

THIRD MIDTERM

3

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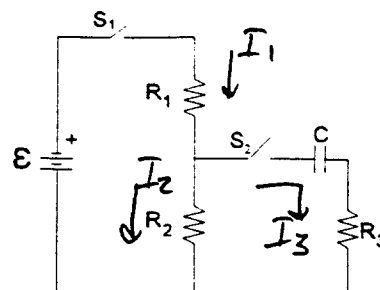
SHOW ALL WORK!!!!

REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!

Use the conversion constants and data given on the front page.

For the circuit shown the capacitor is initially uncharged. Initially S_1 is closed. At $t = 0$ S_2 is closed and S_1 is still closed.

- Calculate the charge on the capacitor at $t = \infty$,
- Find the voltage across the capacitor when $t = 1.50 \tau$.
- Calculate the current in R_1 at $t = 0$.
- With the capacitor fully charged S_1 is opened. Calculate the time constant for discharging C.
- With S_1 and S_2 closed, calculate (numerical value) the time constant for charging C. (No short cuts from advanced courses allowed.)



$\epsilon = 100 \text{ V}$
 $R_1 = 150 \text{ k}\Omega$
 $R_2 = 175 \text{ k}\Omega$
 $R_3 = 125 \text{ k}\Omega$
 $C = 800 \text{ pF}$

$$a) I_{\text{Total}}(\infty) = \frac{\epsilon}{R_1 + R_2}$$

$$V_C(\infty) = V_2^{\infty} = I_{\text{Total}}(\infty) R_2 = \frac{\epsilon R_2}{R_1 + R_2}$$

$$Q_C(\infty) = C V_C(\infty) = \frac{\epsilon R_2 C}{R_1 + R_2} = \frac{(100 \text{ V})(175 \times 10^3 \Omega)(800 \times 10^{-12} \text{ F})}{(150 + 175) \times 10^3 \Omega} = 4.31 \times 10^{-8} \text{ C}$$

(43.1 nC)

$$b) V_C(t) = V_C(\infty) (1 - e^{-t/\tau})$$

$$V_C(1.5\tau) = \frac{\epsilon R_2}{R_1 + R_2} (1 - e^{-1.5}) = \frac{(100 \text{ V})(175 \times 10^3 \Omega)}{(150 + 175) \times 10^3 \Omega} (1 - e^{-1.5}) = 41.8 \text{ V}$$

$$c) I_1(0) = I_{\text{Total}}(0) = \frac{\epsilon}{R_{\text{Total}}} = \frac{\epsilon}{R_1 + \frac{1}{\frac{1}{R_2} + \frac{1}{R_3}}} = \frac{\epsilon}{R_1 + \frac{R_2 R_3}{R_2 + R_3}} = \frac{(R_2 + R_3) \epsilon}{R_2 + R_1 R_3 + R_2 R_3}$$

$$= \frac{(175 + 125) \times 10^3 \Omega (100 \text{ V})}{[(150)(175) + (150)(125) + (175)(125)] \times 10^6 \Omega^2} = 449 \text{ mA}$$