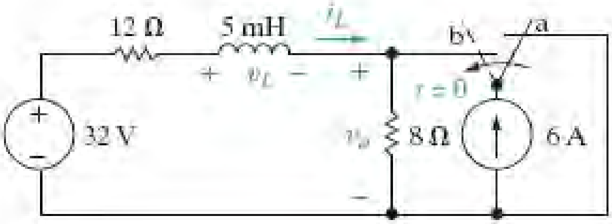
Problem 7.36 PSpice|Multisim

The switch in the circuit shown in has been in position a for a long time before moving to position b at t = 0.



Part A

Choose the correct numerical expression for $i_L(t)$ for $t \geq 0$.

ANSWER:

- ○ $i_L(t) = -0.8 + 2.4e^{-25t}$ A, where t is in milliseconds
- ○ $i_L(t) = 2.4 - 0.8e^{-25t}$ A, where t is in milliseconds
- ○ $i_L(t) = 2.8 + 0.4e^{-4t}$ A, where t is in milliseconds
- ○ $i_L(t) = -0.8 + 2.4e^{-4t}$ A, where t is in milliseconds

---

Part B

Choose the correct numerical expression for $v_o(t)$ for $t \geq 0$.

ANSWER:

- ○ $v_o(t) = 19.2 + 41.6e^{25t}$ V, where t is in milliseconds
- ○ $v_o(t) = 41.6 - 19.2e^{-25t}$ V, where t is in milliseconds
- ○ $v_o(t) = 19.2 - 41.6e^{-4t}$ V, where t is in milliseconds
- ○ $v_o(t) = 41.6 + 19.2e^{-4t}$ V, where t is in milliseconds

---

Part C

Find the numerical value of $v_L(0^+)$.

Express your answer to three significant figures and include the appropriate units.

ANSWER:

$v_L\left(0^+\right)$ =

Part D

Find the numerical value of $v_o\left(0^+\right)$.

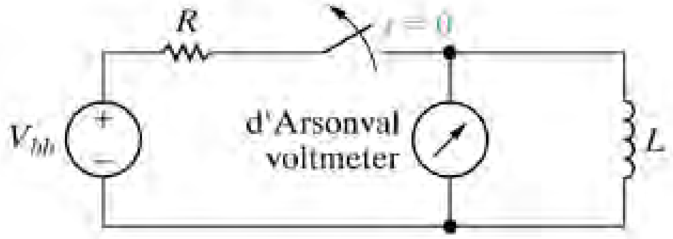
Express your answer to three significant figures and include the appropriate units.

ANSWER:

$v_o\left(0^+\right)$ =

Problem 7.42

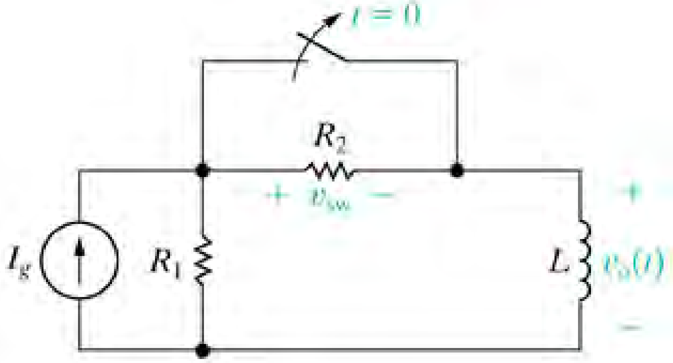
The switch in the circuit in has been closed for a long time. A student abruptly opens the switch and reports to her instructor that when the switch opened, an electric arc with noticeable persistence was established across the switch, and at the same time the voltmeter placed across the coil was damaged.



Part A

On the basis of your analysis of the circuit in , can you explain to the student why this happened?

Drag the terms on the left to the appropriate blanks on the right to complete the sentences.



ANSWER:

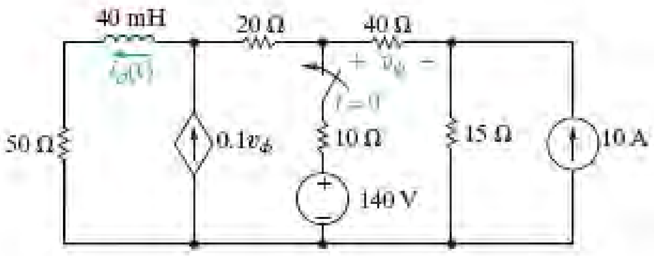
Reset Help

- small
- large
- also appears
- doesn't appear

Opening the inductive circuit causes a very ______ voltage to be induced across the inductor L. This voltage ______ across the switch, causing the switch to arc over. At the same time, the ______ voltage across L damages the meter movement.

Problem 7.44 PSpice|Multisim

The switch in the circuit in has been open a long time before closing at t = 0.



Part A

Find $i_o(t)$ for $t \geq 0$.

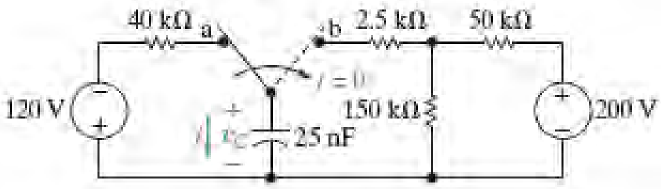
Express your answer in terms of t, where t is in milliseconds.

ANSWER:

$i_o(t)$ = A

Problem 7.51

Assume that the switch in the circuit in has been in position a for a long time and that at t = 0 it is moved to position b.



Part A

Find $v_{\mathrm{C}}(0^{+})$.

Express your answer to three significant figures and include the appropriate units.

ANSWER:

$v_{\mathrm{C}}(0^{+})$ =

Part B

Find $v_{\mathrm{C}}(\infty)$.

Express your answer to three significant figures and include the appropriate units.

ANSWER:

$v_{\mathrm{C}}(\infty)$ =

Part C

Find τ for $t > 0$.

Express your answer to three significant figures and include the appropriate units.

ANSWER:

τ =

Part D

Find $i(0^+)$.

Express your answer to three significant figures and include the appropriate units.

ANSWER:

$i(0^+)$ =

Part E

Choose the correct expression for $v_{\mathrm{C}}(t), t \geq 0$.

ANSWER:

- ○ $v_{\mathrm{C}}(t) = 150 + 270e^{1000t}$ V, where t is in seconds
- ○ $v_{\mathrm{C}}(t) = 15 + 27e^{-t}$ V, where t is in second
- ○ $v_{\mathrm{C}}(t) = 150 - 270e^{-1000t}$ V, where t is in seconds
- ○ $v_{\mathrm{C}}(t) = 15 - 27e^{-t}$ V, where t is in seconds

Part F

Find $i(t), t \geq 0^+$.

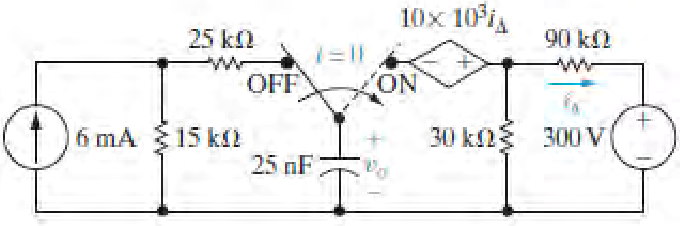
Express your answer in terms of t, where t is in milliseconds.

ANSWER:

$i(t)$ = mA

Problem 7.61 PSpice|Multisim

The switch in the circuit shown in has been in the OFF position for a long time. At $t = 0$, the switch moves instantaneously to the ON position.



Part A

Find $v_o(t)$ for $t \geq 0$.

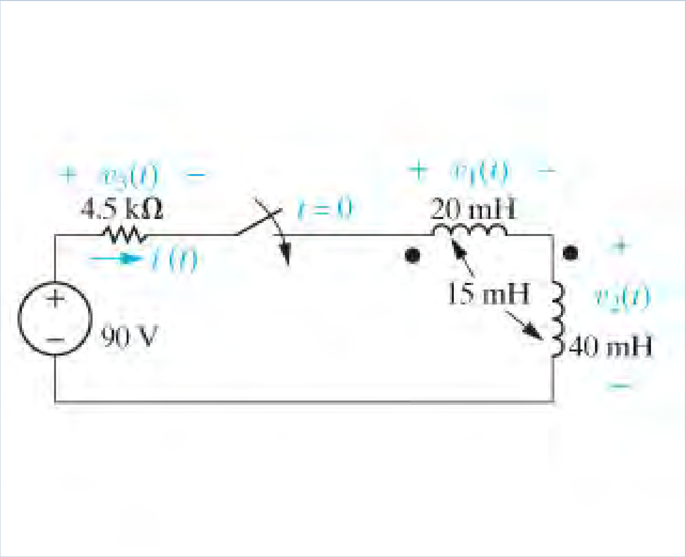
Express your answer in terms of t, where t is in milliseconds.

