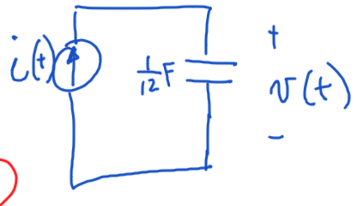
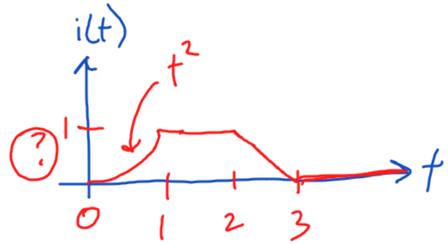
1





$i = Cv'$

$$\boxed{v = \frac{1}{C}\int_{t_0}^{t} i(\tau)\,d\tau + v(t_0)}$$ Cap

$v = L i'$

$$i = \frac{1}{L}\int_{t_0}^{t} v(\tau)\,d\tau + i(t_0)$$ Ind

$$i(t) = \begin{cases} t^2, & 0 < t \le 1 \\ 1, & 1 < t \le 2 \\ -1(t-3), & 2 < t \le 3 \\ 0, & t > 3 \end{cases}$$

a) Find $v(t)$ if $v(t=0) = 0\,V$, $t > 0$

time regions	t_0	$v(t_0)$	$i(t)$	$v = 12\int_{t_0}^{t} i(\tau)\,d\tau + v(t_0)$
$0 < t \le 1$	0	0	t^2	$12\int_0^t \tau^2\,d\tau + 0 = 12\cdot\frac{1}{3}\tau^3\Big]_{\tau=0}^{t} + 0$ $= 4[t^3 - 0] = \boxed{4t^3\,V}$
$1 < t \le 2$	1	$4\cdot 1^3 = 4$	1	$12\int_1^t d\tau + 4 = 12\tau\Big]_{\tau=1}^{t} + 4 = 12(t-1)+4$ $= \boxed{12t - 8\ V}$
$2 < t \le 3$	2	$12\cdot 2 - 8$ 16	$3 - t$	$12\int_2^t (3-\tau)\,d\tau + 16 = 12\cdot\left[3\tau - \frac{1}{2}\tau^2\right]_{\tau=2}^{t} + 16$ $12\left[\left[3t - \frac{1}{2}t^2\right] - \left[\underbrace{3\cdot 2 - \frac{1}{2}\cdot 4}_{4}\right]\right] + 16$ $12\left[3t - \frac{1}{2}t^2 - 4\right] + 16$ $\boxed{36t - 6t^2 - 32}$
$t > 3$	3	$36\cdot 3 - 6\cdot 9 - 32$ 22	0	$12\int 0 + 22 = \boxed{22}$

$$\boxed{v(t) = \begin{cases} 4t^3\,V, & 0 < t \le 1 \\ 12t - 8, & 1 < t \le 2 \\ 36t - 6t^2 - 32, & 2 < t \le 3 \\ 22, & t > 3 \end{cases}}$$

