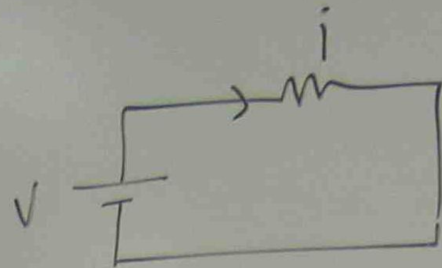
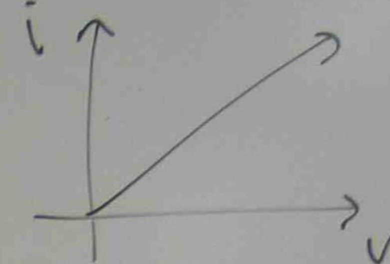
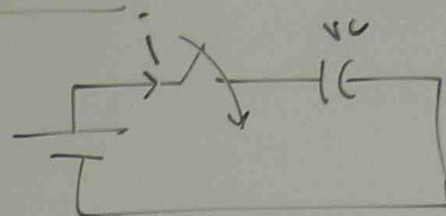
TRANSIENT

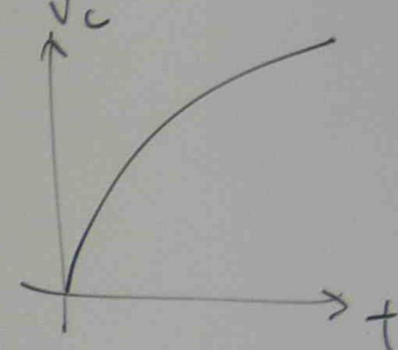
RESISTOR

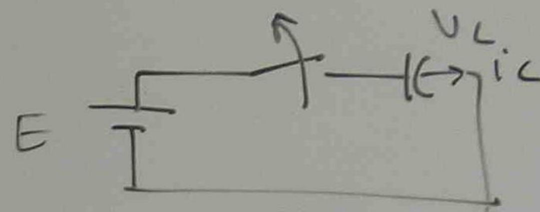


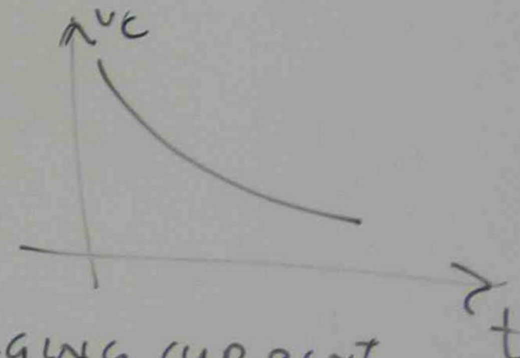


CAPACITOR





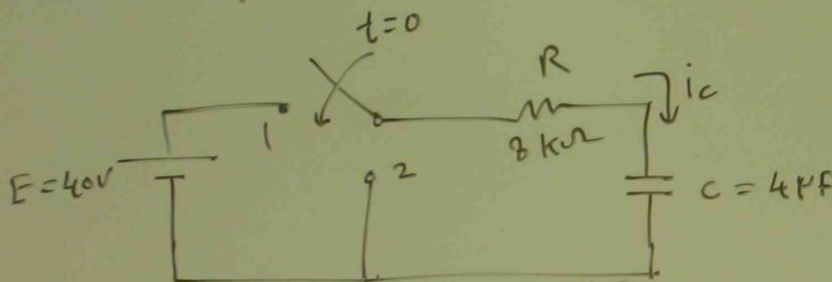




i_c = CHARGING CURRENT FOR CAPACITOR

CHARGING – RC CIRCUIT

Pb: FIND THE MATHEMATICAL EXPRESSIONS FOR THE TRANSIENT BEHAVIOUR OF V_C, i_C AND V_R FOR THE GIVEN CIRCUIT WHEN THE SWITCH IS MOVED TO POSITION 1. PLOT THE CURVES OF V_C, i_C AND V_R



