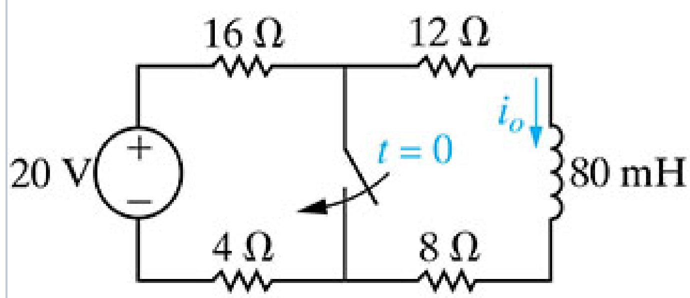
Problem 7.1 PSpice|Multisim

The switch in the circuit has been open for a long time. At t = 0 the switch is closed.



Part A

Determine $i_o(0)$.

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

ANSWER:

$i_o(0)$ =

Part B

Determine $i_o(\infty)$.

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

ANSWER:

$i_o(\infty)$ =

Part C

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

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

ANSWER:

$i_o(t)$ = A

Part D

How many milliseconds after the switch has been closed will i_o equal 120 mA?

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

ANSWER:

t =

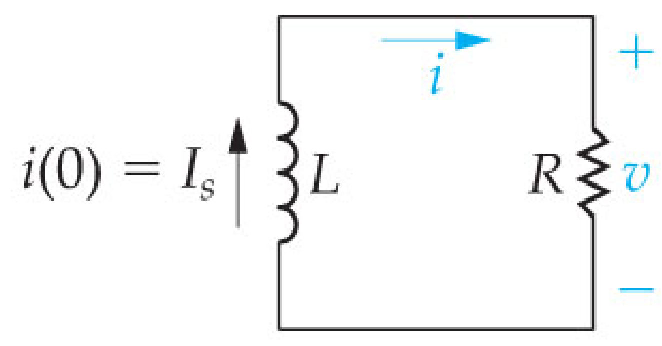
Problem 7.13

Designation	Value (Ω)
R1	10
R2	15
R3	22
R4	33
R5	47
R6	68

Part A

Given $L = 10\ \mathrm{mH}$, use the minimum number of resistors from the table to create a network of resistors, that should be connected to inductor to get first-order RL circuit (see the figure) with a time constant of 1 ms.

Express subcircuit using parallel(||) and series(+) buttons. For example, for capacitor C1 parallel-connected to series-connected resistors R1 and R2 enter (R1+R2)||C1.



ANSWER:

Part B

Suppose the inductor has an initial current of 10 mA. Write an expression for the current through the inductor for $t \geq 0$.

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

ANSWER:

$i(t)$ = ______ mA

Part C

Using your result to calculate the time at which half of the initial energy stored in the inductor has been dissipated by the resistor.

Express your answer with the appropriate units.

ANSWER:

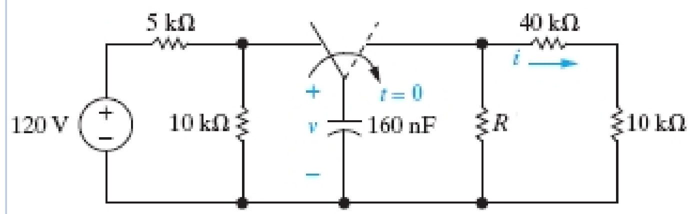
t = ______

Problem 7.24

Part A

What percentage of the initial energy stored in the capacitor in is dissipated by the 40 $\mathrm{k\Omega}$ resistor? Suppose that R = 60 $\mathrm{k\Omega}$.

Express your answer using three significant figures.

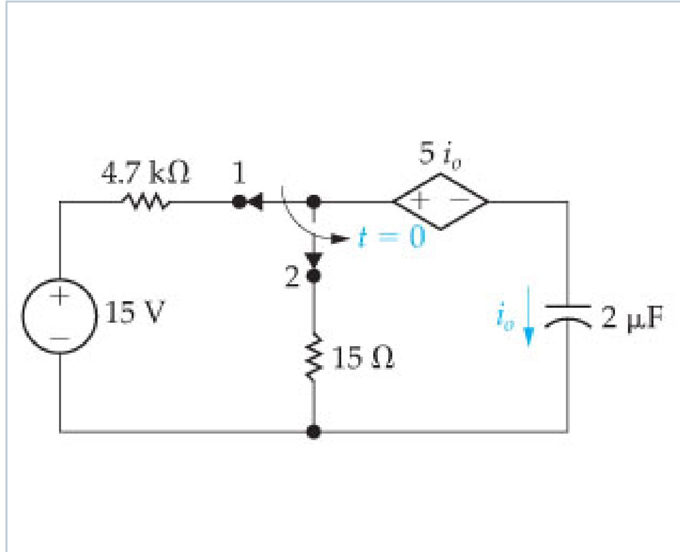


ANSWER:

$\%$ diss = ______ $\%$

Problem 7.28 PSpice|Multisim

The switch in the circuit has been in position 1 for a long time before moving to position 2 at $t = 0$.