ANSWER:

$v_o(t)$ = ______ V

Problem 7.69 PSpice|Multisim

There is no energy stored in the circuit in at the time the switch is closed.



Part A

Find $i(t)$ for $t \geq 0$.

Express your answer in terms of t, where t is in microseconds.

ANSWER:

$i(t)$ = ☐ mA

Part B

Find $v_1(t)$ for $t \geq 0^+$.

Express your answer in terms of t, where t is in microseconds.

ANSWER:

$v_1(t)$ = ☐ V

Part C

Find $v_2(t)$ for $t \geq 0^+$.

Express your answer in terms of t, where t is in microseconds.

ANSWER:

$v_2(t)$ = ☐ V

Part D

Find $v_3(t)$ for $t \geq 0^+$.

Express your answer in terms of t, where t is in microseconds.

ANSWER:

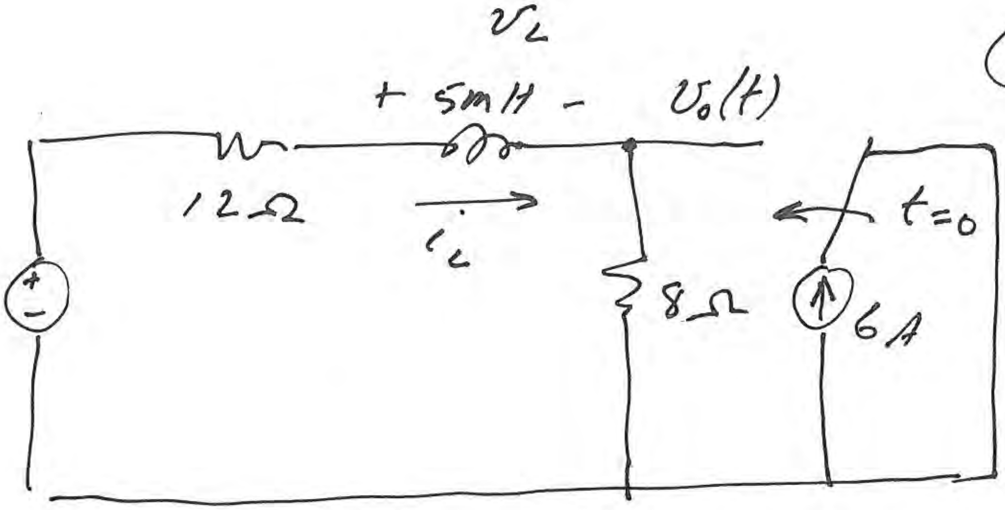
$v_3(t)$ = ☐ V

Part E

This question will be shown after you complete previous question(s).

Instructors: View all hidden parts

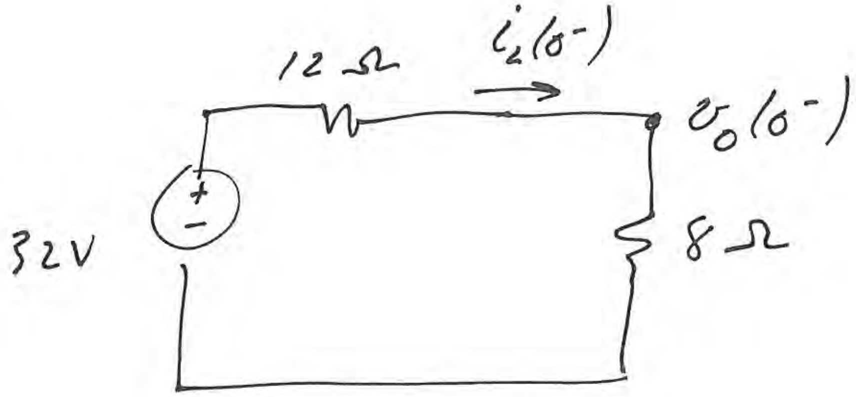
7.36



a) FIND $i_L(t)$ & $v_o(t)$

b) FIND $v_L(0^+)$ & $v_o(0^+)$

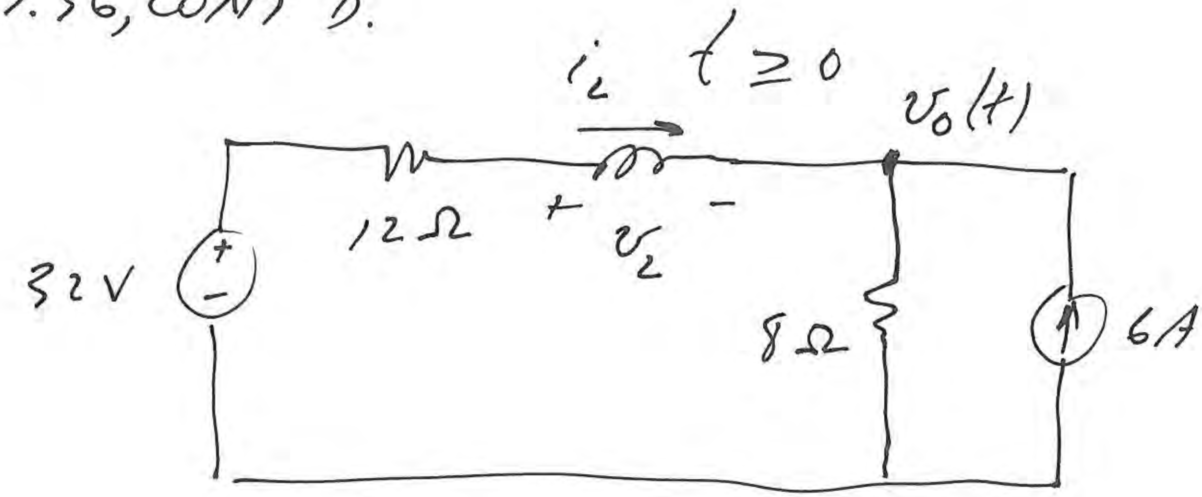
$t < 0$

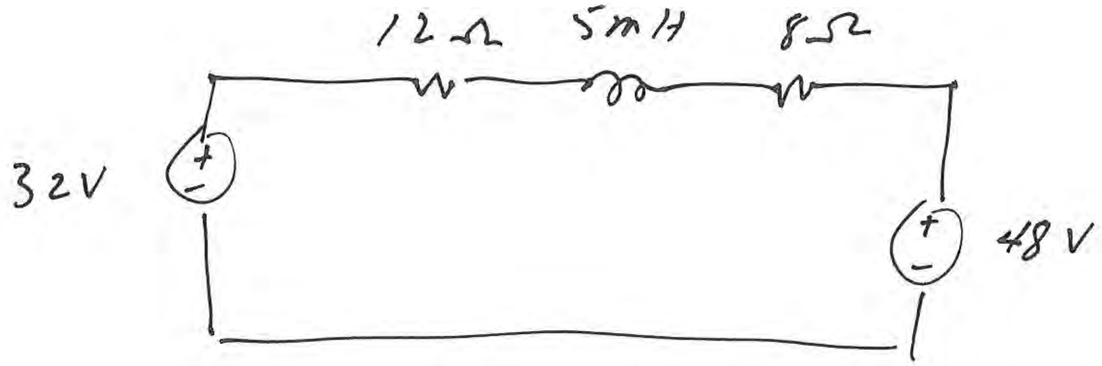


$$i_L(0^-) = \frac{32\ V}{20\ \Omega} = 1.6A = i_L(0^+)$$

$$v_o(0^-) = 1.6A \times 8\Omega = 12.8V$$

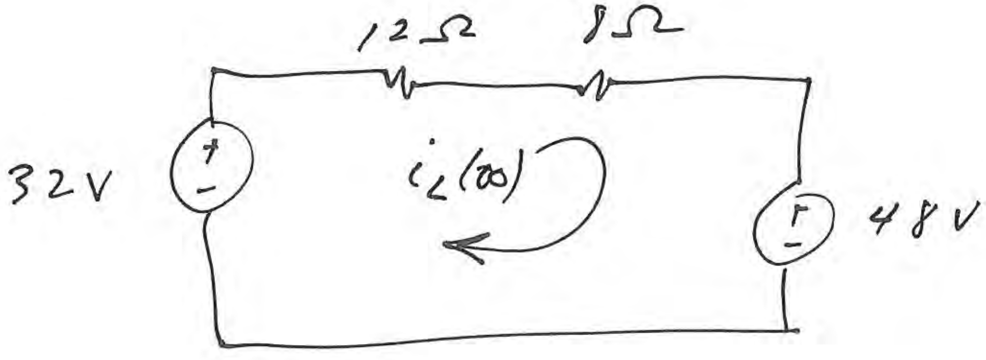
7.36, CONT'D.





