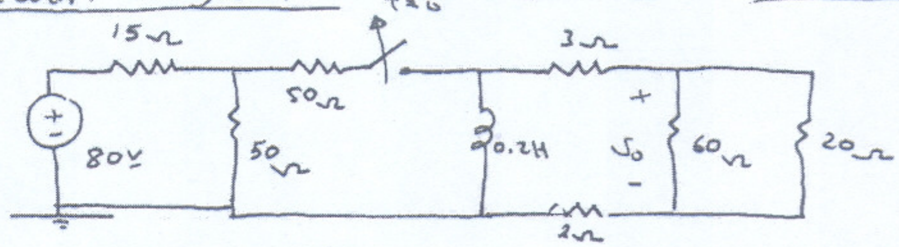
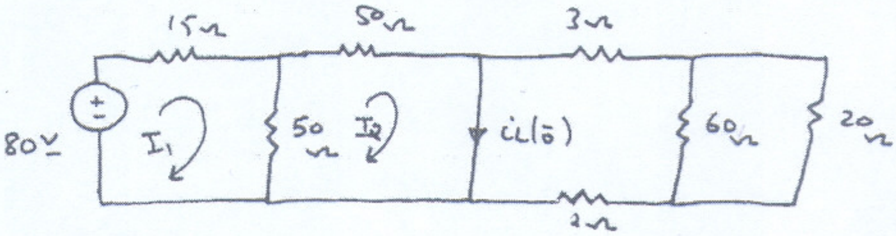
Homework Solutions — Ch. 7 — ENEE 231

7.6

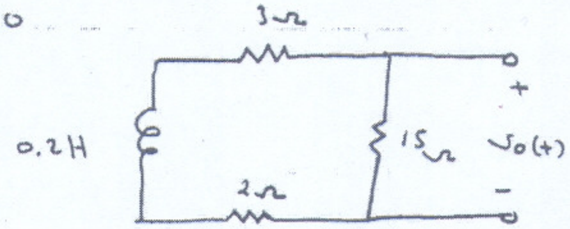


For $t < 0$



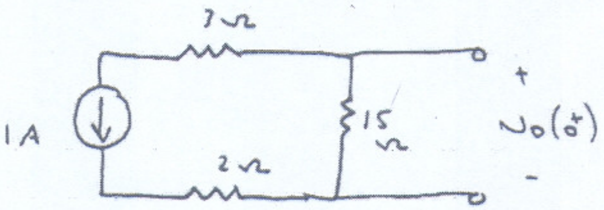
$$80 = 65 I_1 - 50 I_2$$
$$0 = -50 I_1 + 100 I_2$$
$$I_2 = 1A \longrightarrow i_L(0^-) = 1A$$

For $t > 0$



$60\Omega \parallel 20\Omega = 15\Omega$

at $t = 0^+$



$$v_o(0^+) = -15\,\text{V}$$

at $t = \infty$ L is short

$$v_o(\infty) = 0$$

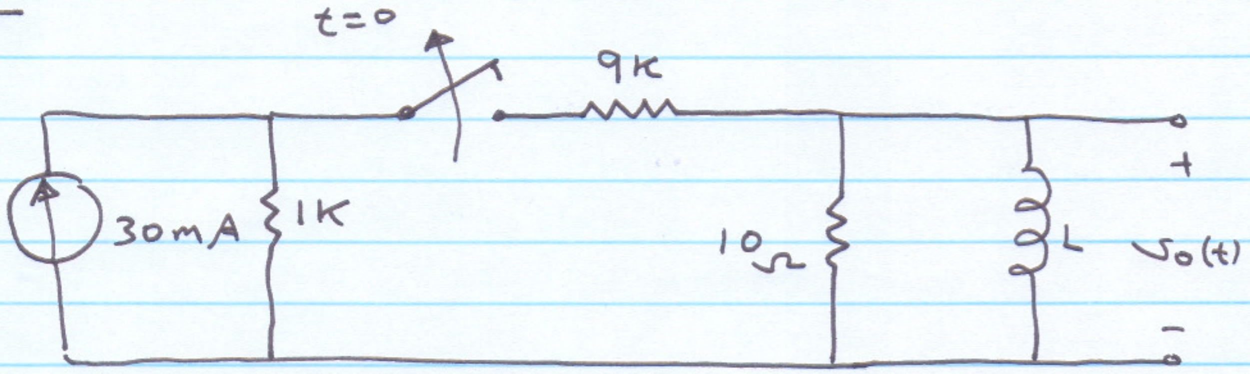
$$v_o(t) = v_o(\infty) + \left[v_o(0^+) - v_o(\infty)\right] e^{-t/\tau}$$