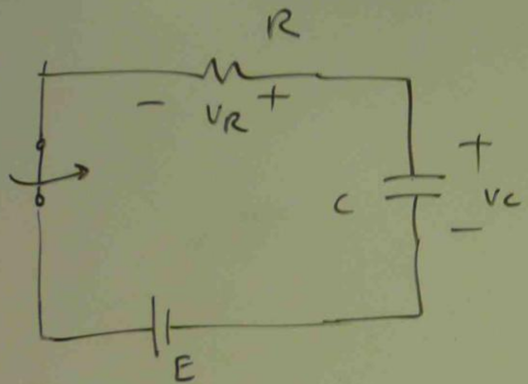
$$\boxed{V_C = E\left(1 - e^{-\frac{t}{RC}}\right)} = 40\left(1 - e^{-\frac{t}{8\times10^{3} \times 4\times10^{-6}}}\right)$$

$$= 40\left(1 - e^{-\frac{t}{32\times10^{-3}}}\right) \text{ V}$$

$$\boxed{i_C = \frac{E}{R} e^{-\frac{t}{RC}}} = \frac{40}{8\times10^{3}} e^{-\frac{t}{32\times10^{-3}}} = 5\times10^{-3} e^{-\frac{t}{32\times10^{-3}}} \text{ Amp}$$

$$\boxed{V_R = E e^{-t/RC}} = 40 e^{-\frac{t}{32\times10^{-3}}} \text{ V}$$

DISCHARGING RC CIRCUIT

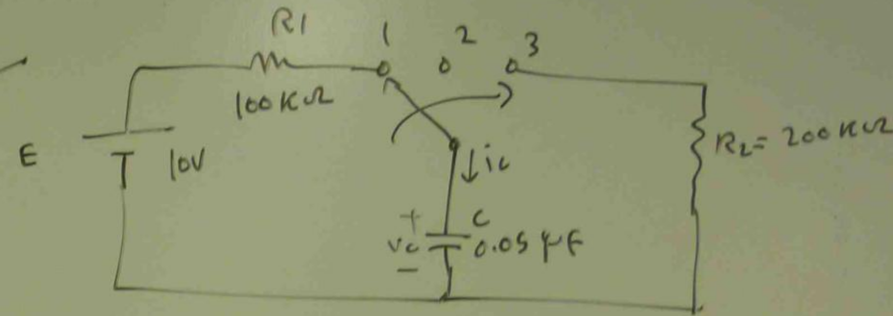


$$V_C = E\, e^{-t/RC}$$

$$i_C = \frac{E}{R}\, e^{-\frac{t}{RC}}$$

$$V_R = E\, e^{-\frac{t}{RC}}$$

pb/



(a) FIND THE MATHEMATICAL EXPRESSION FOR THE TRANSIENT BEHAVIOUR OF THE VOLTAGE ACROSS THE CAPACITOR IF THE SWITCH IS THROWN INTO POSITION 1 AT $t = 0$ sec.

(b) REPEAT PART (a) FOR i_C.

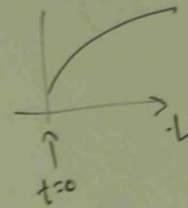
(c) FIND THE MATHEMATICAL EXPRESSIONS FOR THE RESPONSE OF V_C AND i_C IF THE SWITCH IS THROWN INTO POSITION 2 AT 30 ms.

(d) FIND THE MATHEMATICAL EXPRESSION FOR THE VOLTAGE V_C AND CURRENT i_C IF THE SWITCH IS THROWN INTO POSITION 3 AT $t = 48$ ms.

(e) PLOT THE WAVEFORMS OBTAINED IN PART (a) THROUGH (d).

