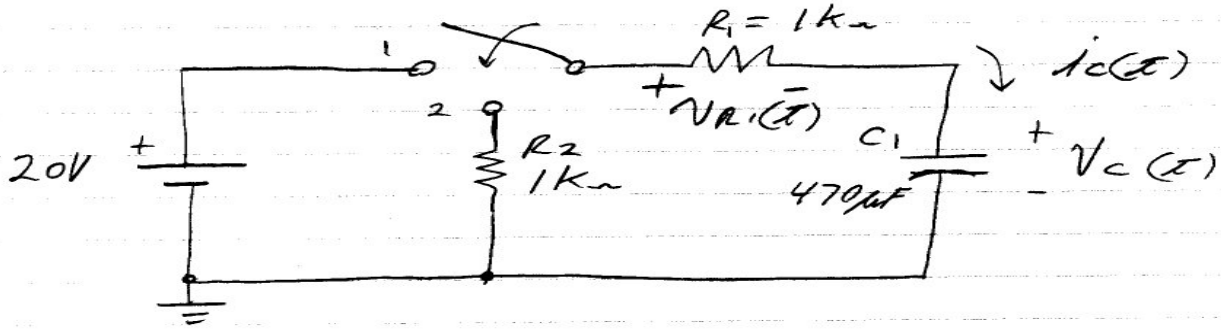
## SIMPLE CAPACITOR CIRCUIT (CHARGE/DISCHARGE)




AT $t = 0$, SW → POSITION 1

AT $t = 10$ SEC, SW → POSITION 2

FIND:

