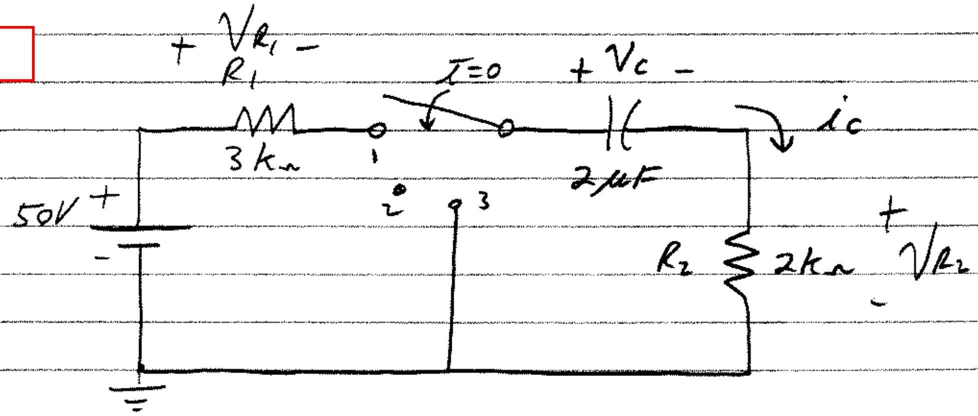


(a) WRITE EXPRESSIONS FOR V_c, V_{R_1}, i_c AFTER THE SWITCH IS PUT INTO POSITION 1. ← $t=0$

$$i_{c\,MAX}\Big|_{t=0+} = \frac{50V}{R_1+R_2} = \underline{10\,mA}$$

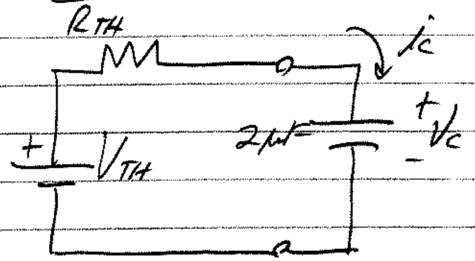
$$\tau = (R_1+R_2)\,C = \underline{10\,ms}$$

$$\therefore \boxed{i_c(t) = 10\,mA\, e^{-t/10\,ms}} \quad (1)$$

$$\boxed{V_{R_1} = i_c(t)\cdot R_1 = 30V\,e^{-t/10\,ms}} \quad (2)$$

$$\boxed{V_c(t) = 50V\left(1 - e^{-t/10\,ms}\right)} \quad (3)$$

ASIDE ($t=0+$)



$V_{TH} = 50V$
$R_{TH} = 5k\Omega$

(b) AT $t = 100\,ms$, POS 1 → POS 2. FIND $V_c(t)$, $V_{R_1}(t)$ & $i_c(t)$

HOLDS CHARGE

AT 100 ms (JUST BEFORE THE SWITCH CHANGES POSITION)

$$\boxed{\begin{aligned} i_c(100\,ms) &= 454\,nA \\ V_{R_1}(100\,ms) &= 1.36\,mV \\ V_c(100\,ms) &= 49.998 \sim 50V \end{aligned}}$$

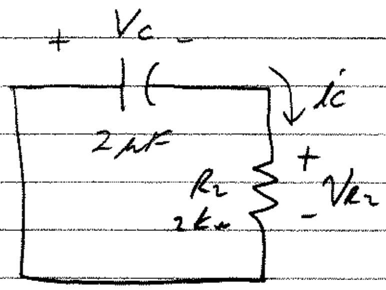
FROM (1) – (3) ABOVE

P26 CONTINUED

(c) WRITE EXPRESSIONS FOR $V_C(t)$, $V_{R_2}(t)$ + $i_C(t)$ IF THE SWITCH IS MOVED TO POS 3 AT 200 mS

DISCHARGE STARTS

POS 3



JUST AFTER THE SWITCH IS MOVED TO POS 3:

$V_C(200\,mS) = 50V$

$\therefore V_C(t) = 50V e^{-(t-200mS)/\tau'}$, $\tau' = (2\mu F)(2k\Omega) = \underline{4\,mS}$

$$\boxed{V_C(t) = 50V\, e^{-(t-200mS)/4mS}} \quad (4)$$

GOOD FOR $t > 200\,mS$

$$\boxed{V_{R_2} = -V_C = -50V e^{-(t-200mS)/4mS}} \quad (5)$$

$$i_C(t) = \frac{V_{R_2}(t)}{R_2} = \boxed{-25mA\, e^{-(t-200mS)/4mS}} \quad (6)$$

(d) PLOT V_C, V_{R_2} + i_C FOR $0 < t < 300\,mS$

$0 \rightarrow 100\,mS$: CHARGE, USE (1) − (3)

$100\,mS \rightarrow 200\,mS$: $V_C = 50V$, $i_C \sim 0A$ (HOLDING CHARGE)

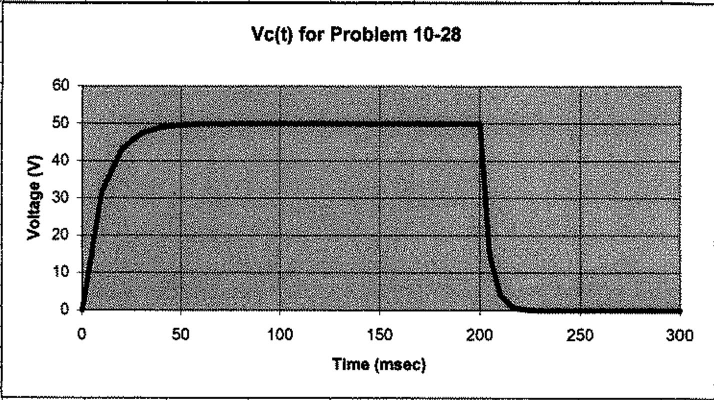
$200\,mS \rightarrow 300\,mS$: USE (4) − (6)