$$\tau = \frac{L}{R_{eq}} = \frac{0.2\,H}{3+2+15} = 0.01\,\text{s}$$

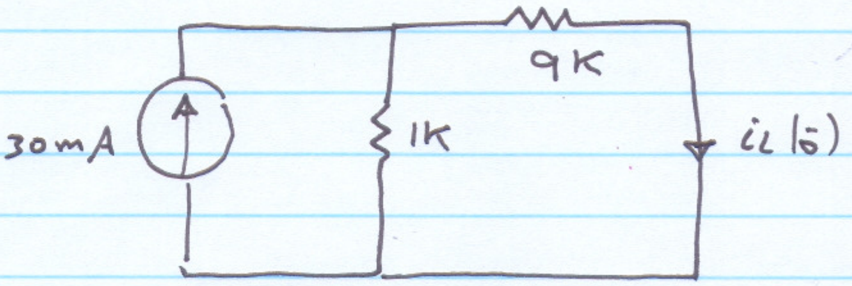
$$\therefore v_o(t) = -15 e^{-100t}\,\text{V} \quad \text{for } t > 0$$

Homework Solutions ch. 7 EE 231

7.11

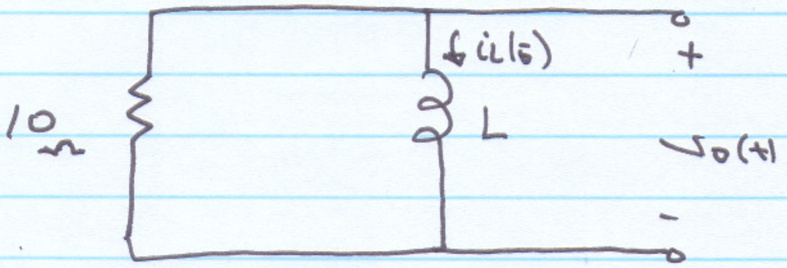


for $t < 0$



$$i_L(0^-) = \frac{1K}{1K+9K}(30mA) = 3mA$$

for $t > 0$



$$v_o(t) = v_o(0^+)\, e^{-t/\tau} \qquad t > 0$$

$$v_o(1ms) = v_o(0^+)\, e^{\frac{-1\times10^{-3}}{\tau}} = 0.5\, v_o(0^+)$$

$$\therefore\ 0.5 = e^{\frac{-1\times10^{-3}}{\tau}}$$

$$\therefore\ \tau = \frac{1\times10^{-3}}{\ln 2} = 1.443\,ms$$

$$\tau = \frac{L}{R} = \frac{L}{10}$$

$\therefore$ $L = 14.43\,mH$

b) $v_o(0^+) = -10\, i_L(0^+) = -10\, i_L(0^-) = -30\,mV$

$\therefore$ $v_o(t) = -0.03\, e^{-t/\tau}\ V$ for $t > 0$

$$P_{10\Omega} = \frac{v_o^2(t)}{10} = 9\times10^{-5}\, e^{-2t/\tau}$$

$$W_{10\Omega}(1ms) = \int_0^{10^{-3}} 9\times10^{-5}\, e^{\frac{-2t}{\tau}}\, dt$$

$$W_{10\Omega}(1ms) = (4.5\,\tau)(10^{-5})\left(1 - e^{-2\left(\frac{0.001}{\tau}\right)}\right)$$