a) $\tau$

b) $i_C(t)$

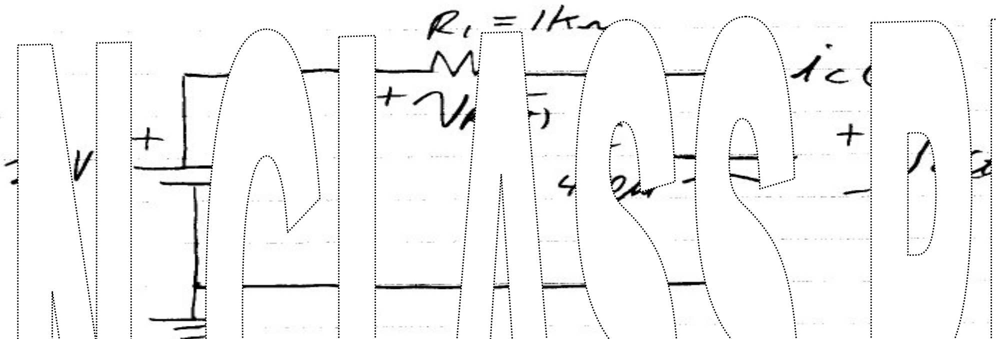
c) $V_{R_1}(t)$

d) $V_C(t)$

e) $t$ FOR $V_C(t) = 10V$

} FOR BOTH CHARGE & DISCHARGE

### CHARGE CIRCUIT




$\tau$ = TAU = RC = (1K)(470μ...) = ...47 SEC

$i_C(t)$ ... $i_{C\,max} = \frac{20V}{R_1} = \frac{...}{1k\Omega}$ = ...A

$$\therefore \boxed{i_C(t) = 20\times10^{-3}\, e^{-t/0.47} \; A}$$

$$V_{R1}(t) = R_1 \cdot i_C(t) = (1k\Omega)\cdot i_C(t)$$

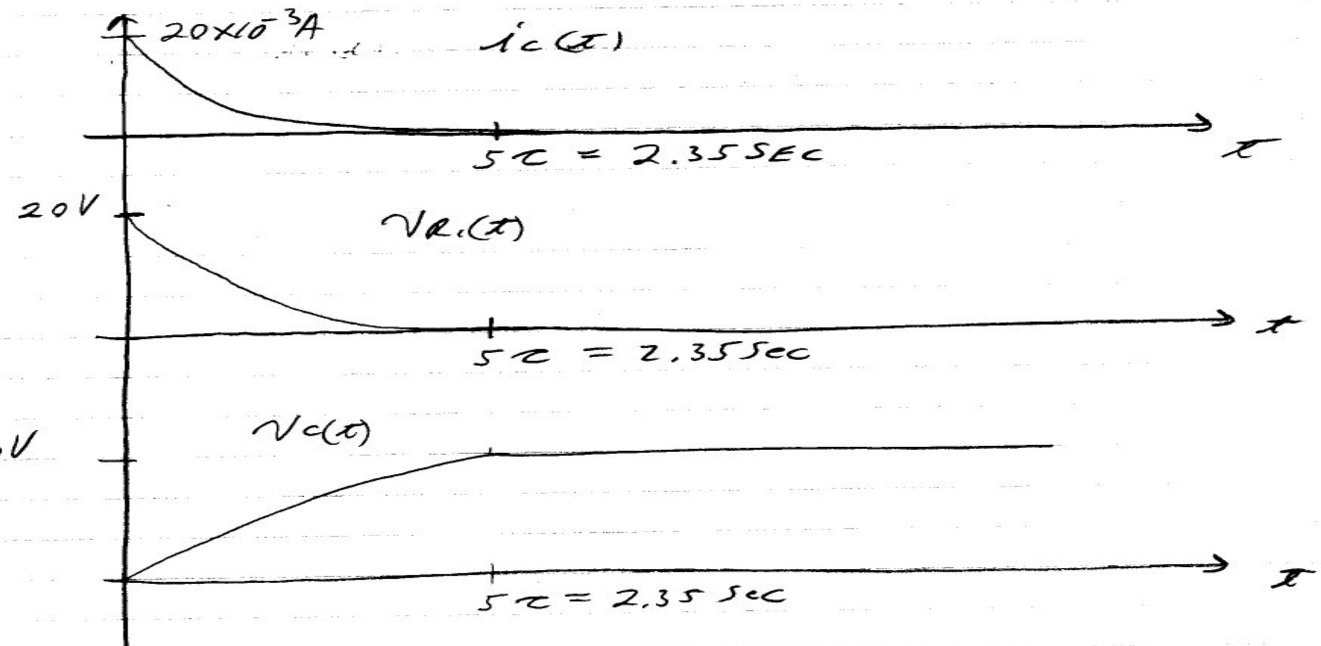
$$\boxed{V_{R1}(t) = 20\, e^{-t/0.47} \; V}$$

$$V_C(t) = 20V - V_{R1}(t)$$

$$= 20 - 20\, e^{-t/0.47}$$

$$\boxed{V_C(t) = 20\left(1 - e^{-t/0.47}\right) \; V}$$

SKETCH




$t$ FOR $V_C(t) = 10V$? ← AROUND 0.4 Sec ($1\tau \rightarrow 63\%$)