Part A

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

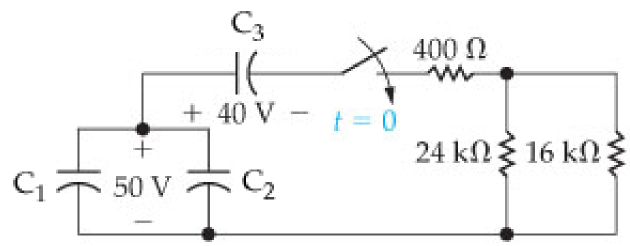
Express your answer in terms of t, where t is in milliseconds.

ANSWER:

$i_o(t)$ = A

Problem 7.34 PSpice|Multisim

At the time the switch is closed in the circuit, the voltage across the paralleled capacitors is 50 V and the voltage on the C_3 capacitor is 40 V. Take that C_1 = 180 nF , C_2 = 760 nF and C_3 = 250 nF .



Part A

What percentage of the initial energy stored in the three capacitors is dissipated in the 24 $\mathrm{k\Omega}$ resistor?

Express your answer using two decimal places.

ANSWER:

$\%$ diss = $\%$

Part B

What percentage of the initial energy stored in the three capacitors is dissipated in the 400 Ω resistor?

Express your answer using two decimal places.

ANSWER:

$\%$ diss = $\%$

Part C

What percentage of the initial energy stored in the three capacitors is dissipated in the 16 $\mathrm{k\Omega}$ resistor?

Express your answer using two decimal places.

ANSWER:

$\%$ diss = $\%$

Part D

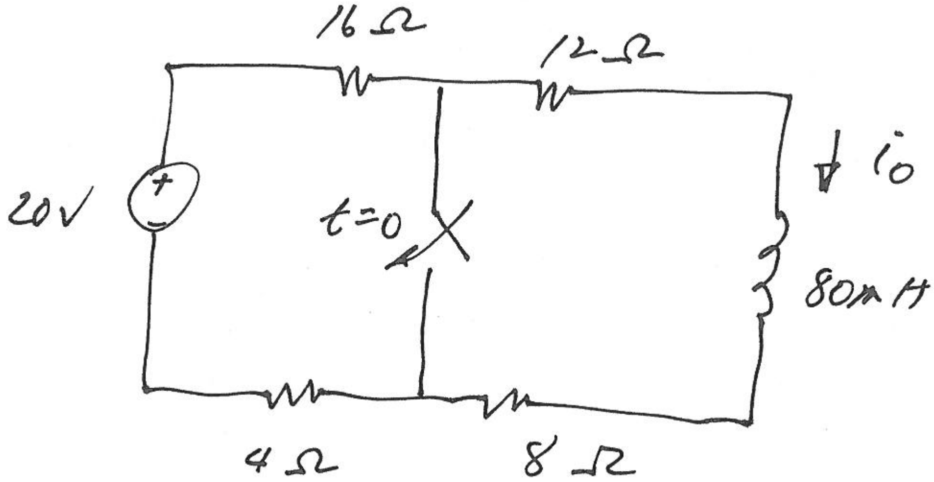
What percentage of the initial energy is trapped in the capacitors?

Express your answer using two decimal places.

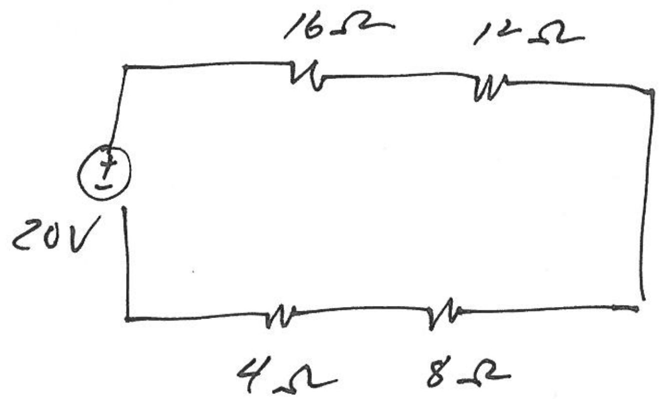
ANSWER:

% trapped = ____ %

7.1



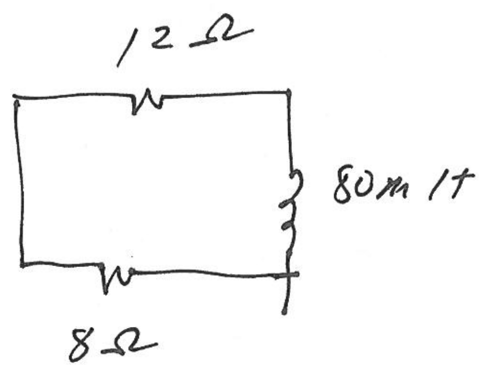
$t<0$



$$i_o(0) = \frac{20}{16+12+8+4}$$

$$\underline{i_o(0) = 0.5A}$$

$t>0$



$$\tau = \frac{L}{R} = \frac{80\times10^{-3}\,H}{20\,\Omega}$$

$$= 4\times10^{-3}\ \text{SEC}$$

7.1, CONT'D.