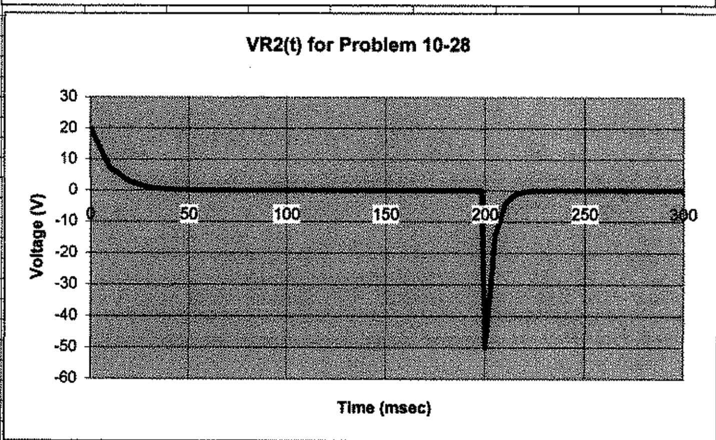
PLOT = EXCEL OR EQUIVALENT

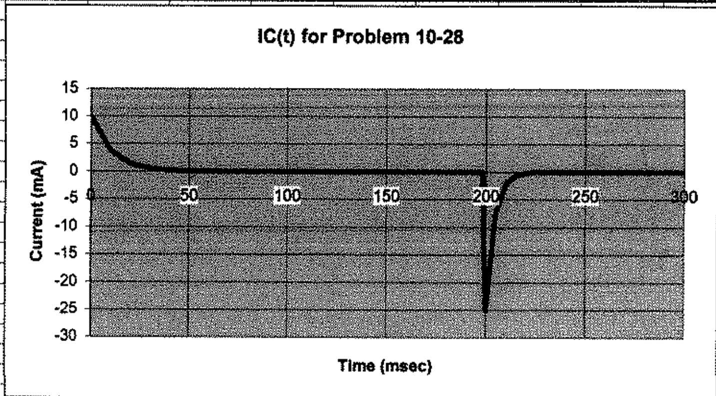
→

P26 CONTINUED

Time	Vc(t)	VR2(t)	Ic(t)
msec	V	V	mA
0	00.0E+0	20.0E+0	10.0E+0
10	31.6E+0	7.4E+0	3.7E+0
20	43.2E+0	2.7E+0	1.4E+0
30	47.5E+0	99.6E-2	49.8E-2
40	49.1E+0	36.6E-2	18.3E-2
50	49.7E+0	13.5E-2	6.7E-2
60	49.9E+0	5.0E-2	2.5E-2
70	50.0E+0	1.8E-2	91.2E-4
80	50.0E+0	67.1E-4	33.5E-4
90	50.0E+0	24.7E-4	12.3E-4
100	50.0E+0	00.0E+0	4.5E-4
110	50.0E+0	00.0E+0	00.0E+0
120	50.0E+0	00.0E+0	00.0E+0
130	50.0E+0	00.0E+0	00.0E+0
140	50.0E+0	00.0E+0	00.0E+0
150	50.0E+0	00.0E+0	00.0E+0
160	50.0E+0	00.0E+0	00.0E+0
170	50.0E+0	00.0E+0	00.0E+0
180	50.0E+0	00.0E+0	00.0E+0
190	50.0E+0	00.0E+0	00.0E+0
192	50.0E+0	00.0E+0	00.0E+0
194	50.0E+0	00.0E+0	00.0E+0
196	50.0E+0	00.0E+0	00.0E+0
198	50.0E+0	00.0E+0	00.0E+0
200	50.0E+0	-50.0E+0	-25.0E+0
205	14.3E+0	-14.3E+0	-7.2E+0
210	4.1E+0	-4.1E+0	-2.1E+0
215	1.2E+0	-1.2E+0	-58.8E-2
220	33.7E-2	-33.7E-2	-16.8E-2
225	9.7E-2	-9.7E-2	-4.8E-2
230	2.8E-2	-2.8E-2	-1.4E-2
235	79.2E-4	-79.2E-4	-39.6E-4
240	22.7E-4	-22.7E-4	-11.3E-4
245	6.5E-4	-6.5E-4	-3.3E-4
250	1.9E-4	-1.9E-4	-93.2E-6
255	53.4E-6	-53.4E-6	-26.7E-6
260	15.3E-6	-15.3E-6	-7.6E-6
265	4.4E-6	-4.4E-6	-2.2E-6
270	1.3E-6	-1.3E-6	-62.8E-8
275	36.0E-8	-36.0E-8	-18.0E-8
280	10.3E-8	-10.3E-8	-5.2E-8
285	3.0E-8	-3.0E-8	-1.5E-8
290	84.6E-10	-84.6E-10	-42.3E-10
295	24.2E-10	-24.2E-10	-12.1E-10
300	6.9E-10	-6.9E-10	-3.5E-10







29. a. $\upsilon_C = V_f + (V_i - V_f)e^{-t/\tau}$

$\tau = RC = (4.7\ \text{k}\Omega)(4.7\ \mu\text{F}) = 22.1\ \text{ms},\quad V_f = 40\ \text{V},\quad V_i = 6\ \text{V}$