SWITCH AT POSITION "1"

CAPACITOR CHARGING



(a)

$$V_c = E\left(1 - e^{-\frac{t}{\tau}}\right)$$

$$= 10\left(1 - e^{-\frac{t}{R_1 C}}\right)$$

$$= 10\left(1 - e^{-\frac{t}{100\times10^{3}\times 0.05\times10^{-6}}}\right)$$

$$= 10\left(1 - e^{-\frac{t}{5\times10^{-3}}}\right) \text{ V}$$

(b)

$$i_c = \frac{E}{R_1} e^{-\frac{t}{R_1 C}}$$

$$= \frac{10}{100\times10^{3}} e^{-\frac{t}{100\times10^{3}\times 0.05\times10^{-6}}}$$

$$= 0.1\times10^{-3} e^{-\frac{t}{5\times10^{-3}}} \text{ Amp}$$

SWITCH AT POSITION "2"

(c) OFF CIRCUIT

$$V_c = 10\text{V}$$

$$i_c = 0$$

(d) SWITCH AT POSITION "3"

DISCHARGE

$$\tau = RC$$

$$V_c = E e^{-t/\tau}$$

$$= 10 e^{-\frac{t}{R_2 C}}$$

$$= 10 e^{-\frac{t}{200\times10^{3}\times C}}$$

$$= 10 e^{-\frac{t}{10\times10^{-3}}} \text{ V}$$

$$i_c = -\frac{E}{R_2} e^{-t/\tau}$$

$$= -\frac{10}{200\times10^{3}} e^{-\frac{t}{10\times10^{-3}}} \text{ A}$$

$$= -0.05\times10^{-3} e^{-\frac{t}{10\times10^{-3}}} \text{ A}$$

SWITCH AT POSITION "2"

OFF CIRCUIT

(c) $V_C = 10V$

$i_c = 0$

(d) SWITCH AT POSITION "3"

DISCHARGE

$\tau = RC$

$V_c = E e^{-t/\tau}$

$= 10\, e^{-\frac{t}{R_2 C}}$

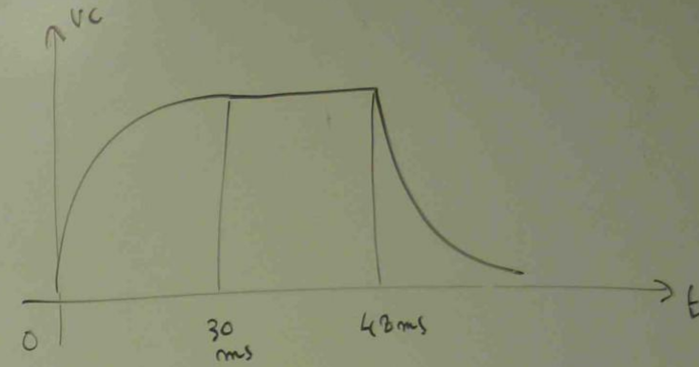
$= 10\, e^{-\frac{t}{200\times10^{3}\times C}}$

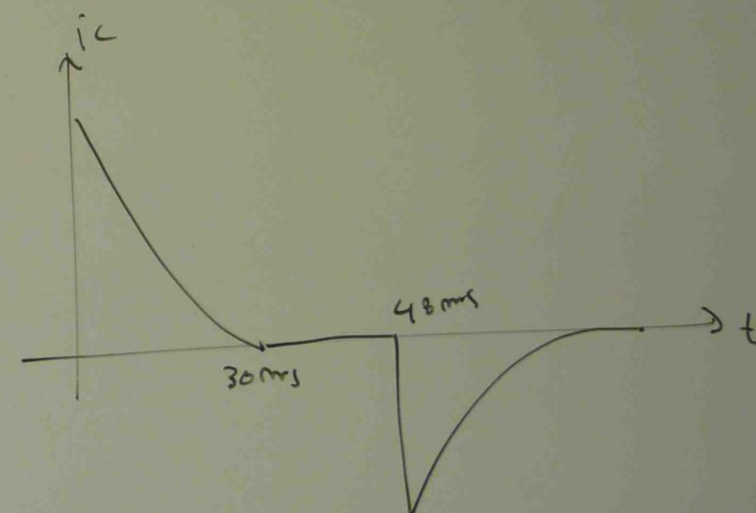
$= 10\, e^{-\frac{t}{10\times10^{-3}}}$ V