b) Find $w(2)$

$w_C(t) = \frac{1}{2}Cv^2$ $\qquad$ $w_L = \frac{1}{2}Li^2$

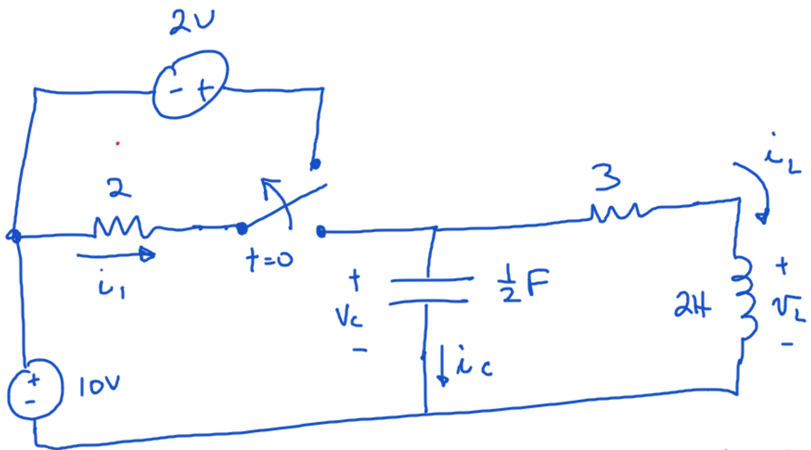
$= \frac{1}{2}\cdot C\cdot v^2(2)$

$= \frac{1}{2}\left(\frac{1}{12}\right)16^2$ $\qquad$ $v_C^2(2) = 12(2) - 8 = 16$

$= \frac{16^2}{24} = \boxed{10.7\,J}$

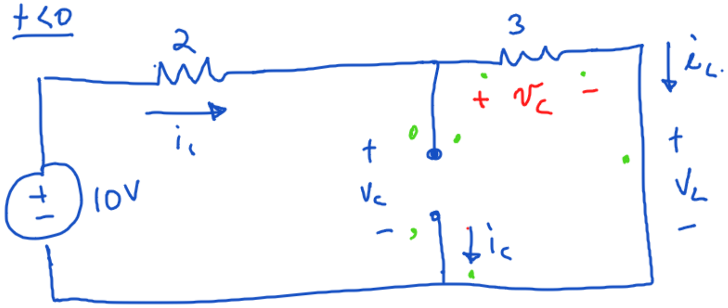
2 DC Steady State

Problem 2/5



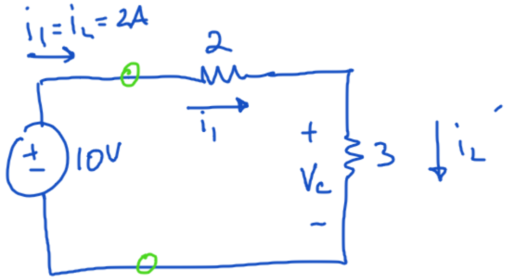
(a) Find i_1, i_c, i_L, v_c, v_L at both $t=-3$ and $t=0^-$

$t<0$

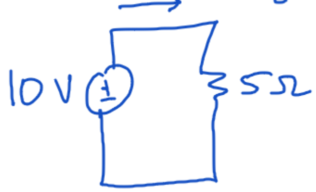


$$\boxed{\begin{aligned} i_1 &= 2A \\ i_c &= 0A \\ i_L &= 2A \\ V_c &= (2A)(3\Omega) = 6V \\ V_L &= 0V \end{aligned}}$$

$i_1 = i_L = 2A$



$i_1 = i_L = \frac{10}{5} = 2$



(b) Find $Q_c(t=-2)$

$$Q_c = C \cdot V$$
$$= \left(\tfrac{1}{2}\right)(6)$$
$$= \boxed{3\ C}$$

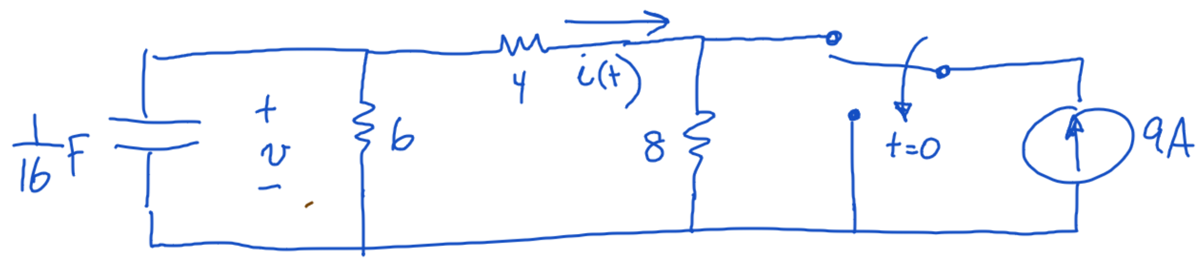
(c) Find $W_L(t=0^+)$

$$W_L = \tfrac{1}{2} L i_L^2$$
$$W_L(0^+) = \tfrac{1}{2}(2)\, i_L^2(0^+)$$
$$= \tfrac{1}{2}(2)\, i_L^2(0^-)$$
$$= \tfrac{1}{2}(2) \cdot 2^2$$
$$= \boxed{4\ J}$$