$$10 = 20\left(1 - e^{-t/0.47}\right)$$

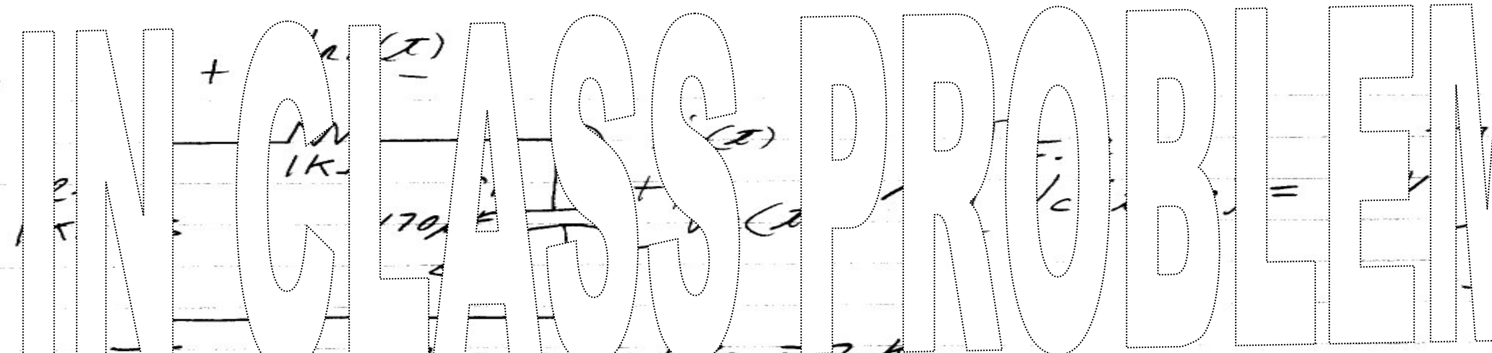
$$+0.5 = +e^{-t/0.47}$$

$$\ln(0.5) = \ln\left(e^{-t/0.47}\right)$$

$$-0.693 = -t/0.47$$

$$\therefore \boxed{t = 0.326 \text{ SECONDS}}$$

DISCHARGE
VALID FOR
$t > 10$



$R_{TH} = R_1 + R_2 = 2k\Omega$

$\tau = R_{TH} \cdot C_T = (2k\Omega)(470\mu F) = \boxed{940ms}$

$i_C(t) = -i_{CMAX}\, e^{-t/\tau}$ ← GENERAL FORM

$i_{CMAX} = \dfrac{20V}{2k\Omega} = \underline{10mA}$

SWITCH CLOSED AT $\underline{t = 10}$

$\therefore \boxed{i_C(t) = -10\times10^{-3}\, e^{-(t-10)/0.94}\ A}$

$V_{R_1}(t) = i_C(t) \cdot R_1 = \boxed{-10\, e^{-(t-10)/0.94}\ V}$

$V_C(t) = V_{CMAX}\, e^{-(t-10)/0.94}\ V$

$\boxed{V_C(t) = 20V\, e^{-(t-10)/0.94}\ V}$

$t$ FOR $V_C(t) = 10V$ ?

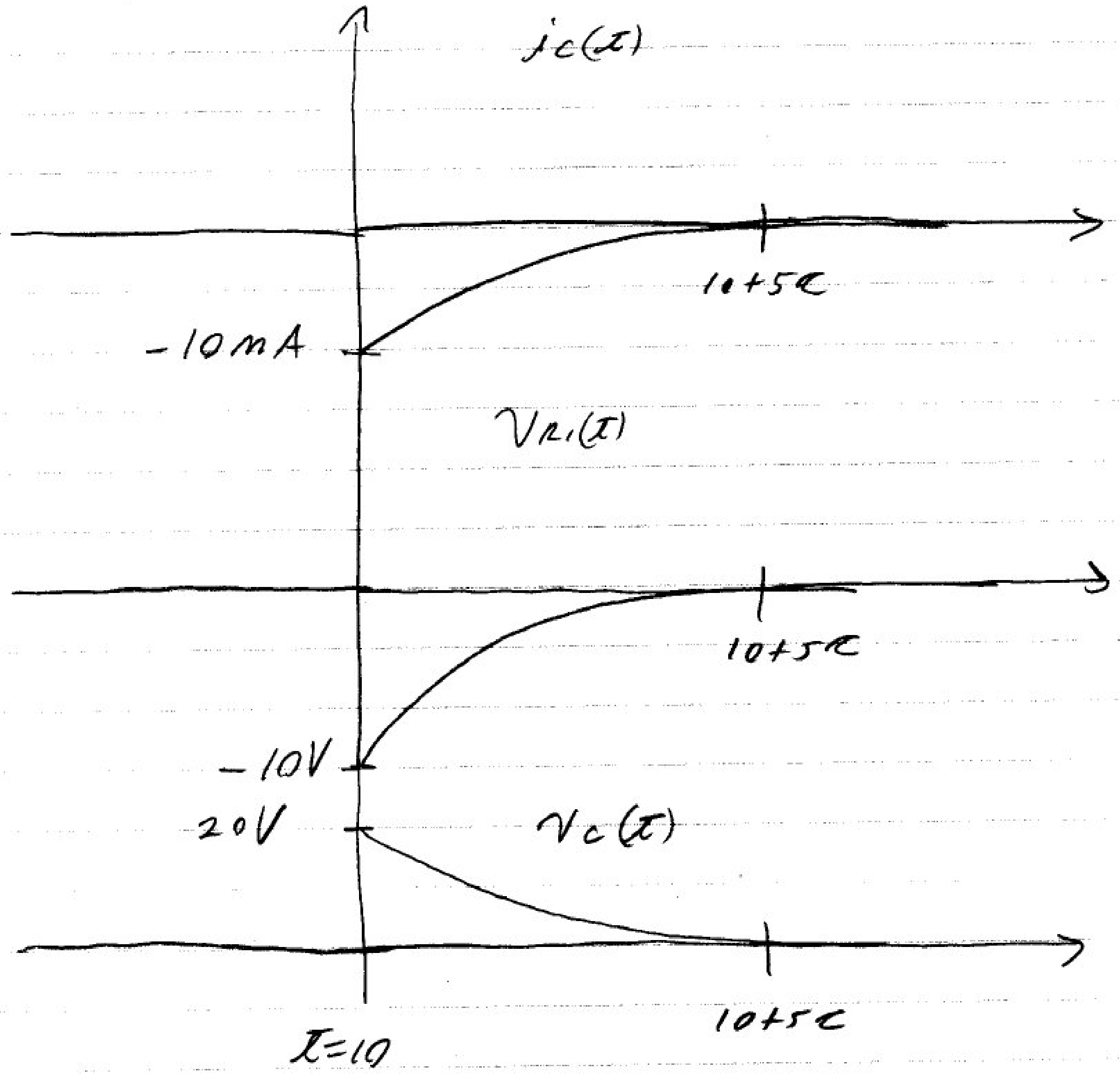
$10 = 2[illegible]\, e^{-(t-10)/0.9[illegible]}$