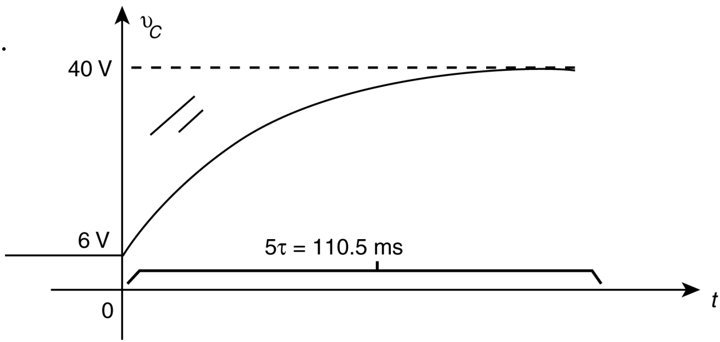
$\upsilon_C = 40\ \text{V} + (6\ \text{V} - 40\ \text{V})e^{-t/22.1\text{ms}}$

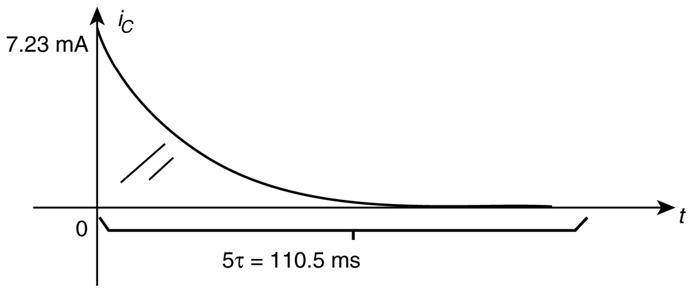
$\upsilon_C = \mathbf{40\ V - 34\ V}\boldsymbol{e^{-t/22.1\text{ms}}}$

b. Initially $V_R = E + \upsilon_C = 40\ \text{V} - 6\ \text{V} = 34\ \text{V}$

$$i_C = \frac{V_R}{R}e^{-t/\tau} = \frac{34\ \text{V}}{4.7\ \text{k}\Omega}e^{-t/22.1\text{ms}} = \mathbf{7.23\ mA}\ \boldsymbol{e^{-t/22.1\text{ms}}}$$

c.





P37

a. $\upsilon_C = 140\text{ mV}(1 - e^{-1\text{ms}/2\text{ ms}}) = 140\text{ mV}(1 - e^{-0.5}) = 140\text{ mV}(1 - 0.6065)$

$= 140\text{ mV}(0.3935) = \mathbf{55.59\ mV}$

b. $\upsilon_C = 140\text{ mV}(1 - e^{-10}) = 140\text{ mV}(1 - 45.4 \times 10^{-6})$

$\cong \mathbf{139.99\ mV}$

c. $100\text{ mV} = 140\text{ mV}(1 - e^{-t/2\text{ ms}})$

$0.714 = 1 - e^{-t/2\text{ ms}}$

$0.286 = e^{-t/2\text{ ms}}$

$\log_e 0.286 = \log_e e^{-t/2\text{ ms}}$

$1.252 = -t/2\text{ ms}$

$t = 1.252\ (2\text{ ms}) = \mathbf{2.5\ ms}$

d. $\upsilon_C = 138\text{ mV} = 140\text{ mV}(1 - e^{t/2\text{ ms}})$

$0.986 = 1 - e^{-t/2\ ms}$

$-14 \times 10^{-3} = -e^{-t/2\text{ ms}}$

$\log_e 14 \times 10^{-3} = -t/2\text{ ms}$

$-4.268 = -t/2\text{ ms}$

$t = (4.268)(2\text{ ms}) = \mathbf{8.54\ \mu s}$

P40

a. $\tau = RC = (12\text{ k}\Omega + 8.2\text{ k}\Omega)(6.8\ \mu\text{F}) = 137.36\text{ ms}$

$$\upsilon_C = 60\text{ V}(1 - e^{-t/\tau})$$

$$48\text{ V} = 60\text{ V}(1 - e^{-t/\tau})$$

$$0.8 = 1 - e^{-t/\tau}$$

$$0.2 = e^{-t/\tau}$$

$$\log_e 0.2 = \log_e e^{-t/\tau}$$

$$-1.61 = -t/\tau$$

$$t = (1.61)\tau = (1.61)(137.36\text{ ms}) = \mathbf{221.15\text{ ms}}$$

b. $i_C = \dfrac{E}{R}e^{-t/\tau} = \dfrac{60\text{ V}}{20.2\text{ k}\Omega}e^{-t/\tau}$