Voltage continuity for a cap
Voltage across a cap cannot change instantaneously

Current continuity for inductor
Current through an inductor cannot change inst.

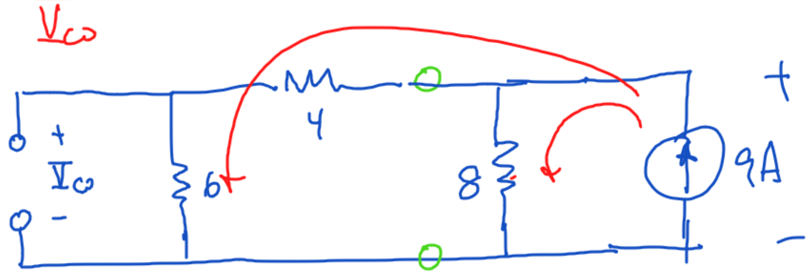
3)

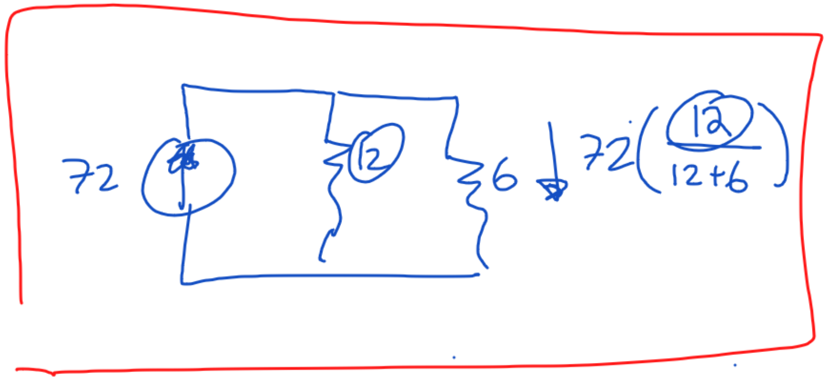


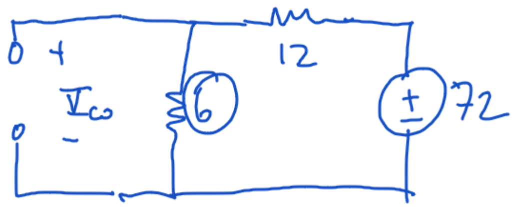
Voltage Dividers
Current Dividers

Find $v(t)$ and $i(t)$ for all time

1 $\boxed{t<0}$ V_{co}







$$V_{co} = 72 \cdot \frac{6}{6+12}$$

$$= 72 \cdot \left(\frac{1}{3}\right)$$