$$\tau = L/R = 5\,mH/20\,\Omega = 0.25\,ms$$

$$1/\tau = 4000\ s^{-1}$$



MESH: $32 - 20\,i_L(\infty) - 48 = 0$

$$\Longrightarrow i_L(\infty) = \frac{(32-48)\,V}{20\,\Omega} = -0.8\,A$$

7.36, CONT'D.

$$i_L(t) = i_L(\infty) + [\,i_L(0) - i_L(\infty)\,]e^{-t/\tau}$$

$$= -0.8 + (1.6 + 0.8)e^{-4{,}000t}$$

$$\boxed{i_L(t) = -0.8 + 2.4e^{-4{,}000t}\ A\ ;\ t \geq 0}$$

$$v_L(t) = L\frac{d}{dt}i_L(t)$$

$$= 5mH(24)(-4{,}000)e^{-4{,}000t}\ V$$

$$\boxed{v_L(t) = -48e^{-4{,}000t}\ V\ ;\ t \geq 0^+}$$

NODAL FOR $v_o(t)$ (SEE TOP PAGE 2)

$$-i_L(t) + \frac{v_o(t)}{8\Omega} - 6A = 0$$

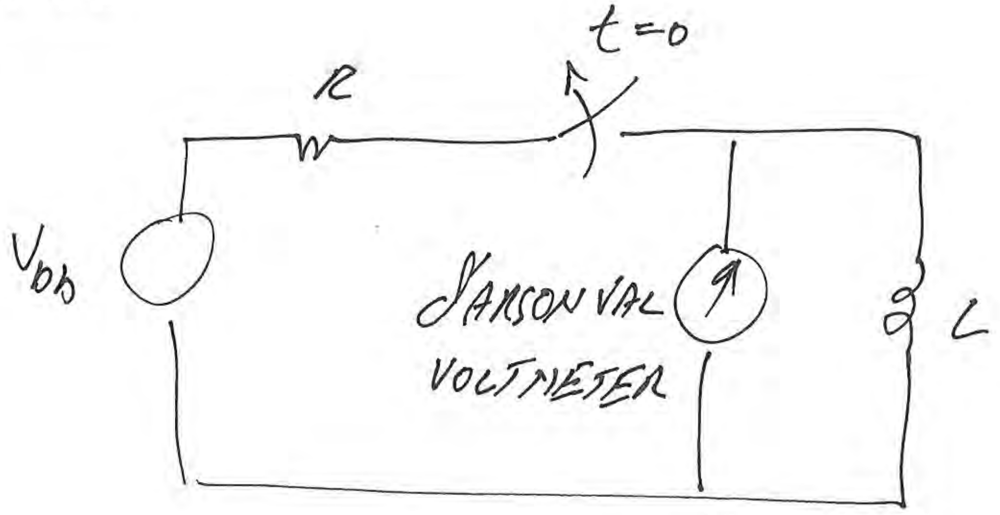
$$v_o(t) = [\,i_L(t) + 6A\,]\,8\Omega$$

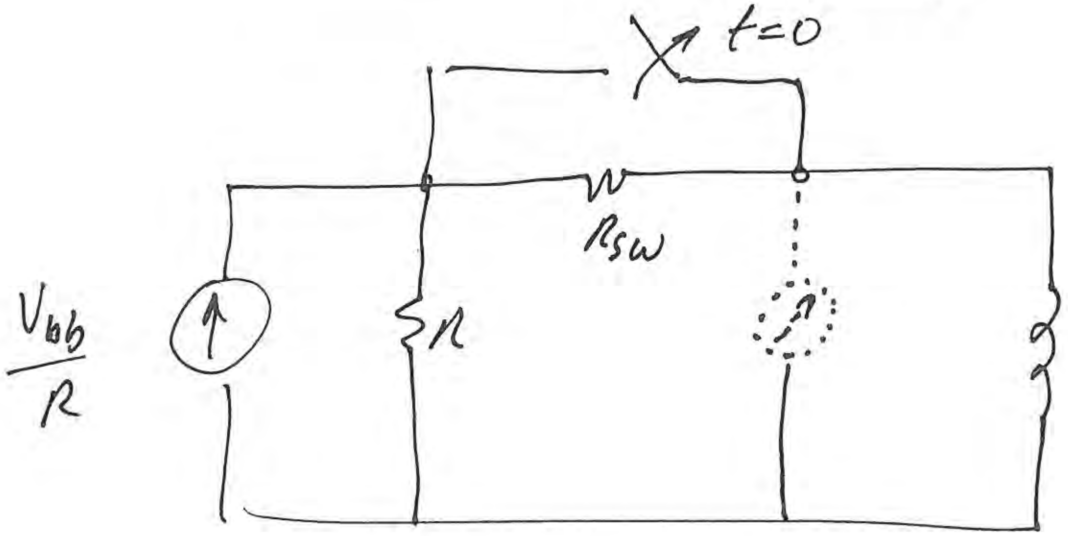
$$= (5.2 + 2.4e^{-4{,}000t})8$$

$$\boxed{v_o(t) = 41.6 + 19.2e^{-4{,}000t}\ V\ ;\ t \geq 0^+}$$

$$\boxed{v_o(0^+) = 60.8\,V}$$

7.42





R_{SW} VERY LARGE

PRIOR TO SWITCH, INDUCTOR IS A SHORT

$$i_L(0) = V_{bb}/R$$

THROWING SWITCH CAUSES ABRUPT CHANGE IN CURRENT

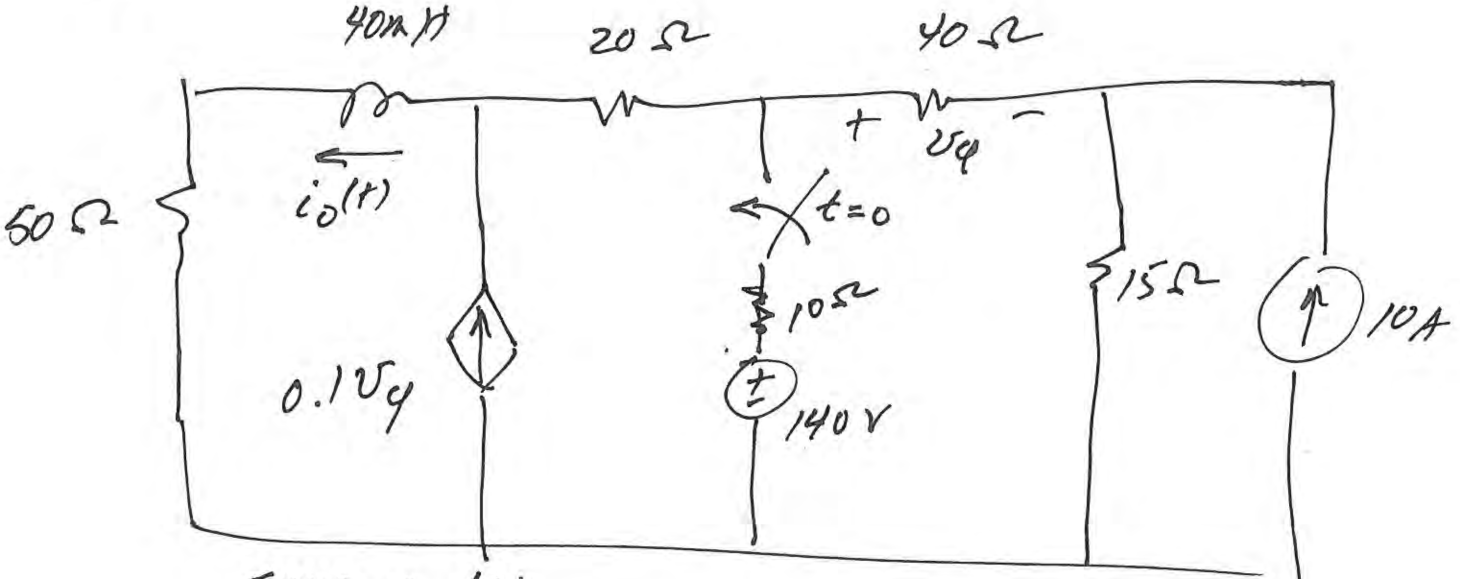
$v_L(t) = L \dfrac{di_L(t)}{dt}$ IS VERY LARGE

7.42, CONT'D.

VERY LARGE, ABRUPT VOLTAGE CAUSES ARC AT SWITCH & DAMAGES METER.