$$= 2.97\text{ mA}e^{-t/137.36\text{ ms}}$$

$$i_C(221.15\text{ ms}) = 2.97\text{ mA}e^{-221.15\text{ ms}/137.36\text{ ms}}$$

$$= 2.97\text{ mA}e^{-1.61}$$

$$= 2.97\text{ mA}\,(199.89 \times 10^{-3})$$

$$= \mathbf{0.594\text{ mA}}$$

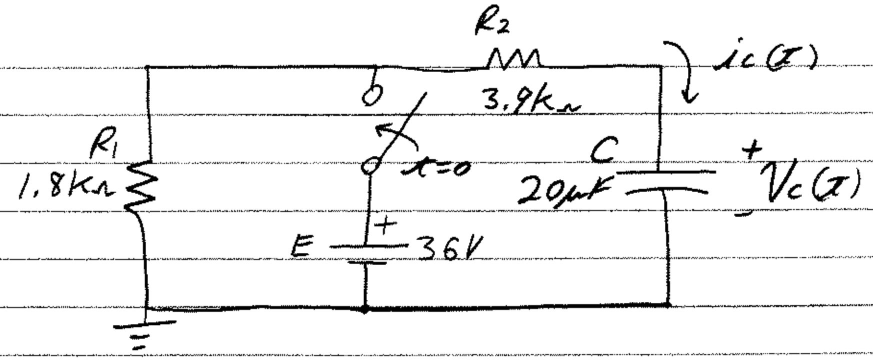
c. $t = 2\tau$

$$i_C = 2.97\text{ mA}e^{-2\tau/\tau} = 2.97\text{ mA}\underbrace{e^{-2}}_{0.135}$$

$$= 0.4\text{ mA}$$

$$P = EI = (60\text{ V})(0.4\text{ mA}) = \mathbf{24\text{ mW}}$$

44)



I.C. $V_C(0) = \underline{-4V}$

(a) FIND $V_C(t)$ & $i_C(t)$ FOR $t > 0$

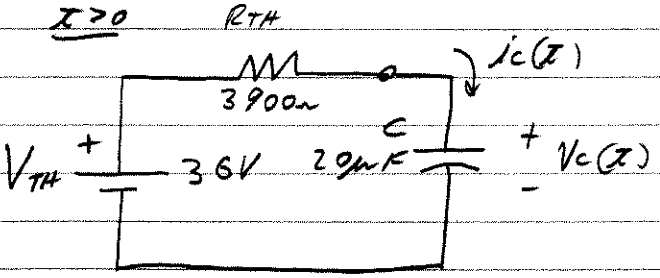
$\underline{t > 0}$

$V_{TH} = E = 36V$

$R_{TH} = R_2 = 3.9k\Omega$

$\tau = (R_{TH})(C) = 78\ mSec$

$\underline{t > 0}$



$i_C(t) = i_{CMAX}\, e^{-t/\tau}$ BUT $i_{CMAX} = \dfrac{36V - (-4V)}{3900\Omega} = \underline{10.26mA}$