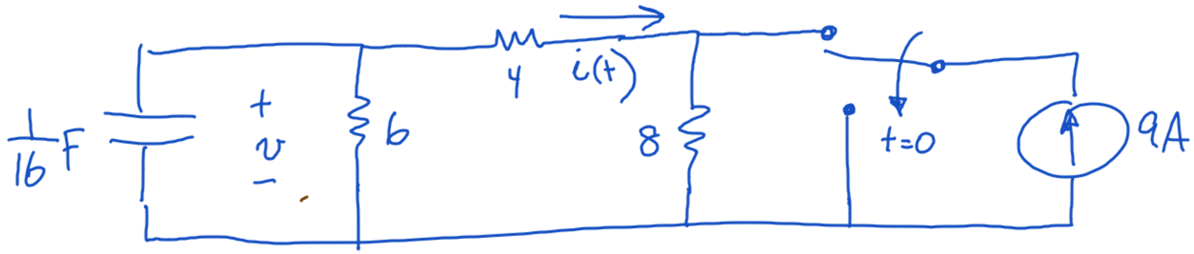
$$\boxed{V_{co} = 24\,V}$$

$v_c(t=0^+) = 24V$

V_{cap} continuous

I_{nd} continuous

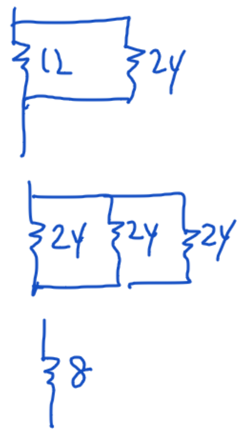
3)



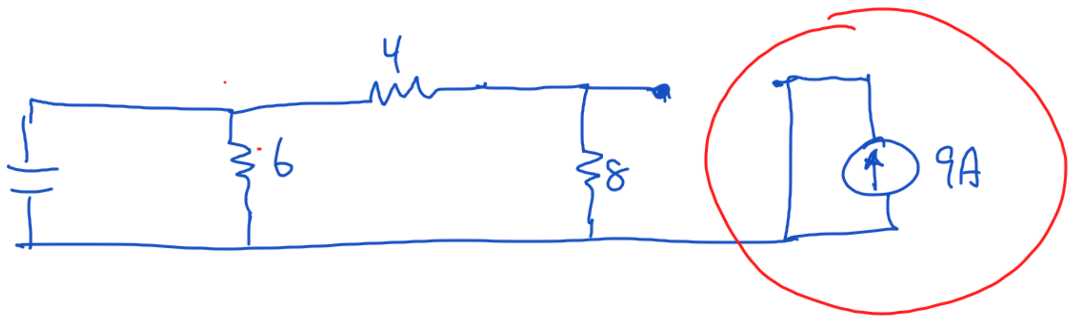
Voltage Dividers
Current Dividers

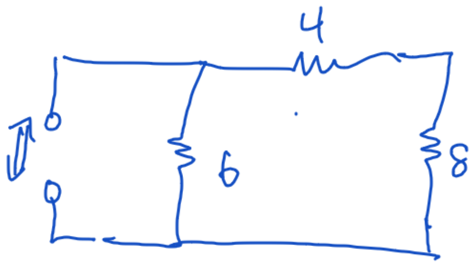
Problem 3/5

Find $v(t)$ and $i(t)$ for all time



2 $t > 0$ Find τ





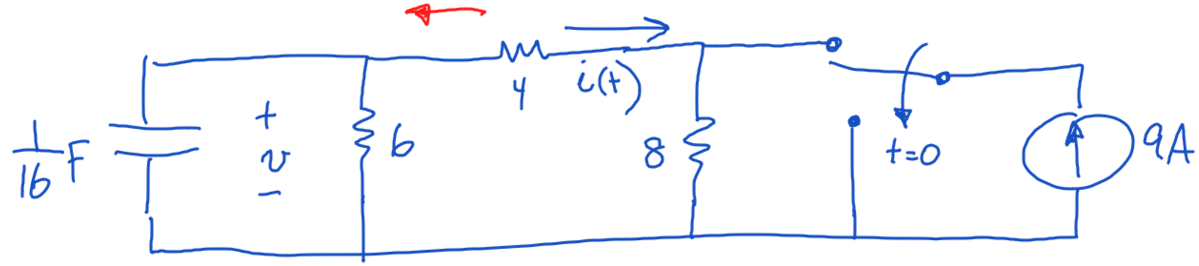
$$R_{eq} = 6 \,//\, (4+8)$$
$$= 6 \,//\, 12$$
$$= 4$$