$W_{10\Omega}(1ms) = 48.69\ nJ$

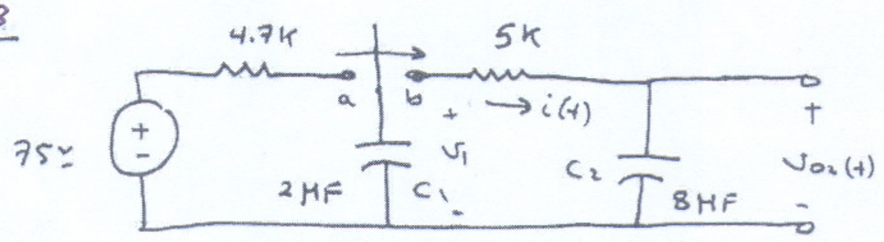
$W_L(0) = \frac{1}{2} L\, i_L^2(0^-)$

$W_L(0) = 64.92\ nJ$

% dissipated in 1ms $= \frac{48.69}{64.92} \times 100\%$

$= 75\%$

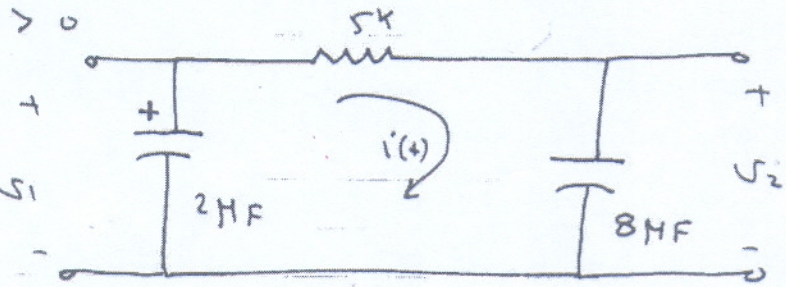
7.23



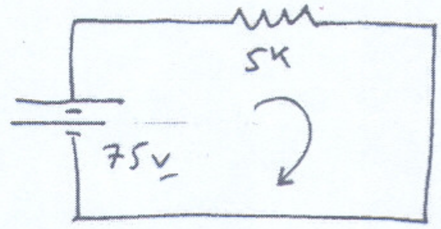
For $t < 0$

$v_{c1}(0^-) = 75\,V$, $v_{c2}(0^-) = 0$

For $t > 0$



at $t = 0^+$



$i(0^+) = \frac{75v}{5K} = 15\,mA$

$v_{c1}(0^+) = 75\,V$, $v_{c2}(0^+) = 0$

at $t = \infty$

$i(\infty) = 0$

$\therefore \; i(t) = 15\, e^{-t/\tau} \quad t > 0$

$$\tau = R\,C_{eq} = (5K)\left(\frac{(2\mu)(8\mu)}{2\mu + 8\mu}\right) = 8\ ms$$

$$v_2(t) = \frac{1}{C_2}\int_0^t i(t)\,dt = \frac{1}{8\mu}\int_0^t 15\, e^{-t/\tau}\,dt$$

$$v_2(t) = 15 - 15\, e^{-t/\tau} \qquad t \geq 0$$

$$v_1(t) = v_c(0^-) - \frac{1}{C_1}\int_0^t i(t)\,dt$$

$$v_1(t) = 15 + 60\, e^{-t/\tau} \qquad t \geq 0$$

b) $$W_i = \frac{1}{2} C_1\, V_{C_1}^2(0^-) = \left(\frac{1}{2}\right)(2\times 10^{-6})(75)^2$$

$$W_i = 5625\ \mu J$$

c)

The total energy dissipated in the 5K Ω

$$W_R = \int_0^\infty P(t)\,dt = \int_0^\infty i^2(t)\,R\cdot dt$$

$$= \int_0^\infty R(15\times 10^{-3})^2\, e^{-2t/\tau}\,dt$$

$$W_R = (15\times 10^{-3})^2 \left.\frac{e^{-2t/\tau}\cdot R}{-2/\tau}\right|_0^\infty = 4500\mu J$$