$i_c = -\frac{E}{R_2} e^{-t/\tau}$

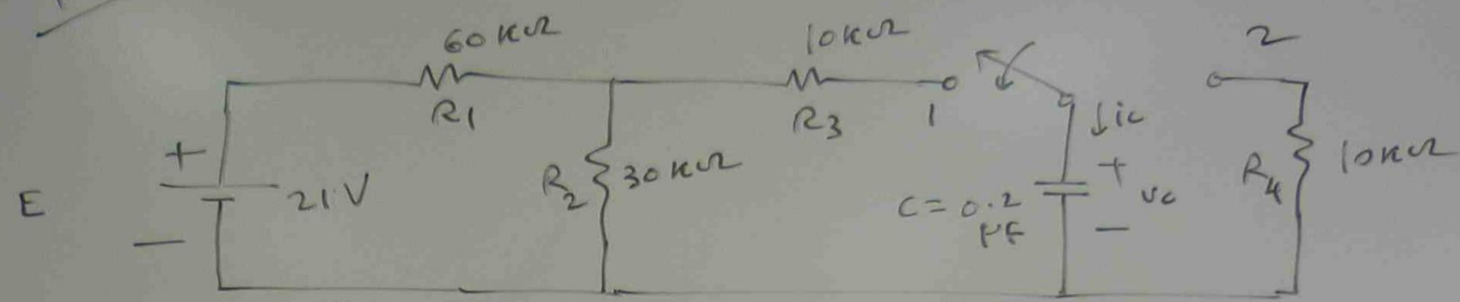
$= -\frac{10}{200\times10^{3}} e^{-\frac{t}{10\times10^{-3}}}$ A

$-3 \quad -\frac{t}{\;}$ A





pb FOR THE NETWORK GIVEN IN FIGURE :



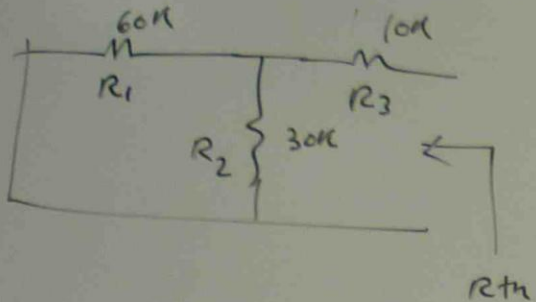
(a) FIND THE MATHEMATICAL EXPRESSION FOR THE TRANSIENT BEHAVIOUR OF THE VOLTAGE V_c AND THE CURRENT i_c FOLLOWING THE CLOSING OF THE SWITCH POSITION 1 AT $t = 0$ sec.

(b) FIND THE MATHEMATICAL EXPRESSION FOR THE VOLTAGE V_c AND CURRENT i_c AS A FUNCTION OF TIME IF THE SWITCH IS THROWN INTO POSITION 2 AT $t = 9$ ms

(c) DRAW THE RESULTANT WAVEFORMS.