$$\cancel{\frac{1}{\frac{1}{6}+\frac{1}{12}}}$$

$$\frac{6 \cdot 12}{6+12} \checkmark$$

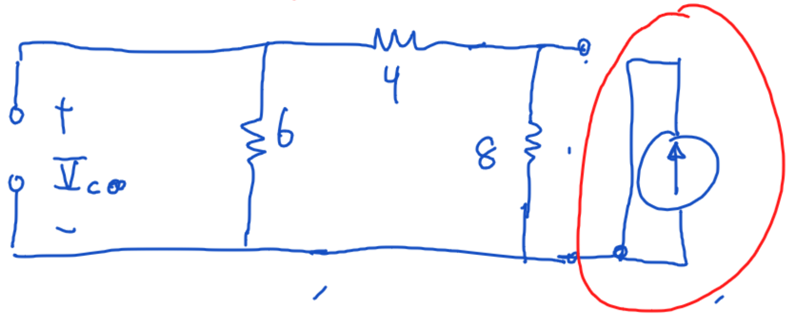
$$\tau = R_{eq} \cdot C$$
$$= 4 \cdot \frac{1}{16}$$
$$= \boxed{\frac{1}{4}\ s}$$

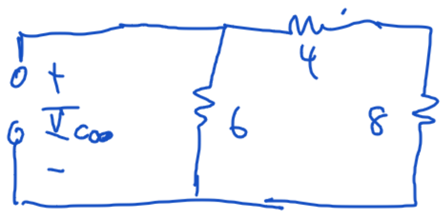
3)



Find $v(t)$ and $\boxed{i(t)}$ for all time

(3) $t=\infty$ $V_{c\infty}$





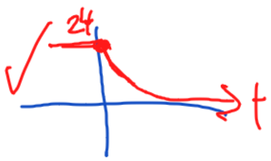
$$\boxed{V_{c\infty} = 0\,V}$$

(4) $0 \le t < \infty$

$$v_c(t) = V_\infty + (V_0 - V_\infty)e^{-\frac{t}{\tau}}$$

$$= 24e^{-4t}, \; t>0$$

$$\boxed{v_c(t) = \begin{cases} 24 & t<0 \\ 24e^{-4t}\,V & t \ge 0 \end{cases}}$$

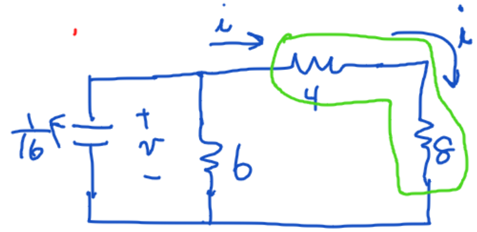


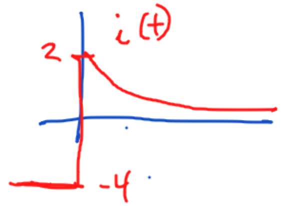
(5) Find asked to find

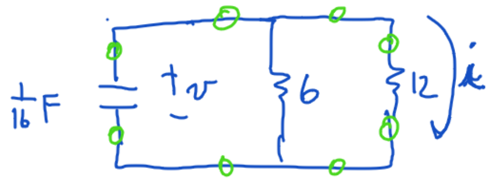
$t<0$ $\boxed{i = -4A}$

$t>0$

$$\boxed{i(t) = \begin{cases} -4A & t<0 \\ 2e^{-4t}A, & t \ge 0 \end{cases}}$$





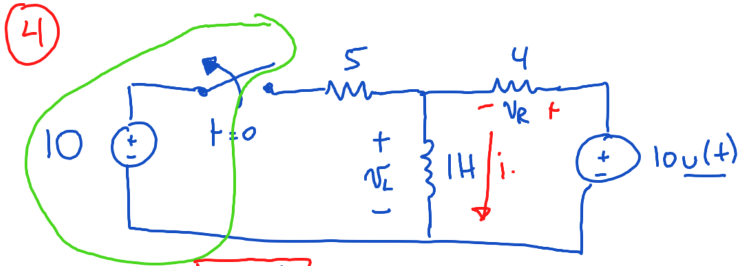


$$i = \frac{v_{12}}{R_{12}}$$

$$= \frac{24e^{-4t}}{12}$$

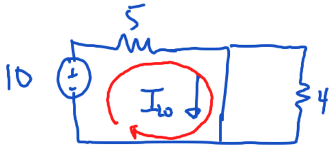
$$= \boxed{2e^{-4t}\,A, \; t \ge 0}$$

(4)