$0.6[illegible] \ldots (t[illegible]) \ldots 4$

$0.652 = (t-[illegible]$

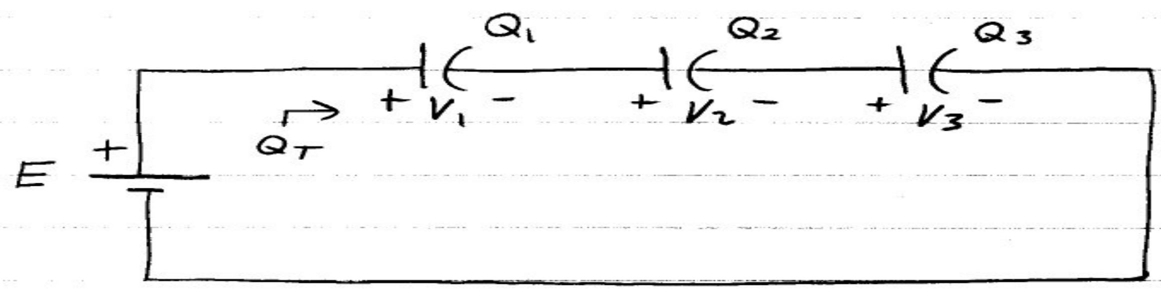
[illegible]

# SKETCH - DISCHARGE



10.13 CAPACITORS IN SERIES & PARALLEL

SERIES




RECALL: $I = \frac{Q}{t}$ $\therefore$ $Q = I \cdot t$

$Q_T = Q_1 = Q_2 = Q_3$, THE SAME CHARGE EXISTS ON EACH CAPACITOR

KVL: $E = V_1 + V_2 + V_3$ (1)

RECALL: $V = Q/C$ (2)

(2) INTO (1):

$$\frac{Q_T}{C_T} = \frac{Q_1}{C_1} + \frac{Q_2}{C_2} + \frac{Q_3}{C_3} \qquad (3)$$

SINCE $Q_T = Q_1 = Q_2 = Q_3$, (3) BECOMES:

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

$$\therefore \quad C_T = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}} \qquad (4)$$

