{-\frac{t}{0.16 \cdot ms}}$ b) $2.65 \cdot V$ 3. $6.61 \cdot V$ 4. $6.44 \cdot ms$ 5. a) $5.87 \cdot ms$ b) $5 \cdot V$ 6.a) $\tau = R \cdot \frac{1}{\left(\frac{1}{C_1} + \frac{1}{C_2}\right)}$

6.b) $i(t) = 45 \cdot mA \cdot e^{-\frac{t}{3.2 \cdot ms}}$ c) $12 \cdot V - 12 \cdot V \cdot e^{-\frac{t}{3.2 \cdot ms}}$ d) $1.3 \cdot mJ$ dissipated in resistor