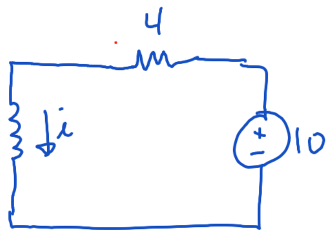
Find $\boxed{v_L(t)}$, $t \geq 0$

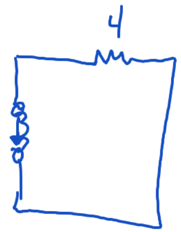
(1) $t<0$ $\boxed{\text{Find } I_{L0}}$



$\boxed{I_{L0} = \frac{10}{5} = 2\text{ A}}$

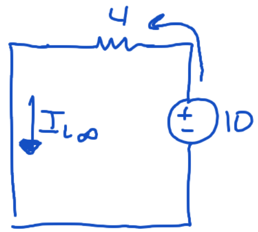
(2) $t>0$ τ





$R_{eq} = 4\,\Omega$ $\tau = RC = \frac{L}{R} = \boxed{\frac{1}{4}}$

(3) $t=\infty$ $I_{L\infty} = \frac{10\text{V}}{4\Omega} = \boxed{\frac{5}{2}\text{ A}}$



(4) $i(t) = I_\infty + (I_0 - I_\infty)e^{-t/\tau}$

$= \boxed{\frac{5}{2} - \frac{1}{2}e^{-4t}\text{ A}}$, $t \geq 0$

(5) KVL : $+v_L - 10 + v_R = 0$

$v_L = 10 - v_R$

$= 10 - i \cdot 4$

$= 10 - [10 - 2e^{-4t}]$

$= \boxed{2e^{-4t}\text{ V}}$

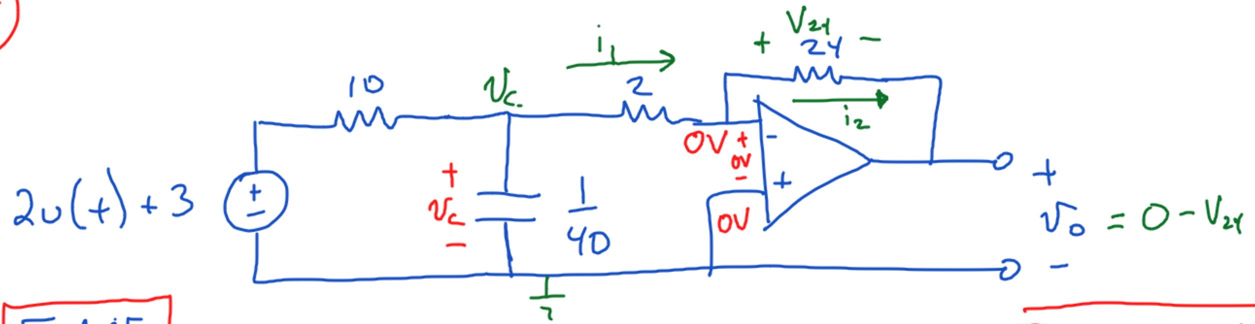
Different way

$v_L = L\,i'$

$= \left(\frac{5}{2} - \frac{1}{2}e^{-4t}\right)'$

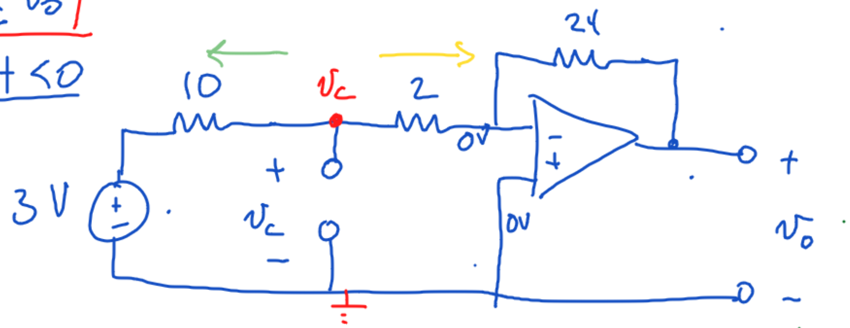
$= \boxed{2e^{-4t}\text{ V}}$

5



Find v_o

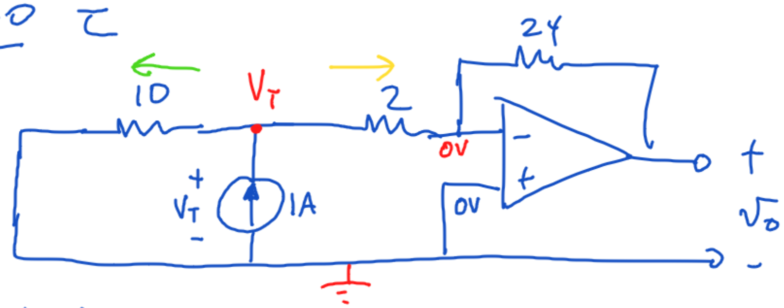
1 $t<0$



$$\frac{v_c-3}{10}+\frac{v_c-0}{2}=0 \qquad v_c-3+5v_c=0$$