(a) SWITCH AT POSITION (1) CHARGING

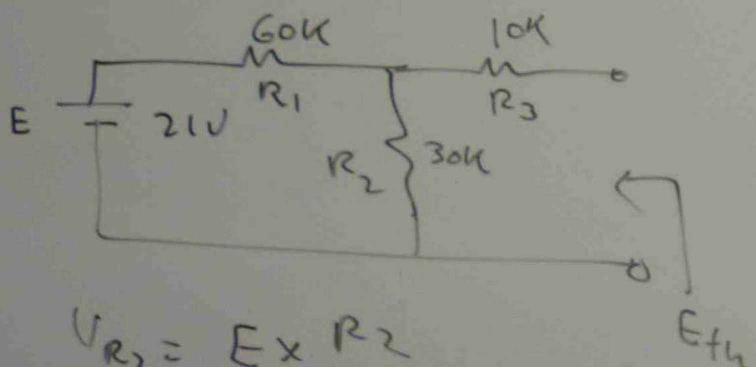
R_{th}



$$R_{th} = R_1 // R_2 + R_3$$

$$= \frac{60 \times 30}{60 + 30} + 10$$

$$R_{th} = 30\,k\Omega$$



$$V_{R_2} = E \times \frac{R_2}{R_1 + R_2} = 21 \times \frac{30}{60+30} = 7V$$

$$E_{th} = V_{R_2} = 7V$$

$$V_c = E_{th}\left(1 - e^{-\frac{t}{\tau}}\right)$$

$$= 7\left(1 - e^{-\frac{t}{R_{th}C}}\right)$$

$$= 7\left(1 - e^{-\frac{t}{30\times10^{3} \times 0.2\times10^{-6}}}\right)$$

$$i_c = \frac{E_{th}}{R} e^{-t/6\times10^{-3}} = \frac{7}{30k\Omega} e^{-t/6\times10^{-3}}$$

$$= (0.233 \times 10^{-3})\, e^{-\frac{t}{6\times10^{-3}}}$$

(b) SWITCH AT POSITION "2"

DISCHARGING

CHARGING VOLTAGE UP TO 9ms

$$V_c = 7\left(1 - e^{-\frac{t}{6\times10^{-3}}}\right) V$$

AT $t = 9ms$

$$V_c = 7\left(1 - e^{-\frac{9\times10^{-3}}{6\times10^{-3}}}\right)$$

$E_{th} = V_{R_2} = 7V$

$$V_c = E_{th}\left(1 - e^{-\frac{t}{\tau}}\right)$$

$$= 7\left(1 - e^{-\frac{t}{R_{th}C}}\right)$$

$$= 7\left(1 - e^{-\frac{t}{30\times10^3 \times 0.2\times10^{-6}}}\right)$$

$$= 7\left(1 - e^{-t/6\times10^{-3}}\right)$$

$$i_c = \frac{E_{th}}{R} e^{-t/6\times10^{-3}} = \frac{7}{30k\Omega} e^{-t/6\times10^{-3}}$$

$$= (0.233\times10^{-3})\, e^{-\frac{t}{6\times10^{-3}}}$$

(b) SWITCH AT POSITION "2"

DISCHARGING

CHARGING VOLTAGE UP TO 9ms

$$V_c = 7\left(1 - e^{-\frac{t}{6\times10^{-3}}}\right) V$$

AT $t = 9ms$

$$V_c = 7\left(1 - e^{-\frac{9\times10^{-3}}{6\times10^{-3}}}\right)$$

$$V_{c\,(9ms)} = 7\left(1 - e^{-1.5}\right) = 5.44V$$

$$i_c(9ms) = 0.233\times10^{-3} \times e^{-\frac{9\times10^{-3}}{6\times10^{-3}}}$$