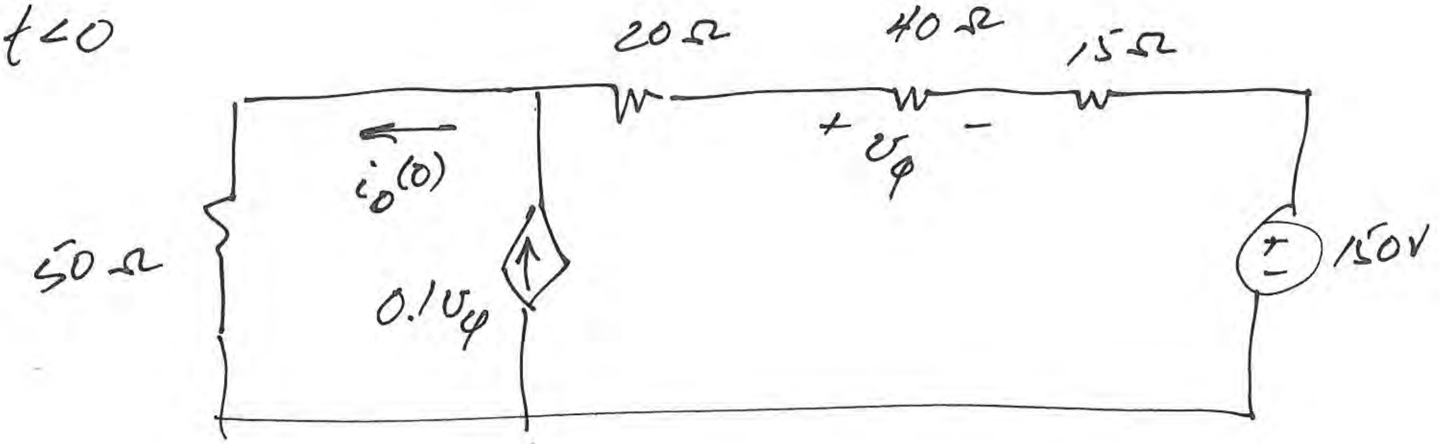
①

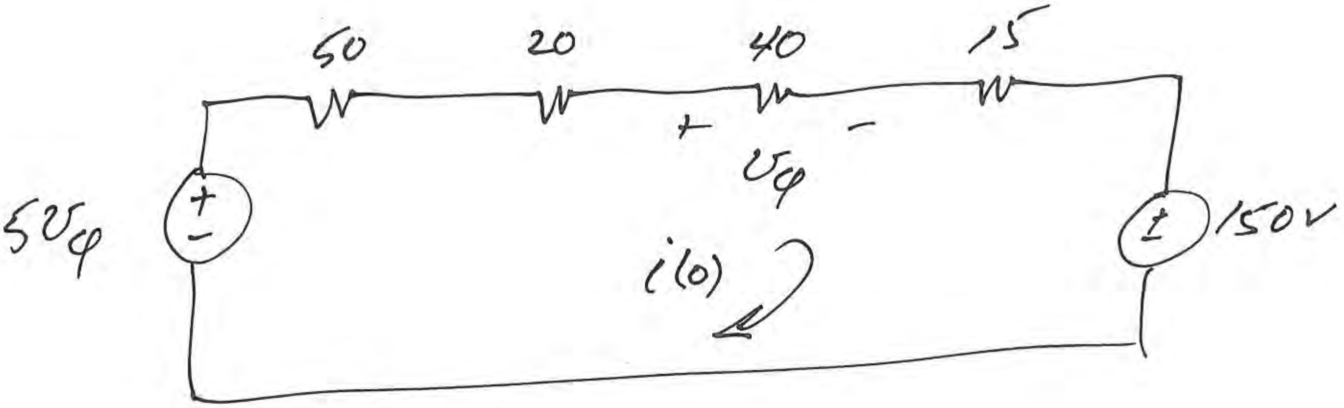
7.44



FIND $i_o(t)$

t<0





7.44, CONT'D

Mesh analysis

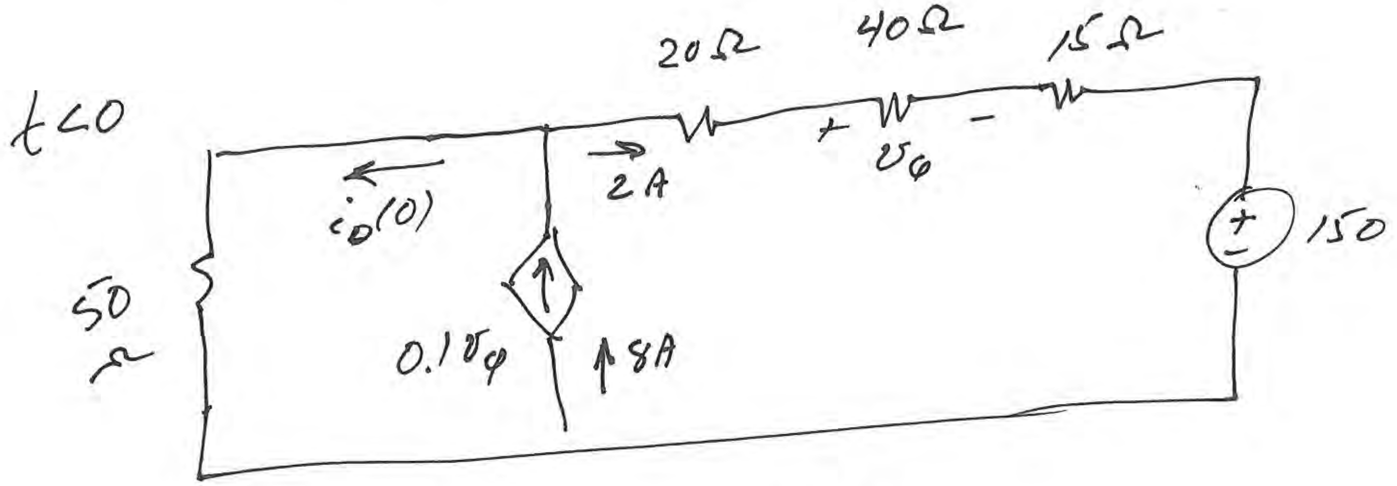
$$5v_\phi - (50+20+40+15)\,i(0) - 150\,V = 0$$

But $v_\phi = 40\,i(0)$

$$200\,i(0) - 125\,i(0) = 150\,V$$

$$75\,i(0) = 150\,V$$

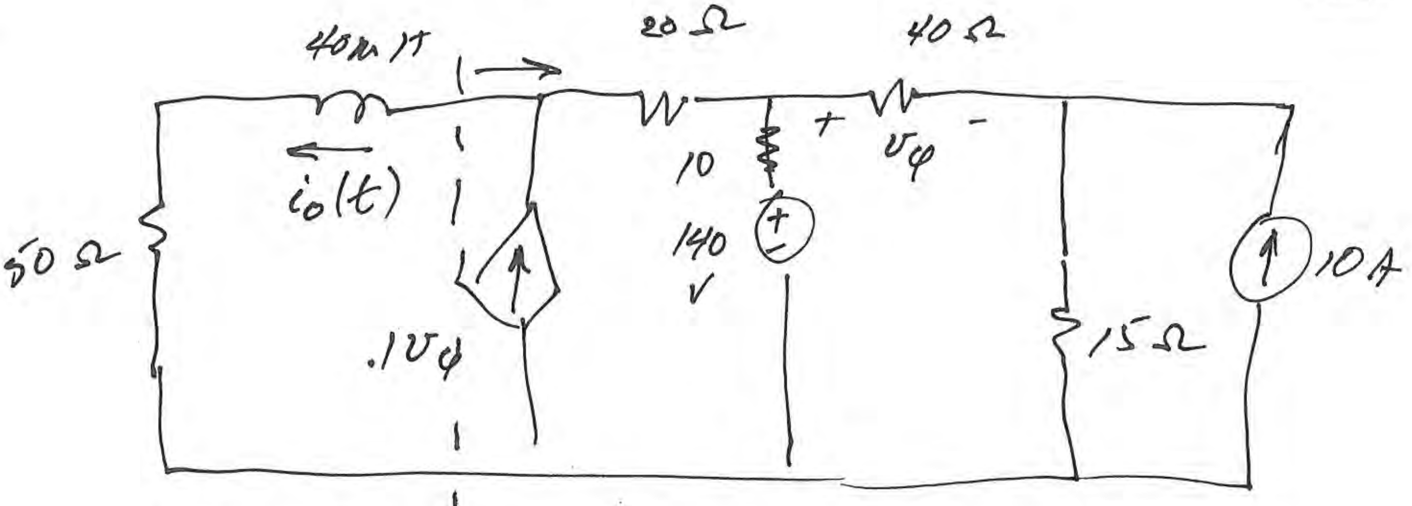
$$i(0) = \frac{150\,V}{75\,\Omega} = 2\,A$$