$$6v_c=3 \qquad \boxed{v_o=\frac{1}{2}}$$

2 $t>0$ τ



Zero all indep. sources

$$\frac{V_T-0}{10}+\frac{V_T-0}{2}+-1=0$$

$$V_T+5V_T=10$$

$$6V_T=10$$

$$3V_T=5$$

$$V_T=\frac{5}{3}\text{V}$$

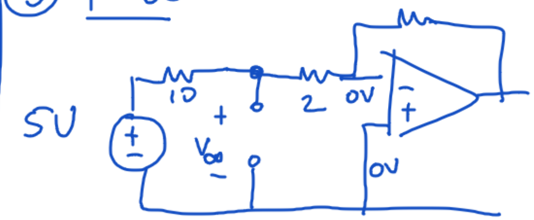
$$R_{eq}=\frac{V_T}{I_T}=\frac{5/3}{1}=\frac{5}{3}$$

$$\tau=R_{eq}C=\left(\frac{5}{3}\right)\left(\frac{1}{40}\right)$$

$$=\boxed{\frac{1}{24}\text{ s}}$$

Golden Rules for Op amps
1. $i^+=0$, $i^-=0$
2. if neg fdbk $v^+=v^-$

3 $t=\infty$



$$\frac{V_\infty-5}{10}+\frac{V_\infty-0}{2}=0$$

$$V_\infty-5+5V_\infty=0$$

$$6V_\infty=5 \Rightarrow \boxed{V_\infty=\frac{5}{6}}$$

4 $v_c(t)=V_\infty+(V_0-V_\infty)e^{-t/\tau}$

$$=\boxed{\frac{5}{6}-\frac{1}{3}e^{-24t}\text{ V},\quad t\geq 0}$$

5 $v_o=?$

a) $i_1=\frac{v_c-0}{2}=\frac{v_c}{2}$

b) $i_2=i_1=\frac{v_c}{2}$

c) $V_{24}=i_2\cdot 24=\frac{v_c}{2}\cdot 24=12\cdot v_c$

d) $V_o=-V_{24}=-12V_c$

$$\boxed{V_o=-10+4e^{-24t}\text{ V}}$$

$0+V_{24}+V_o=0$

$V_o=-V_{24}$