∴ The energy trapped in the circuit $= W_t$

$W_t = W_i - W_R$

$= 5625 - 4500$

$W_t = 1125\ \mu J$

or second method

$v_{c1}(\infty) = 15\ V$

$v_{c2}(\infty) = 15\ V$

$W_{c1}(\infty) = \left(\frac{1}{2}\right)(2)(10^{-6})(15)^2 = 225\ \mu J$

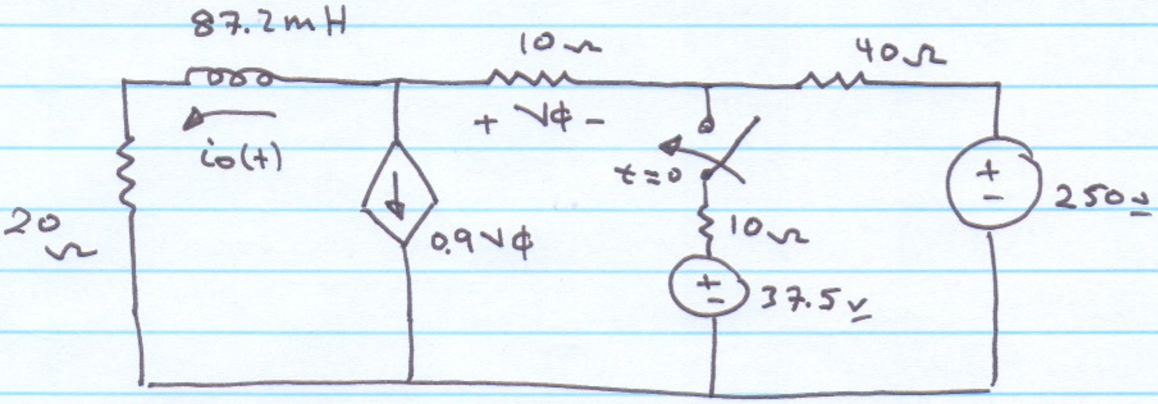
$W_{c2}(\infty) = \left(\frac{1}{2}\right)(8)(10^{-6})(15)^2 = 900\ \mu J$