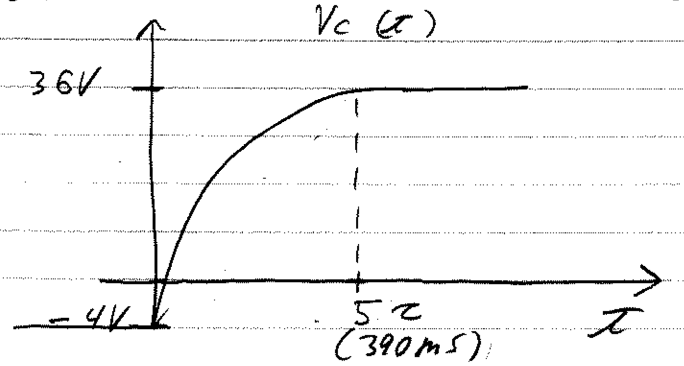
$\tau = 78ms$

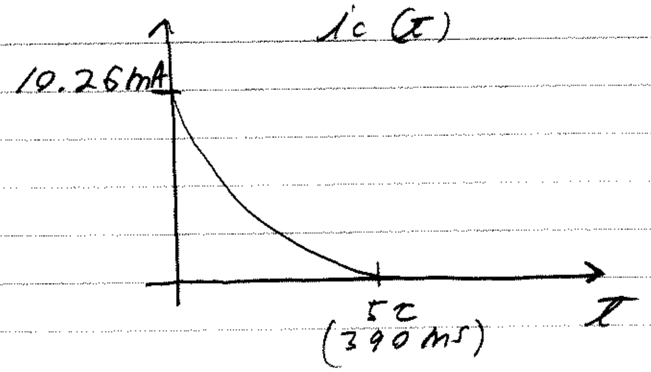
$\therefore \boxed{i_C(t) = 10.26\ mA\ e^{-t/78ms}}$

BY KVL: $V_C(t) = V_{TH} - i_C(t)\, R_{TH}$

$\boxed{V_C(t) = 36V - 40V\, e^{-t/78ms}}$

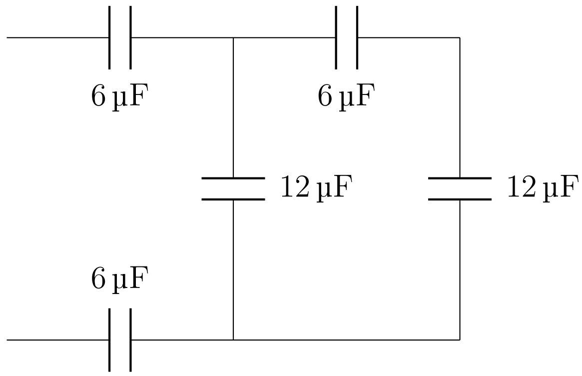
(b) SKETCH $V_C(t)$ & $i_C(t)$





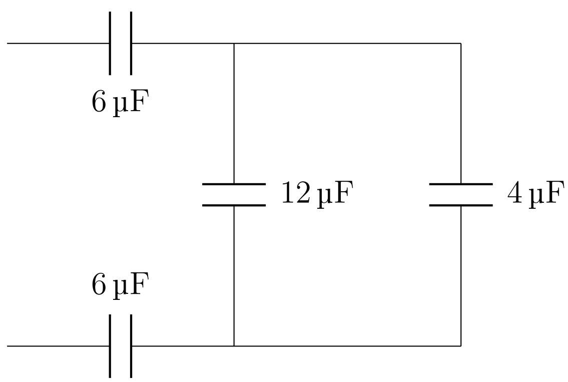
P 52

Find the total capacitance C_T for the network in Fig. 10.120.



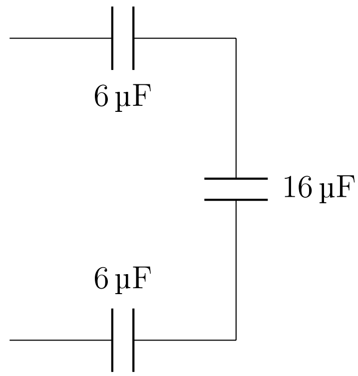
Step 1: Series combination of the 6 µF and 12 µF capacitors

$$C_{EQ_1} = \frac{1}{\frac{1}{6\,\mu\text{F}} + \frac{1}{12\,\mu\text{F}}} = 4\,\mu\text{F}$$