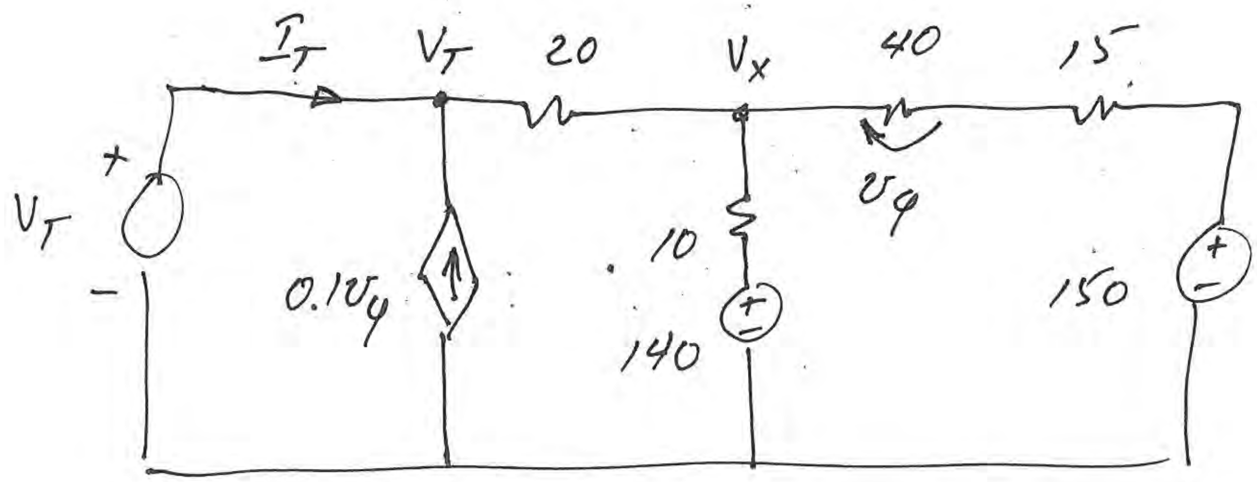
$$v_\phi = 80\,V$$

$$\Rightarrow i_o(0) = 6A$$

7. 44, CONT'D. $t \geq 0$ ③



DETERMINE THÉVENIN EQ TO RIGHT OF INDUCTOR & 50 Ω RESISTOR: APPLY TEST SOURCE



NODAL ANALYSIS

① $$\frac{V_T - V_x}{20} - I_T - 0.1 v_\varphi = 0$$

② $$\frac{V_x - 150}{55} + \frac{V_x - 140}{10} + \frac{V_x - V_T}{20} = 0$$

7.44, CONT'D.

VOLTAGE DIV FOR v_φ:

③ $$v_\varphi = (V_x - 150)\left(\frac{40}{55}\right)$$

COMBINE EQ'S ① & ③:

$$\frac{V_T - V_x}{20} - I_T - 0.1\,(V_x - 150)\left(\frac{40}{55}\right) = 0$$

⋮

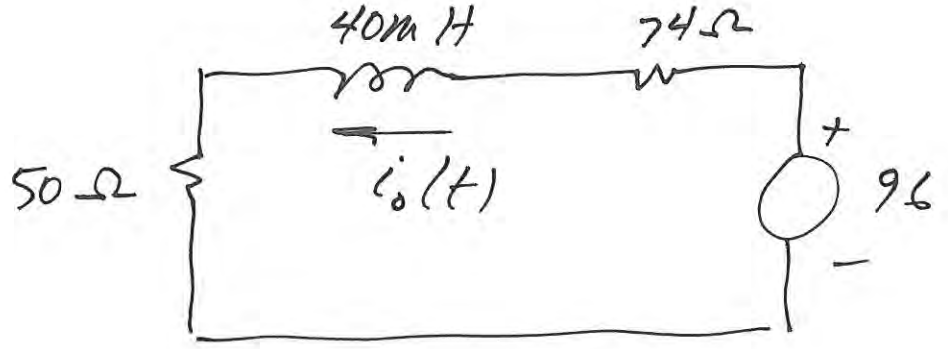
④ $$135\,V_x - 55\,V_T + 1{,}100\,I_T = 12{,}000$$

REWRITE EQ ② AS:

⑤ $$185\,V_x - 55\,V_T = 18{,}400$$

ELIMINATE V_x BETWEEN EQ'S ④ & ⑤:

$$V_T = \underset{\overset{\uparrow}{V_{TH}}}{96} + \underset{\overset{\uparrow}{R_{TH}}}{74}\,I_T$$



7.44, CONT'D.