∴

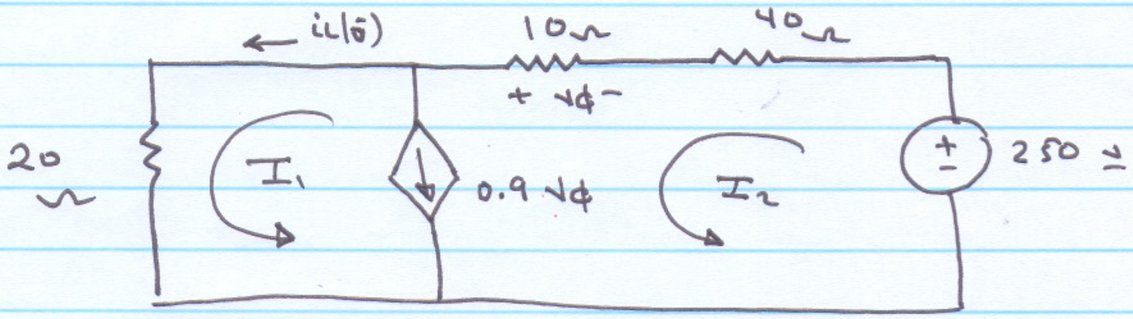
$W_t = W_{c1}(\infty) + W_{c2}(\infty)$

$= 1125\ \mu J.$

7.42



for t < 0



$I_2 - I_1 = 0.9 V\phi$ Constrain equation

$V\phi = -10 I_2$

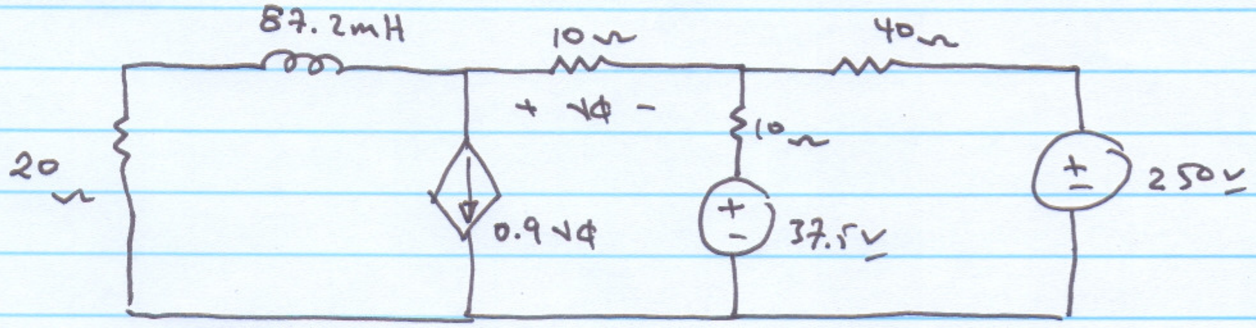
$\therefore \; 10 I_2 - I_1 = 0$

$250 = 20 I_1 + 50 I_2$ Supermesh

$\therefore \; I_1 = 10A$

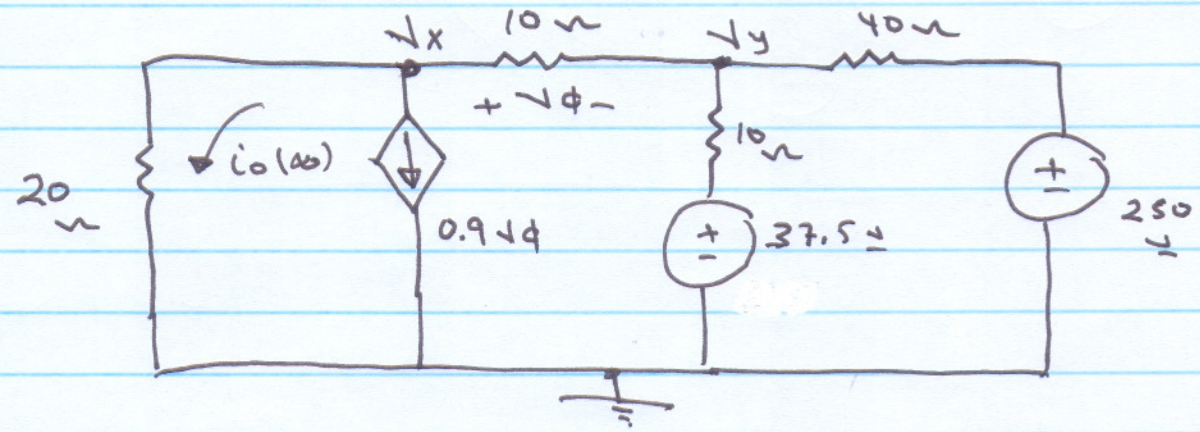
$\therefore \; i_L(0^-) = I_1 = 10A$

for t > 0



$$i_o(t) = i_o(\infty) + \left[i_o(0^+) - i_o(\infty) \right] e^{-t/\tau}$$

at $t = \infty$



$$-0.9V_\phi = \left(\frac{1}{20} + \frac{1}{10}\right)V_x - \frac{1}{10}V_y$$

$$V_\phi = V_x - V_y$$

$$\frac{V_y - V_x}{10} + \frac{V_y - 37.5}{10} + \frac{V_y - 250}{40} = 0$$