$$= 0.233\times10^{-3} \times e^{-1.5}$$

$$i_c(9ms) = 0.052\,mA$$

$$V_c = E\, e^{-t/RC}$$

$$= V_c(9ms)\, e^{-t/RC}$$

$$= 5.44\, e^{-\frac{t}{R_4 C}}$$

$$= 5.44\, e^{-\frac{t}{10\times10^3 \times 0.2\times10^{-6}}}$$

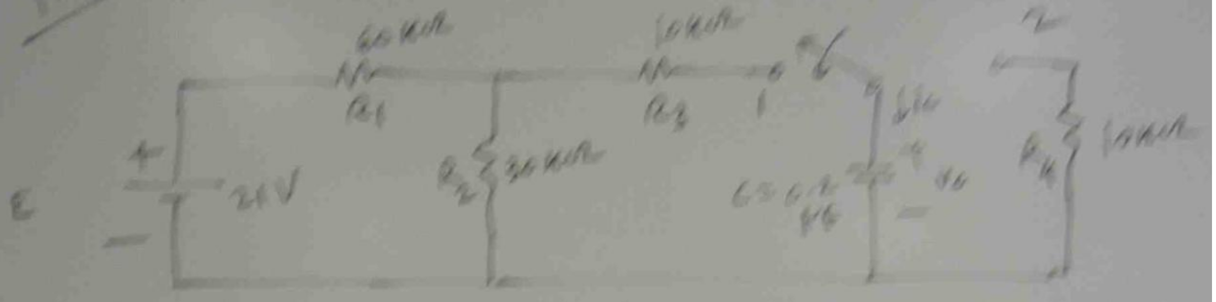
$$= 5.44\, e^{-\frac{t}{2\times10^{-3}}}\ V$$

$$i_c = -\frac{V_c(9ms)}{R} e^{-\frac{t}{R_4 C}}$$

$$= -\frac{5.44}{10\times10^3} e^{-\frac{t}{2\times10^{-3}}}$$

$$i_c = -0.054\, e^{-\frac{t}{2\times10^{-3}}}\ A$$

Q3) FOR THE NETWORK GIVEN IN FIGURE:



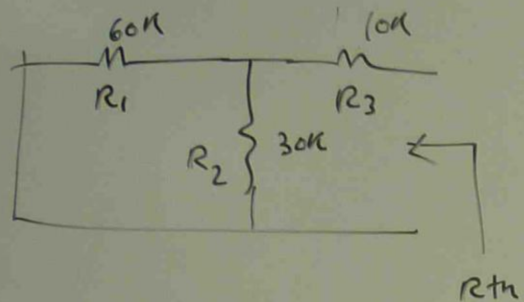
(a) FIND THE MATHEMATICAL EXPRESSION FOR THE TRANSIENT BEHAVIOUR OF THE VOLTAGE V_C AND THE CURRENT I_C FOLLOWING THE CLOSING OF THE SWITCH POSITION 1 AT $t = 0$ SEC

(b) FIND THE MATHEMATICAL EXPRESSION FOR THE VOLTAGE V_C AND CURRENT I_C AS A FUNCTION OF TIME IF THE SWITCH IS THROWN INTO POSITION 2 AT $t = 9$ ms

(c) DRAW THE RESULTANT WAVEFORMS.