$$i_o(\infty) = \frac{96\,V}{124\,\Omega} = 0.774\,A$$

$$\tau = L/R = 40mH/124\,\Omega$$

$$= 0.3226\,ms$$

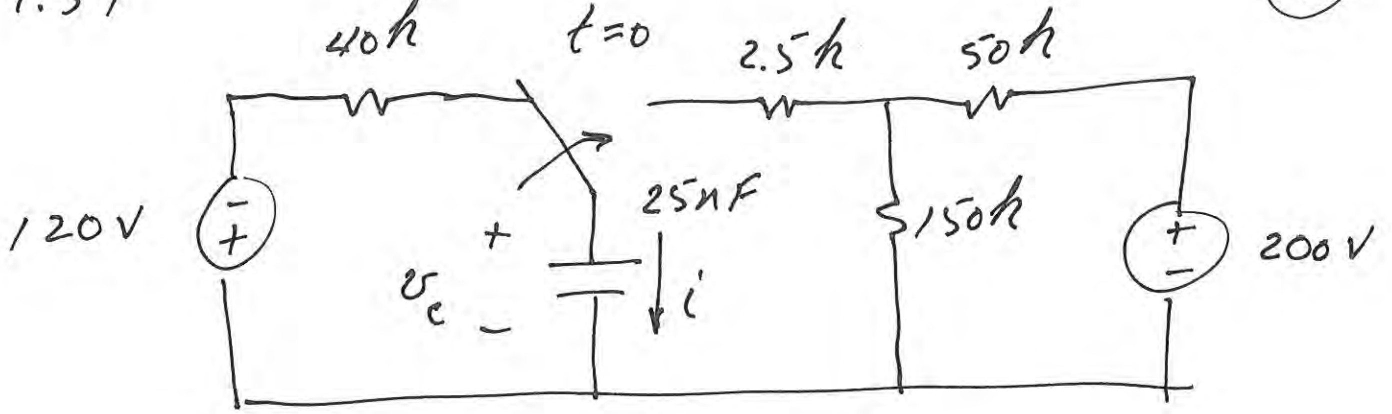
$$1/\tau = 3,100\ s^{-1}$$

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

$$= 0.774 + (6 - 0.774)e^{-3,100t}$$

$$\boxed{i_o(t) = 0.774 + 5.226e^{-3,100t}\ A,\ t \geq 0}$$

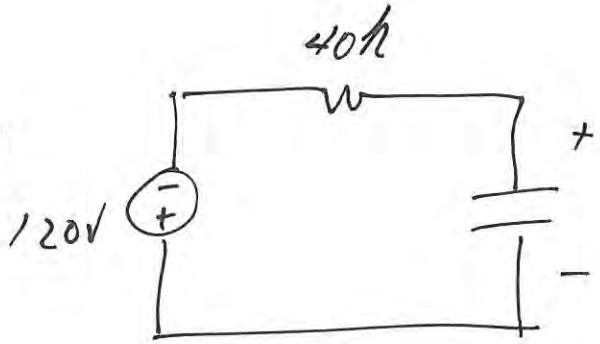
7.51



a) $v_c(0^+)$ b) $v_c(\infty)$ c) τ

d) $i(0^+)$ e) $v_c(t);\ t \geq 0$ f) $i(t);\ t \geq 0^+$

$t < 0$

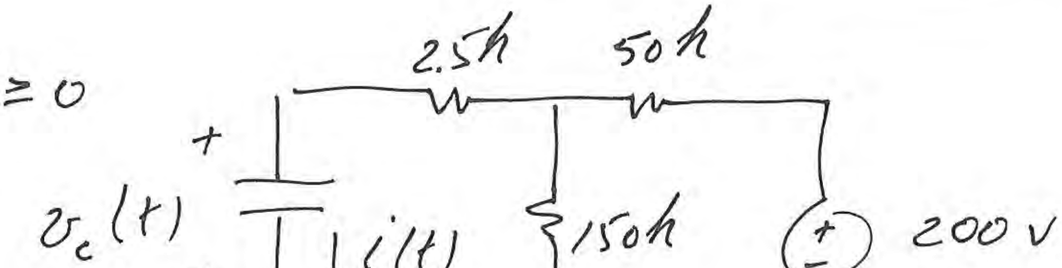


$v_c(0^-) = -120\text{ V}$

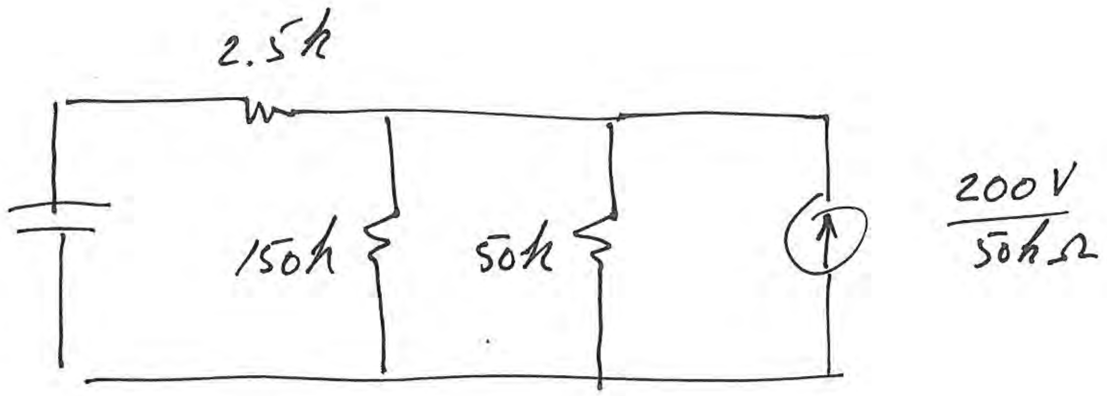
$= v_c(0^+)$

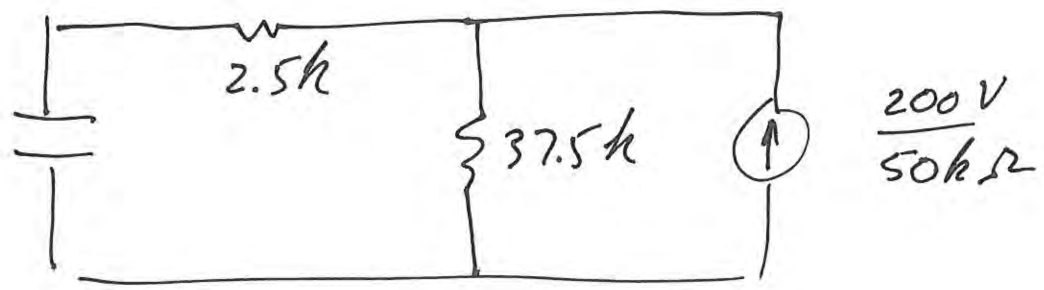
$\boxed{a)\ v_c(0^+) = -120\text{ V}}$

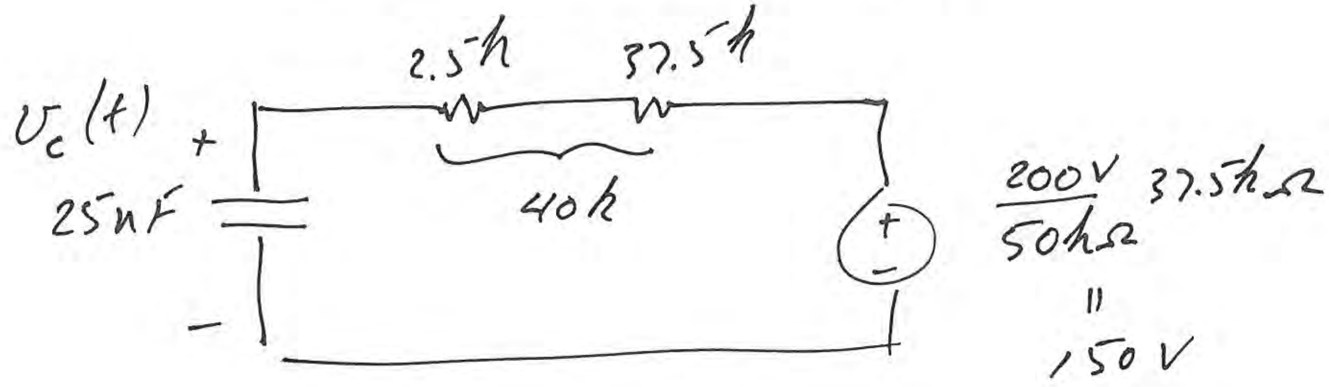
$t \geq 0$



7.51, CONT'D.







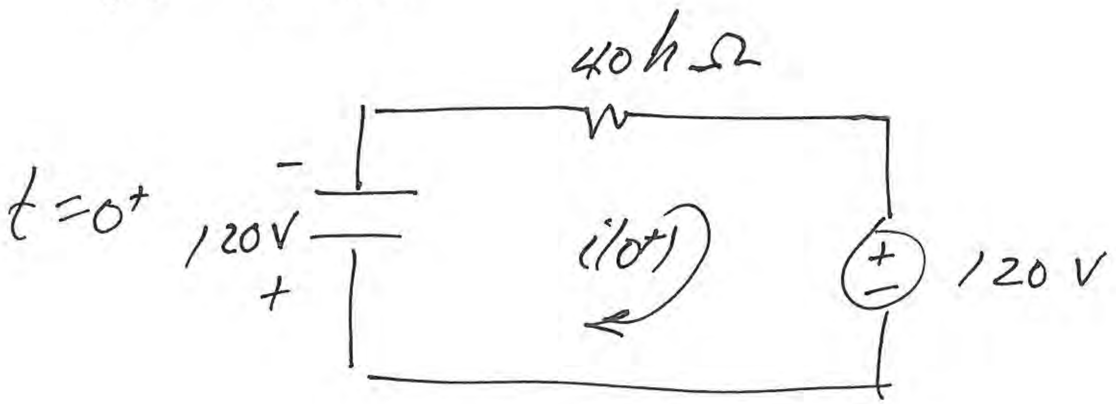
$$\boxed{b)\ v_c(\infty) = 150\text{ V}}$$

c) $\tau = RC = (40k\Omega)(25nF) = 1ms$

$1/\tau = 1{,}000\ s^{-1}$ $\boxed{c)\ \tau = 1ms}$

7.51, CONT'D. ③

TO GET $i(0^+)$ CONSIDER MESH EQ AT $t=0^+$



$$-120V - 40k\Omega\, i(0^+) - 120V = 0$$

$$i(0^+) = \frac{+270V}{40k\Omega}$$

$$\boxed{d)\ i(0^+) = 6.75mA}$$

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

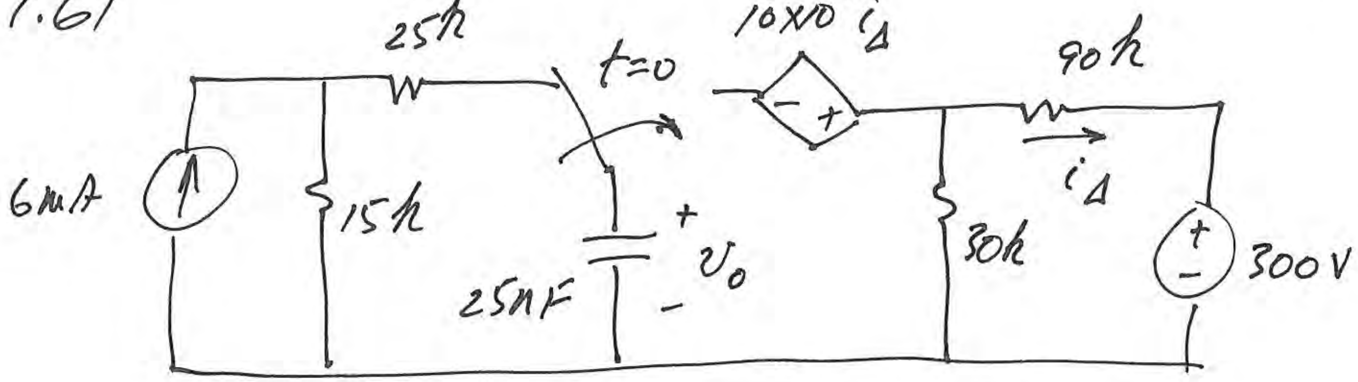
$$= 150V + (-120 - 150)e^{-1,000t}$$

$$\boxed{e)\ v_c(t) = 150 - 270e^{-1,000t}; t \geq 0}$$

$$i(t) = C\frac{dv_c(t)}{dt} = (25\times10^{-9})(-270)(-1000)e^{-1,000t}$$

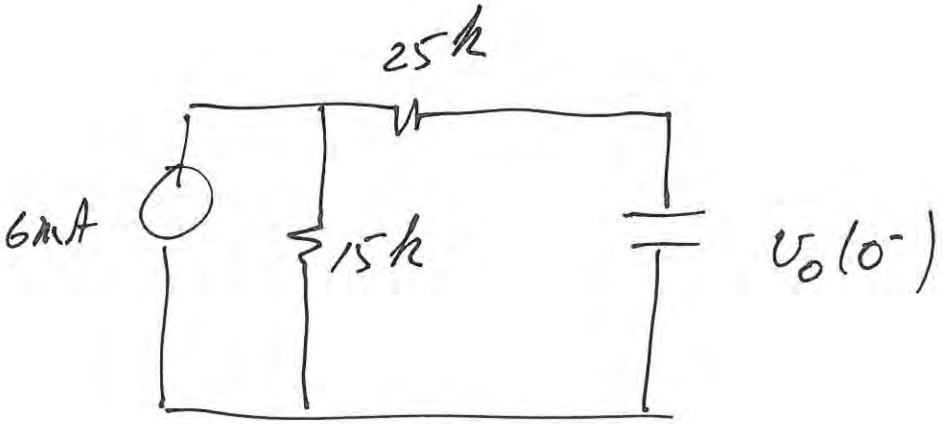
$$\boxed{i(t) = 6.75e^{-1,000t}\ mA; t \geq 0^+}$$