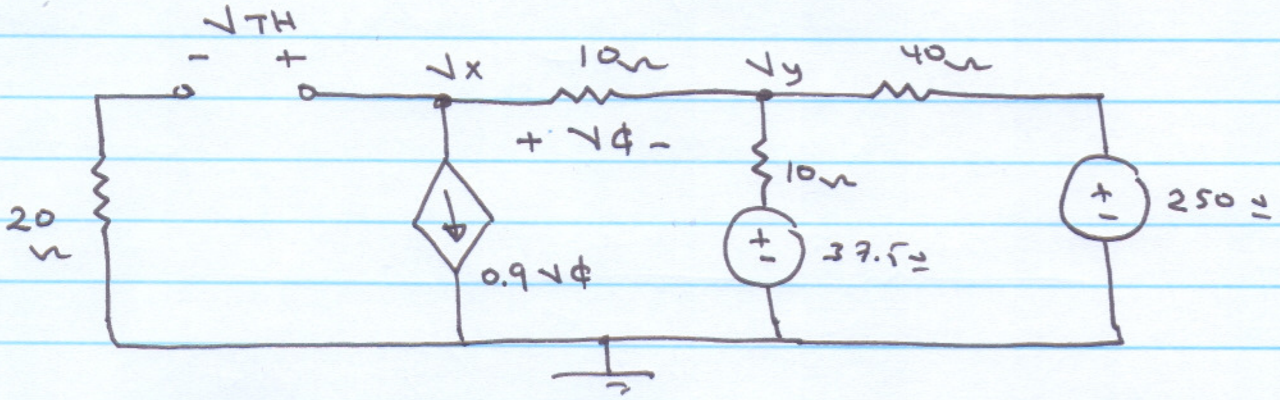
$$\therefore V_x = 73.39 \ V$$

$$i_o(\infty) = \frac{V_x}{20} = 3.67 \ A$$

$$i_o(0^+) = i_o(0^-) = 10 \ A$$

To find R_{TH}

$$R_{TH} = \frac{V_{TH}}{I_N}$$



$v_{TH} = v_x$

$$-0.9 v_\phi = \frac{1}{10} v_x - \frac{1}{10} v_y$$

$$v_\phi = v_x - v_y$$

$$\frac{v_y - v_x}{10} + \frac{v_y - 37.5}{10} + \frac{v_y - 250}{40} = 0$$

$\therefore \; v_{TH} = v_x = 80 \text{ V}$

$I_N = 3.67 \text{ A}$

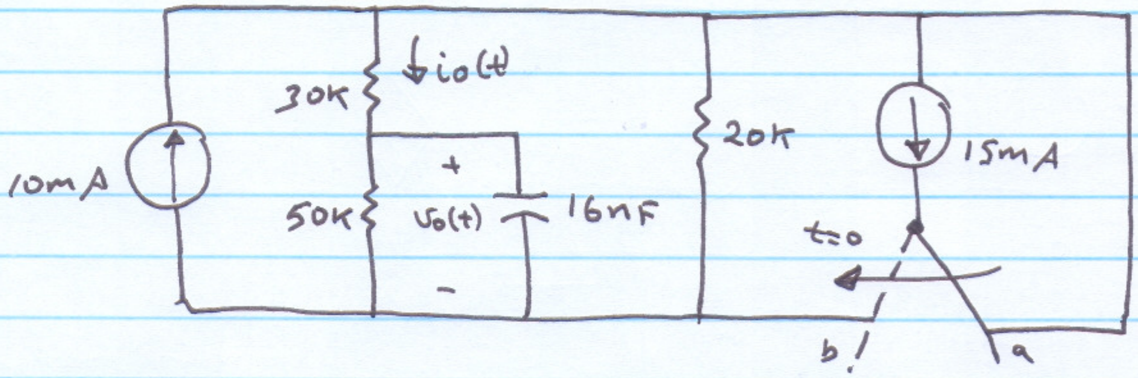
$$R_{TH} = \frac{v_{TH}}{I_N} = 21.8 \; \Omega$$

$$\tau = \frac{L}{R_{TH}} = 4 \text{ ms}$$

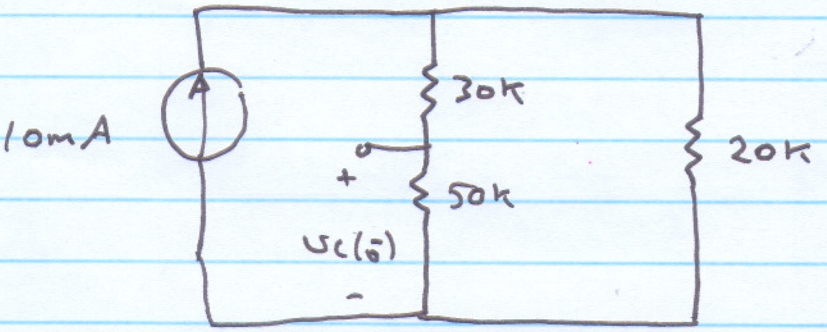
$$i_o(t) = \left[3.67 + (10 - 3.67) e^{-2500t} \right] \text{ A} \quad \text{for } t > 0$$

