ECE 2210 / 00 homework 1stTr1 1^{st} - Order Transients

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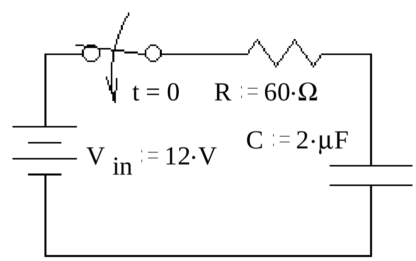
c

Name ________________________________

1. 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 (An FE style problem)

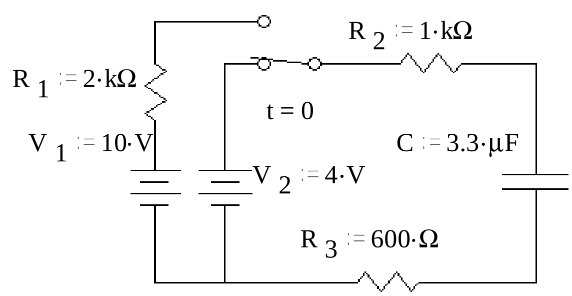
(A) 1.0×10^{-7} joules
(B) 1.1×10^{-1} joules
(C) 9.0×10^{1} joules
(D) 1.1×10^{3} joules
(E) 9.0×10^{3} joules

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 shown, the switch has been in the upper position for a long time and is switched down at time $t = 0$.
a) Find the initial and final capacitor voltages.
$v_C(0) = ?$ $v_C(\infty) = ?$



b) Find the time constant.
(after $t = 0$)

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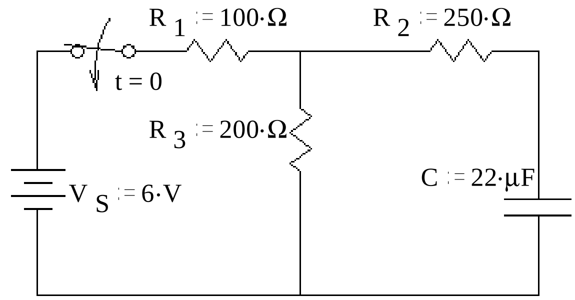
3. continued c) Find $v_C(t)$. (always after t = 0)

d) At what time is $v_C = 5\ V$?

4. a) What will be the final value of v_C? $v_C(\infty)$ = ?

Hint: Use a Thevenin equivalent circuit.



b) What is the time constant of this circuit?

c) Find $v_C(t)$. The switch had been open for a long time before t = 0.

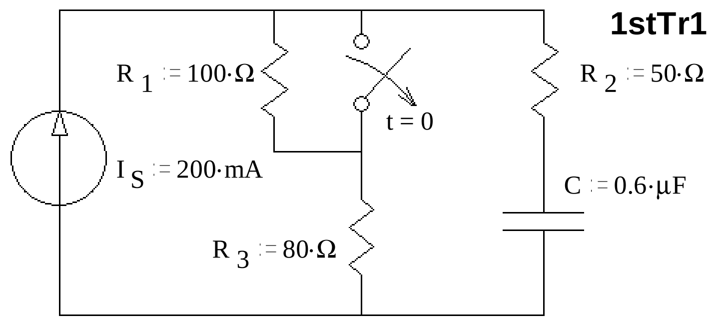
Answers

1. B 2.a) $12\cdot V - 12\cdot V\cdot e^{-\frac{t}{0.12\cdot ms}}$ b) $3.4\cdot V$ 3. a) $10\cdot V$ $4\cdot V$ b) $5.28\cdot ms$ c) $4\cdot V + 6\cdot V\cdot e^{-\frac{t}{5.28\cdot ms}}$ d) $9.46\cdot ms$

4. a) $4\cdot V$ b) $6.97\cdot ms$ c) $4\cdot V - 4\cdot V\cdot e^{-\frac{t}{6.97\cdot ms}}$ 5. a) $36\cdot V - 20\cdot V\cdot e^{-\frac{t}{138\cdot \mu s}}$ b) $27\cdot V$ c) $16\cdot V + 11\cdot V\cdot e^{-\frac{t'}{78\cdot \mu s}}$

6.a) $\tau = R\cdot\frac{1}{\left(\frac{1}{C_1}+\frac{1}{C_2}\right)}$ 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

5. The switch has been closed for a long time and is opened (as shown) at time $t = 0$.

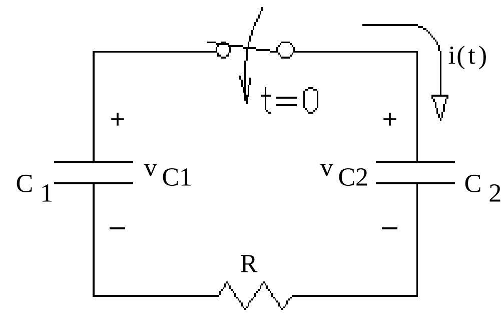


a) Find the initial and final conditions and write the full expression for $v_C(t)$, including all the constants that you find.

b) What is v_C when $t = 0.8\tau$? $v_C(0.8 \cdot \tau) = ?$

c) At time $t = 0.8\tau$ the switch is closed again. Find the complete expression for $v_C(t')$, where t' starts when the switch closes. Be sure to clearly show the time constant.

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

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?