7.61



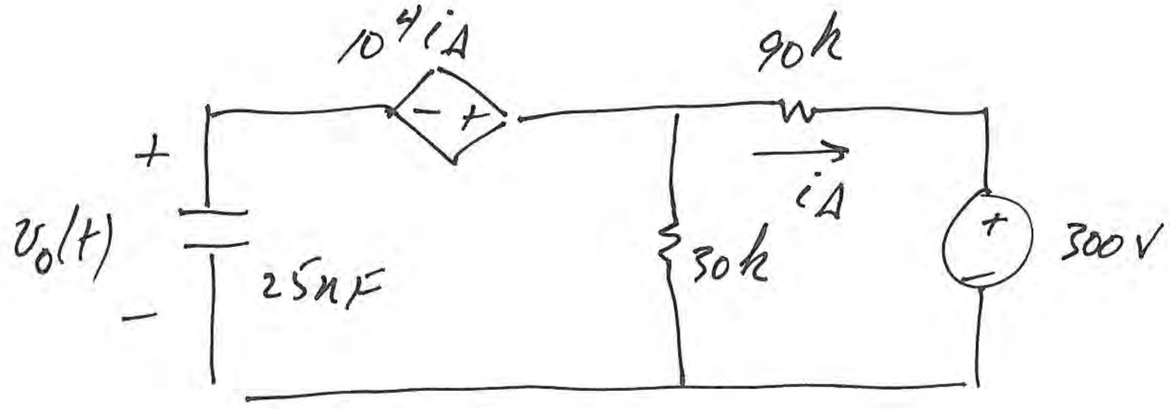
FIND $v_o(t)$; $t \geq 0$

$t < 0$



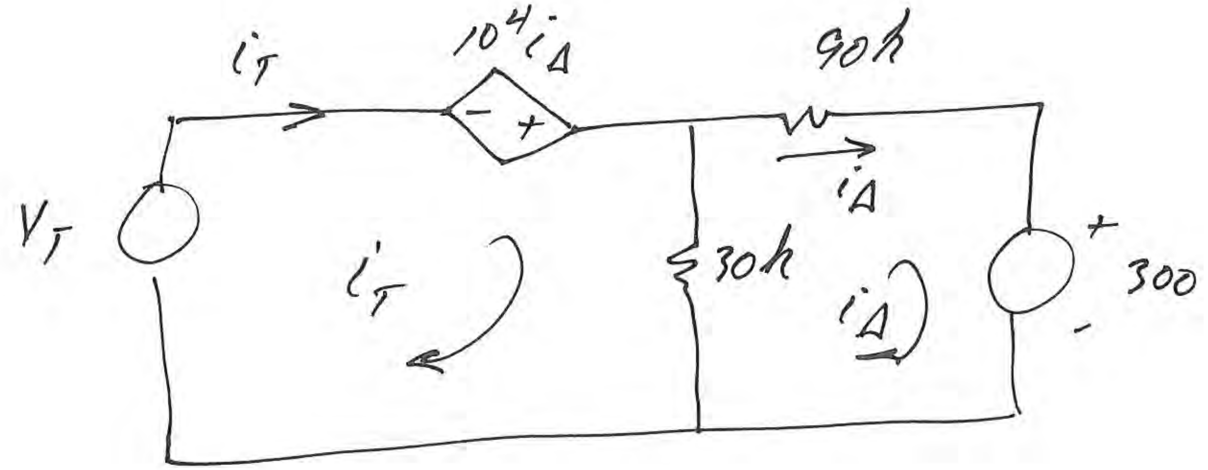
$$v_o(0^-) = (6mA)(15k\Omega) = 90V = v_o(0^+)$$

$t \geq 0$



7.61, CONT'D.

THÉVENIN EQ "SEEN" BY CAP



MESH EQ'S: ① $V_T + 10^4 i_\Delta - 30k\Omega(i_T - i_\Delta) = 0$

② $-90k\Omega\, i_\Delta - 300V - 30k\Omega(i_\Delta - i_T) = 0$

ELIMINATE i_Δ

FROM EQ ①: $V_T - 30k\, i_T + i_\Delta(10^4 + 30k)$

③ $i_\Delta = \dfrac{30k\Omega\, i_T - V_T}{40k\Omega}$

FROM EQ ②: $i_\Delta(-90k\Omega - 30k\Omega) - 300 + 30k\Omega\, i_T$

④ $= 0$

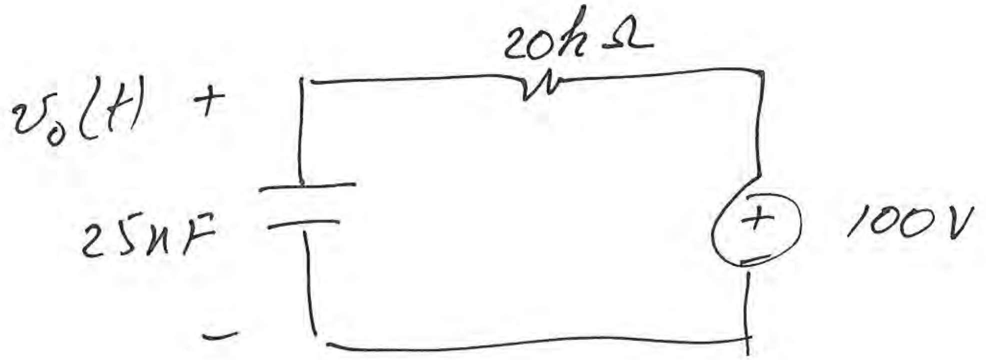
EQ'S ③ & ④:

$$-120k\Omega\left(\frac{30k\Omega i_T - V_T}{40k\Omega}\right) - 300V + 30k\Omega\, i_T = 0$$

7.61, CONT'D.

$$-3(30k\Omega\, i_T - v_T) - 300\,V + 30k\Omega\, i_T = 0$$

$$V_T = \underset{\underset{V_{TH}}{\uparrow}}{100\,V} + \underset{\underset{R_{TH}}{\uparrow}}{20k\Omega}\, i_T$$



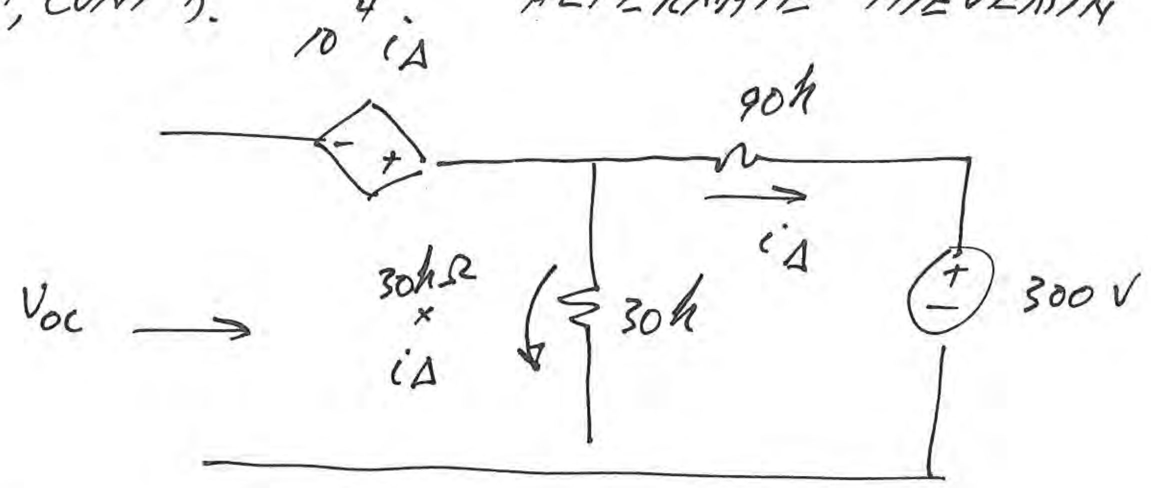
$$v_o(\infty) = 100\,V \quad , RC = (25uF)(20k\Omega)$$