$$i_o(t) = 3.67 + 6.33 e^{-2500t} \quad \text{A} \quad \text{for } t > 0$$

7.54

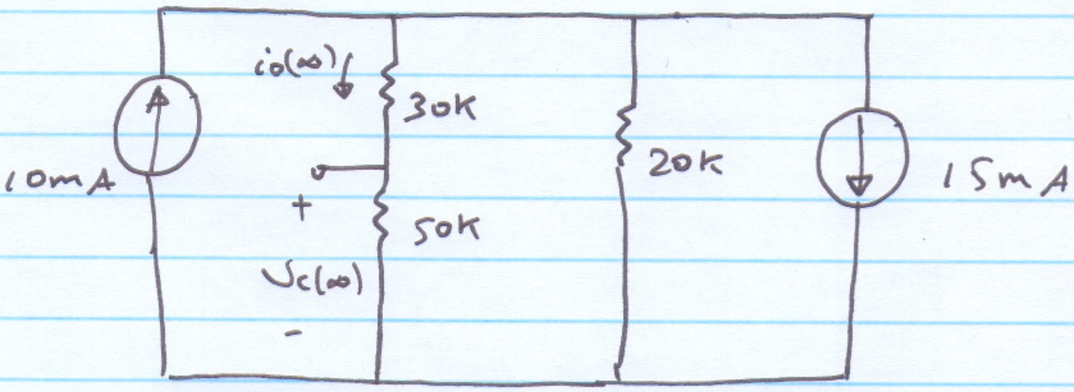


for t < 0



$$v_c(0^-) = (50K)\left(\frac{20K}{20K+80K}\right)(10mA) = 100\,v$$

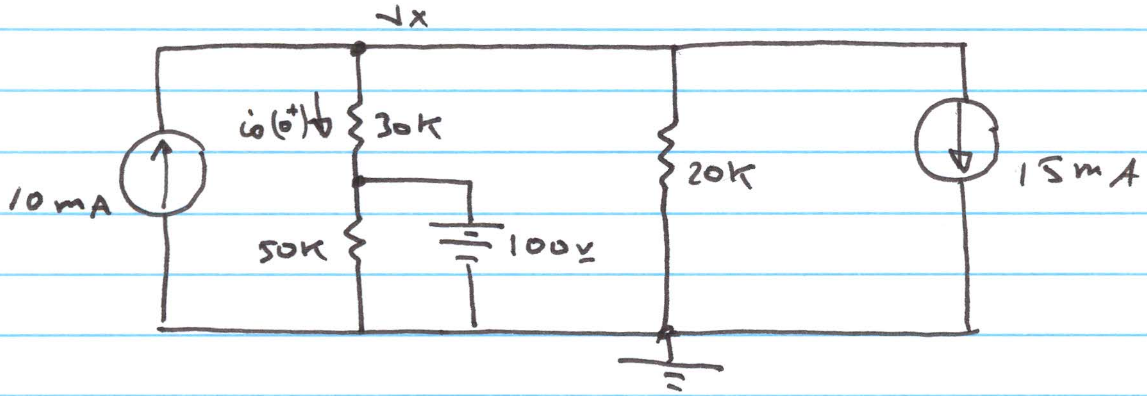
at t = ∞



$$v_c(\infty) = (10mA - 15mA)\left(\frac{20K}{20K+80K}\right)(50K) = -50\,v$$

$$i_o(\infty) = (10mA - 15mA)\left(\frac{20k}{20k + 80k}\right) = -1mA$$

at $t = 0^+$



$$v_o(0^+) = 100\ v$$

$$10mA = \frac{v_x - 100}{30k} + 15mA + \frac{v_x}{20k}$$

$$v_x = -20\ v$$

$$i_o(0^+) = \frac{v_x - v_c(0^+)}{30k} = -4mA$$

$$\tau = R_{TH}C$$

$$R_{TH} = (30k + 20k) \| 50k = 25k$$

$$\tau = 0.4ms$$

$$i_o(t) = i_o(\infty) + \left[i_o(0^+) - i_o(\infty)\right] e^{-t/\tau} \quad t > 0$$

$$i_o(t) = -\left(1 + 3e^{-2500t}\right) mA \quad \text{for } t > 0$$

$$v_o(t) = v_o(\infty) + \left[v_o(0^+) - v_o(\infty)\right] e^{-t/\tau} \quad \text{for } t > 0$$

$$v_o(t) = \left(-50 + 150e^{-2500t}\right) v \quad \text{for } t > 0$$