(a) SWITCH AT POSITION (1) CHARGING

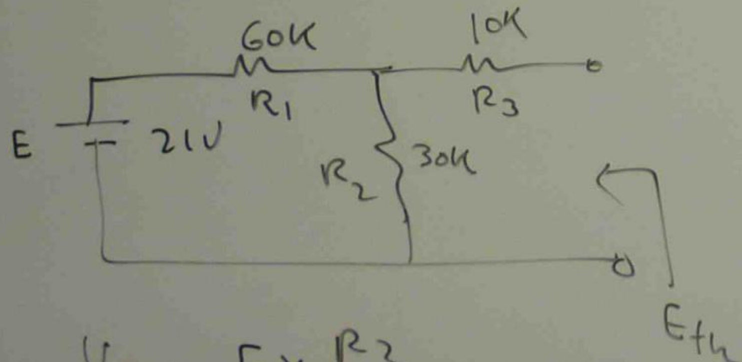
R_{th}



$$R_{th} = R_1 \,||\, R_2 + R_3$$

$$= \frac{60 \times 30}{60+30} + 10$$

$$R_{th} = 30\,k\Omega$$



$$V_{R_2} = E \times \frac{R_2}{R_1 + R_2} = 21 \times \frac{30}{60+30} = 7V$$

$$E_{th} = V_{R_2} = 7V$$

$$V_c = E_{th}\left(1 - e^{-\frac{t}{\tau}}\right)$$

$$= 7\left(1 - e^{-\frac{t}{R_{th}C}}\right)$$

$$= 7\left(1 - e^{-\frac{t}{30\times10^{3} \times 0.2\times10^{-6}}}\right)$$

$$= 7\left(1 - e^{-t/6\times10^{-3}}\right)$$

$$i_c = \frac{E_{th}}{R} e^{-t/6\times10^{-3}} = \frac{7}{30\,k\Omega} e^{-t/6\times10^{-3}}$$

$$= (0.233\times10^{-3})\, e^{-\frac{t}{6\times10^{-3}}}$$

(b) SWITCH AT POSITION "2"

DISCHARGING

CHARGING VOLTAGE UP TO 9ms

$$V_c = 7\left(1 - e^{-\frac{t}{6\times10^{-3}}}\right) V$$

AT $t = 9ms$

$$V_c = 7\left(1 - e^{-\frac{9\times10^{-3}}{6\times10^{-3}}}\right)$$

$E_{th} = V_{R_2} = 7V$

$$V_c = E_{th}\left(1 - e^{-\frac{t}{\tau}}\right)$$

$$= 7\left(1 - e^{-\frac{t}{R_{th}C}}\right.$$

$$= 7\left(1 - e^{-\frac{t}{30\times10^{3}\times0.2\times10^{-6}}}\right)$$

$$i_c = \frac{E_{th}}{R} e^{-t/6\times10^{-3}} = \frac{7}{30k\Omega} e^{-t/6\times10^{-3}}$$

$$= (0.233\times10^{-3})\, e^{-\frac{t}{6\times10^{-3}}}$$

(b) SWITCH AT POSITION "2"

DISCHARGING

CHARGING VOLTAGE UP TO 9ms

$$V_c = 7\left(1 - e^{-\frac{t}{6\times10^{-3}}}\right) V$$

AT $t = 9ms$

$$V_c = 7\left(1 - e^{-\frac{9\times10^{-3}}{6\times10^{-3}}}\right)$$

$$V_{c\,(9ms)} = 7\left(1 - e^{-1.5}\right) = 5.44V$$

$$i_c(9ms) = 0.233\times10^{-3} \times e^{-\frac{9\times10^{-3}}{6\times10^{-3}}}$$

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$$i_c(9ms) = 0.052mA$$

$$V_c = E\, e^{-t/RC}$$

$$= V_c(9ms)\, e^{-t/RC}$$

$$= 5.44\, e^{-\frac{t}{R_4 C}}$$

$$= 5.44\, e^{-\frac{t}{10\times10^{3}\times0.2\times10^{-6}}}$$

$$= 5.44\, e^{-\frac{t}{2\times10^{-3}}} \quad V$$

$$i_c = -\frac{V_c(9ms)}{R} e^{-\frac{t}{R_4 C}}$$

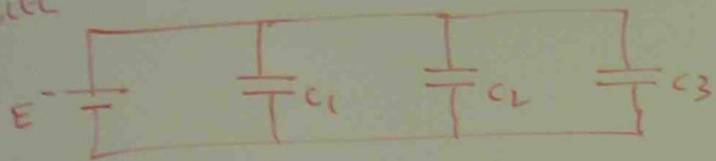
$$= -\frac{5.44}{10\times10^{3}} e^{-\frac{t}{2\times10^{-3}}}$$