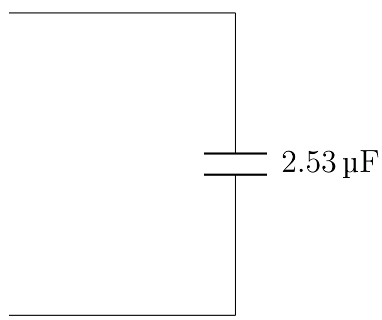
Step 2: Parallel combination of C_{EQ_1} and 12 µF

$$C_{EQ_2} = C_{EQ_1} + 12\,\mu\text{F}$$
$$C_{EQ_2} = 4\,\mu\text{F} + 12\,\mu\text{F} = 16\,\mu\text{F}$$



Step 3: Parallel combination of 6 µF, C_{EQ_2} and 6 µF

$$C_T = \frac{1}{\frac{1}{6\,\mu\text{F}} + \frac{1}{16\,\mu\text{F}} + \frac{1}{6\,\mu\text{F}}} = 2.53\,\mu\text{F}$$



P 53

Find the steady-state voltage across and the charge on each capacitor for the circuit in Fig. 10.121.

The total capacitance of the circuit is:
Step 1: Series combination of the 10 µF and 100 µF

$$C_{EQ_1} = \frac{1}{\frac{1}{10\,\mu\text{F}} + \frac{1}{100\,\mu\text{F}}} = 9.09\,\mu\text{F}$$

Step 2: Parallel combination of C_{EQ_1} and 20 µF capacitor

$$C_T = C_{EQ_1} + 20\,\mu\text{F} = 9.09\,\mu\text{F} + 20\,\mu\text{F}$$
$$C_T = 29.09\,\mu\text{F}$$

Given the 20 V drop across the total capacitance, the total charge across the total capacitor is:

$$Q_T = C_T \cdot V = 29.09\,\mu\text{F} \cdot 20 = 581.82\,\mu\text{C}$$

The charge across the 20 µF capacitor is:

$$Q_{20\,\mu\text{F}} = 20\,\mu\text{F} \cdot 20 = 400\,\mu\text{C}$$

The charge across the C_{EQ_1} is:

$$Q_{EQ_1} = C_{EQ_1} \cdot V = 9.09\,\mu\text{F} \cdot 20 = 181.82\,\mu\text{C}$$

The voltage across the C_{EQ_1} is:

$$Q_{EQ_1} = C_{EQ_1} \cdot V = 9.09\,\mu\text{F} \cdot 20 = 181.82\,\mu\text{C}$$

Given that there is equal amount of charge on the 10 µF and 100 µF, the voltage across the capacitors are:

$$V_{10\,\mu\text{F}} = \frac{C_{EQ_1}}{10\,\mu\text{F}} = \frac{181.82\,\mu\text{C}}{10\,\mu\text{F}} = 18.82\,\text{V}$$
$$V_{100\,\mu\text{F}} = \frac{C_{EQ_1}}{100\,\mu\text{F}} = \frac{181.82\,\mu\text{C}}{10\,\mu\text{F}} = 1.82\,\text{V}$$

P55

See the next page for my solution to this problem

steady – state – ignore 10 kΩ resistor

$330\ \mu\text{F} + 120\ \mu\text{F} = 450\ \mu\text{F}$

$C_T = 220\ \mu\text{F} \parallel 450\ \mu\text{F} = 147.76\ \mu\text{F}$

$Q_T = Q_1 = C_T E = (147.76\ \mu\text{F})(20\ \text{V}) = \mathbf{2.96\ mC}$

$$V_1 = \frac{Q_1}{C_1} = \frac{2.96\ \text{mC}}{220\ \mu\text{F}} = \mathbf{13.45\ V}$$