$$= 0.5ms$$

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

$$\boxed{v_o(t) = 100 - 10e^{-2,000t}\,V \; ; \; t \geq 0}$$

7.61, CONT'D. ALTERNATE THÉVENIN ①



MESH:

$$V_{oc} + 10^4 i_\Delta + 30k\, i_\Delta = 0$$

$$V_{oc} = -40k\Omega\, i_\Delta \quad ①$$

MESH $$-90k\, i_\Delta - 300\,\text{V} - 30k\, i_\Delta = 0$$

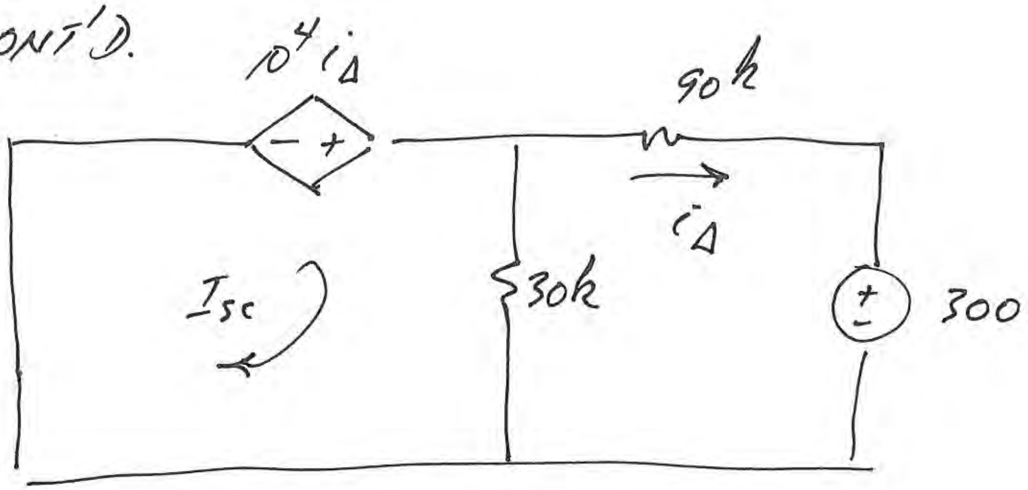
$$-120k\, i_\Delta = 300\,\text{V}$$

$$i_\Delta = \frac{-300\,\text{V}}{120k\Omega} = \underline{\underline{-2.5\,\text{mA}}} \quad ②$$

① & ②: $$V_{oc} = (-40k\Omega)(-2.5\,\text{mA}) = 100\,\text{V}$$

$$\underline{\underline{V_{TH} = 100\,\text{V}}}$$

7.61, CONT'D.



MESH EQ'S

$$10^4 i_\Delta - (I_{sc} - i_\Delta)30k = 0 \quad ①$$

$$-90k i_\Delta - 300 - (i_\Delta - I_{sc})30k = 0 \quad ②$$

$$① \rightarrow \quad 40k i_\Delta = 30k I_{sc} \longrightarrow i_\Delta = \frac{3}{4} I_{sc} \quad ③$$

$$② \rightarrow \quad -120k i_\Delta + 30k I_{sc} = 300$$

$$②' \,\&\, ③ \rightarrow \quad -120k\left(\frac{3}{4}\right) I_{sc} + 30k I_s = 300$$

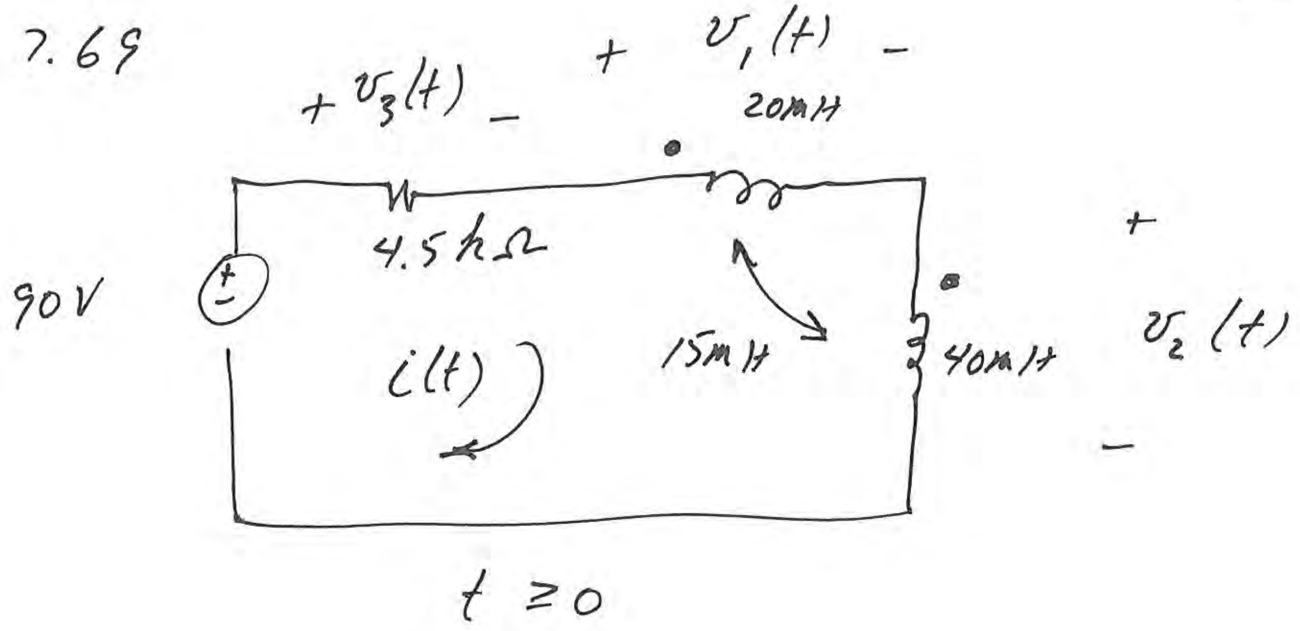
$$-60k I_{sc} = 300 \longrightarrow \underline{\underline{I_{sc} = -5mA}}$$

$$R_{TH} = \frac{V_{TH}}{-I_{sc}} = 20k\Omega$$

(NOTE SENSE OF I_{sc} & V_{TH} IN SAME DIRECTION)

$$\underline{R_{TH} = 20k\Omega}$$

7.69



$i(0) = 0$

$i(\infty) = 90V/4.5k\Omega = 0.02A = 20mA$

$L_{eq} = L_1 + L_2 + 2M = 20mH + 40mH + 30mH$

$= 0.090H$

$\tau = L_{eq}/R = 0.090/4.5k = 20\mu s$

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

$$\boxed{a)\ i(t) = 20(1 - e^{-50{,}000t})\,mA;\ t \geq 0}$$

7.69, CONT'D.

$$v_1(t) = L_1 \frac{di(t)}{dt} + M \frac{di(t)}{dt}$$

$$= (0.02 + 0.015) \frac{d}{dt}\left[20(1 - e^{-50{,}000t}) \text{mA} \right]$$

$$= (0.02 + 0.015)(-20\text{mA})(-50{,}000)\, e^{-50{,}000t}$$

$$\boxed{\text{b)}\ v_1(t) = 35\, e^{-50{,}000t};\ t \geq 0^+} \quad \text{VOLTS}$$

$$v_2(t) = L_2 \frac{di(t)}{dt} + M \frac{di(t)}{dt}$$

$$= (0.04 + 0.015)(-20\text{mA})(-50{,}000)\, e^{-50{,}000t}$$

$$\boxed{\text{c)}\ v_2(t) = 55\, e^{-50{,}000t};\ t \geq 0^+} \quad \text{VOLTS}$$

d) $v_3(t) = 4.5k\Omega \times i(t)$

$$\boxed{v_3(t) = 90(1 - e^{-50{,}000t})\,\text{V};\ t \geq 0}$$

7.69, CONT'D.

DO ANSWERS FOR b), c), & d) MAKE SENSE?

MESH EQ:

$$90 \overset{?}{=} v_1(t) + v_2(t) + v_3(t)$$

$$R.H.S. = 35e^{-50,000t} + 55e^{-50,000t} + 90(1 - e^{-50,000t})$$

$$= 90 = L.H.S.$$

YES, ANSWERS MAKE SENSE