$$i_c = -0.054\, e^{-\frac{t}{2\times10^{-3}}}$$

A

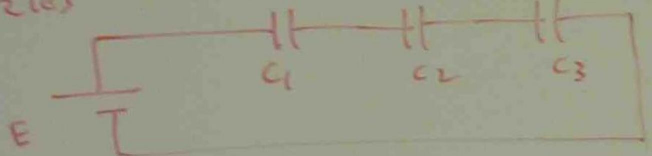
CAPACITORS IN SERIES & PARALLEL

PARALLEL



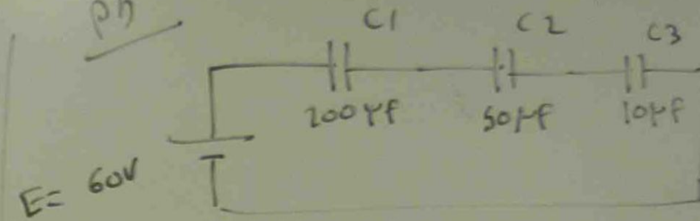
$$C_T = C_1 + C_2 + C_3$$

SERIES



$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

pb



FIND (a) TOTAL CAPACITANCE

(b) DETERMINE THE CHARGE ON EACH PLATE

(c) FIND VOLTAGE ACROSS EACH CAPACITOR.

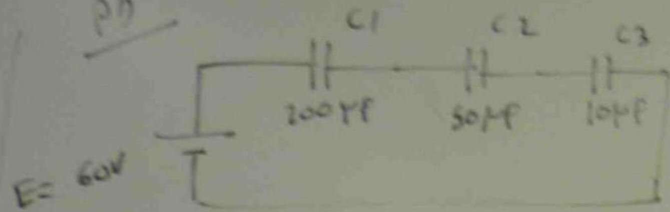
$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$= \frac{1}{200} + \frac{1}{50} + \frac{1}{10}$$

$$\frac{1}{C_T} = 0.125$$

$$C_T = \frac{1}{0.125} = 8\mu f$$

ph



FIND (a) TOTAL CAPACITANCE

(b) DETERMINE THE CHARGE ON EACH PLATE

(c) FIND VOLTAGE ACROSS EACH CAPACITOR.

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$= \frac{1}{200} + \frac{1}{50} + \frac{1}{10}$$

$$\frac{1}{C_T} = 0.125$$

$$C_T = \frac{1}{0.125} = 8\mu F$$

SAME CHARGE

$$Q_T = Q_1 = Q_2 = Q_3$$

$$\boxed{Q_T = C_T E}$$

$$Q_T = 8 \times 10^{-6} \times 60 = 480 \times 10^{-6} C$$

$$V_1 = \frac{Q_T = Q_1}{C_1} = \frac{480 \times 10^{-6}}{200 \times 10^{-6}} = 2.4V$$

$$V_2 = \frac{Q_2}{C_2} = \frac{480 \times 10^{-6}}{50 \times 10^{-6}} = 9.6V$$

$$V_3 = \frac{Q_3}{C_3} = \frac{480 \times 10^{-6}}{10 \times 10^{-6}} = 48V$$

SAME CHARGE

$Q_T = Q_1 = Q_2 = Q_3$

$\boxed{Q_T = C_T E}$

$Q_T = 8 \times 10^{-6} \times 60 = 480 \times 10^{-6}\ C$

$V_1 = \frac{Q_T = Q_1}{C_1} = \frac{480 \times 10^{-6}}{200 \times 10^{-6}} = 2.4V$

$V_2 = \frac{Q_2}{C_2} = \frac{480 \times 10^{-6}}{50 \times 10^{-6}} = 9.6V$

$V_3 = \frac{Q_3}{C_3} = \frac{480 \times 10^{-6}}{10 \times 10^{-6}} = 48V$

ENERGY STORED IN CAPACITOR $= \frac{1}{2} C V^2$

(Joules)

ENERGY STORED IN CAPACITOR $C_1 = \frac{1}{2} C_1 V_1^2$

$= \frac{1}{2} \times 200 \times 10^{-6} \times 2.4^2$

$= 576 \times 10^{-6}$

$= 0.576\ mJ$