GENERALIZING, FOR N CAPACITORS IN SERIES:

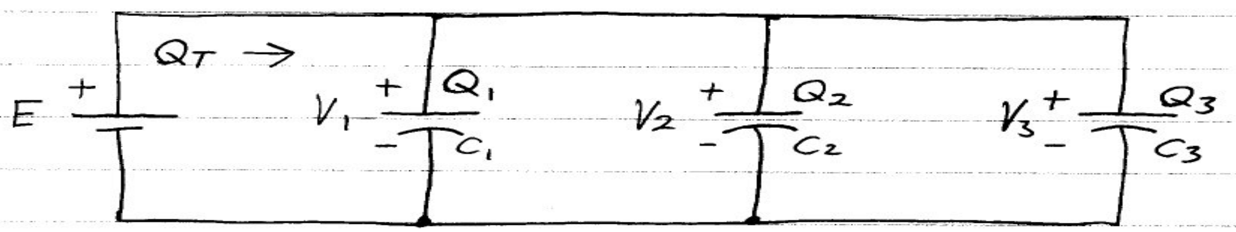
$$\boxed{C_T = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \ldots + \frac{1}{C_N}}}$$

CAPACITORS IN SERIES COMBINE LIKE RESISTORS IN PARALLEL

FOR TWO CAPACITORS IN SERIES:

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

PARALLEL




$$Q_T = Q_1 + Q_2 + Q_3 \qquad (5)$$

USING $Q = CV$, (5) BECOMES:

$$C_T \cdot E = C_1 \cdot V_1 + C_2 \cdot V_2 + C_3 \cdot V_3$$

BUT $V_1 = V_2 = V_3 = E \quad \therefore$

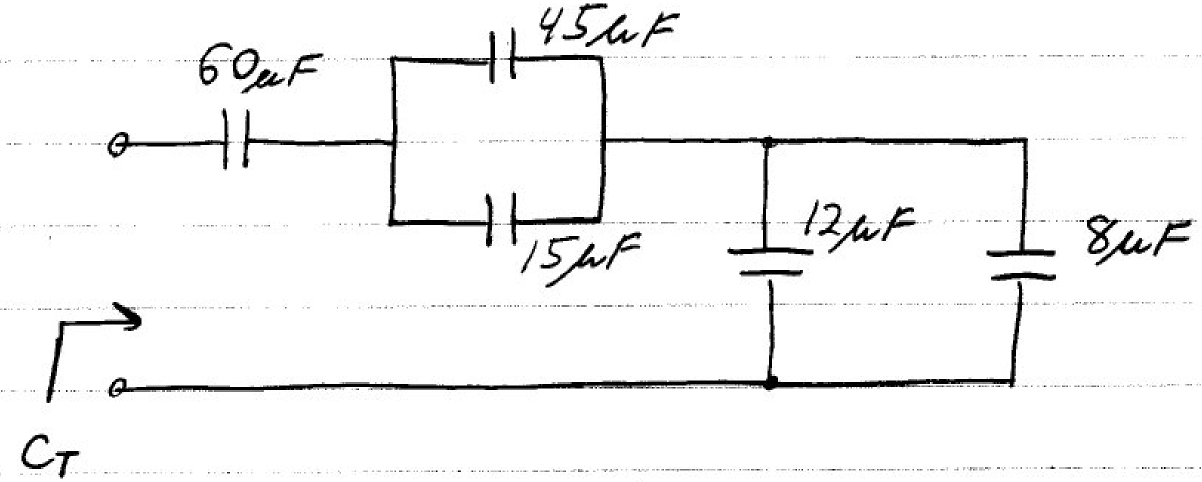
$$\boxed{C_T = C_1 + C_2 + C_3}$$

FOR N CAPACITORS IN PARALLEL:

$$\boxed{C_T = C_1 + C_2 + \ldots + C_N}$$

CAPACITORS IN PARALLEL COMBINE LIKE RESISTORS IN SERIES

(EXAMPLE 1) FIND $C_T$:




IN CLASS PROBLEM

[illegible]