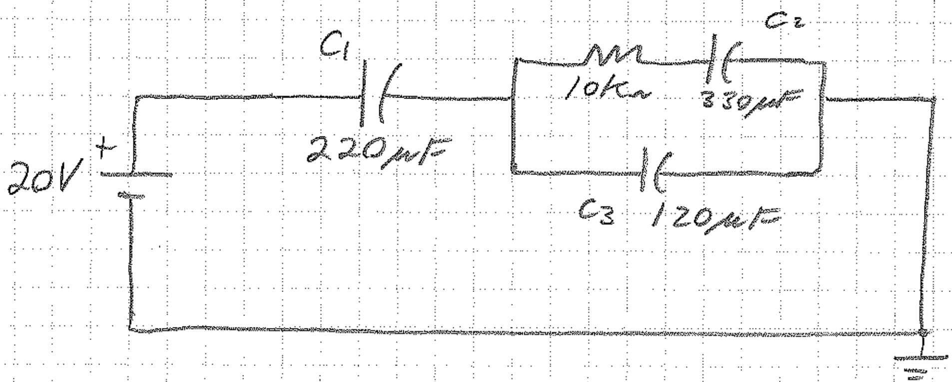
$V_3 = V_2 = E - V_1 = 20\ \text{V} - 13.45\ \text{V} = \mathbf{6.55\ V}$

$Q_2 = C_2 V_2 = (330\ \mu\text{F})(6.55\ \text{V}) = \mathbf{2.16\ mC}$

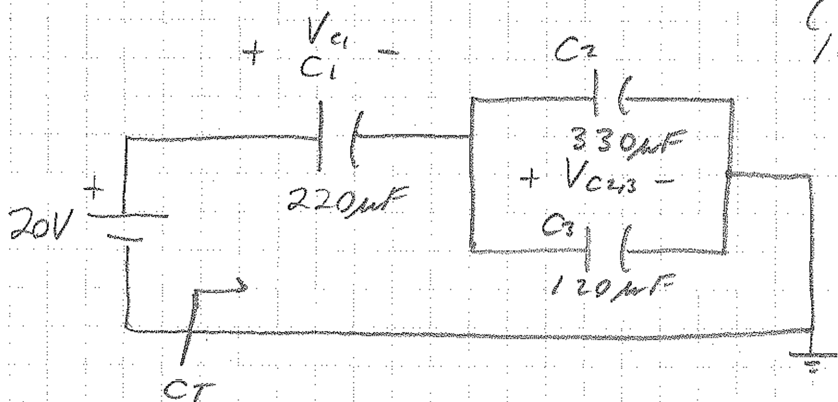
$Q_3 = C_3 V_3 = (120\ \mu\text{F})(6.55\ \text{V}) = \mathbf{0.786\ mC}$

P55

FIND THE VOLTAGE ACROSS & CHARGE ON EACH CAPACITOR (STEADY STATE).



STEADY-STATE CONDITIONS, CAPS FULLY CHARGED (NO I FLOW) ∴ IGNORE THE 10kΩ R



$C_T = (C_2 + C_3)$ COMBINED W/ C_1 IN SERIES

$C_2 + C_3 = 450\mu F \longrightarrow C_{EQ}$

$\therefore\ C_T = \dfrac{(450\mu F)(220\mu F)}{450\mu F + 220\mu F} = \underline{147.8\mu F}$

HENCE $Q_T = C_T V = (147.8\mu F)(20V) = \underline{2.96mC}$

SERIES CIRCUIT, HENCE

$Q_{C1} = Q_{CEQ} = Q_T = \boxed{2.96\,mC}$

HENCE $V_{C1} = \dfrac{Q_{C1}}{C_1} = \dfrac{2.96mC}{220\mu F} = \boxed{13.43V}$

$V_{C2,3} = \dfrac{Q_{CEQ}}{C_{EQ}} = \dfrac{2.96mC}{450\mu F} = \boxed{6.57V}$

$Q_2 = (C_2)(V_{C2,3}) = (330\mu F)(6.57V) = \boxed{2.17\,mC}$

$Q_3 = (C_3)(V_{C2,3}) = (120\mu F)(6.57V) = \boxed{788\mu C}$