$$i_o(t) = i_o(0)\, e^{-t/\tau}$$

$$= 0.5\, e^{-250t} \text{ A}$$

$$\underline{\underline{i_o(\infty) = 0}}$$

$i_o(t_x) = 100\text{mA}$?

$$0.5\, e^{-250t_x} = 0.1$$

$$-250t_x = \ln(0.1/0.5)$$

$$t_x = \frac{\ln(0.1/0.5)}{-250}$$

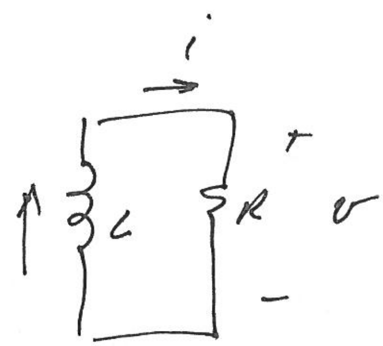
$$\underline{\underline{t_x = 6.438 \times 10^{-3}\text{ s}}}$$

7.13

~~2.2~~

FIG 7.4

$i(0) = I_s$



$\tau = 1\,ms \qquad \tau = \frac{L}{R}$

a) $L = 10\,mH$

$R = 10\,\Omega$

$\tau = \frac{10 \times 10^{-3}}{10} = 10^{-3}\,s$

b) $i(0) = 10\,mA$ FOR $t \geq 0$ CANNOT CHANGE INSTANTANEOUSLY

$i(t) = i(0)e^{-t/\tau}$

$i(t) = 10e^{-1000t}\ mA$

c) $W_L(0) = \frac{1}{2} i^2(0) L = \frac{1}{2}(10^{-2})^2 10^{-2} = 0.5\,\mu J$

DISSIPATED IN R:

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

7.13
~~2~~c, CONT'D

$$w_R(t) = i^2(0)R \int_0^t dt\, e^{-2t/\tau}$$

$$= i^2(0)R\left(-\frac{\tau}{2} e^{-2t/\tau}\Big|_0^t\right)$$

$$= \frac{1}{2} i^2(0) \cancel{R} \frac{L}{\cancel{R}} \left(1 - e^{-2t/\tau}\right)$$

$$= \frac{1}{2} i^2(0) L \left(1 - e^{-2000t}\right)$$

$$w_R(t) = w_L(0)\left(1 - e^{-2000t}\right)$$

SEEK t FOR WHICH $w_R(t) = \frac{w_L(0)}{2}$

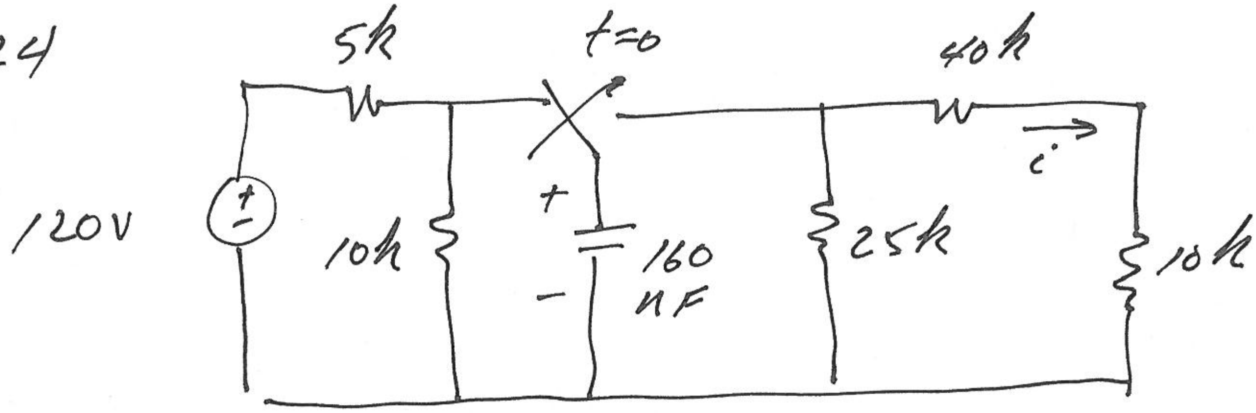
$$\frac{1}{2} = 1 - e^{-2000t} \longrightarrow e^{-2000t} = \frac{1}{2}$$

$$-2000t = -\ln 2$$

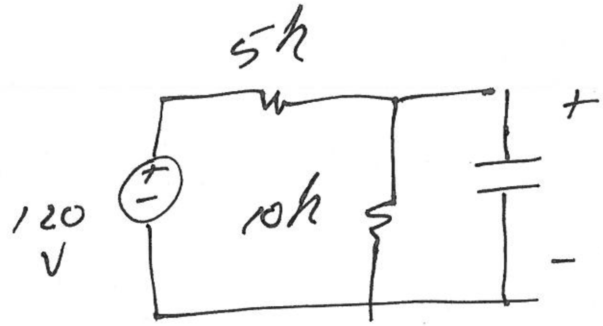
$$t = \frac{\ln 2}{2000} = 0.346\,\text{ms}$$

$$\boxed{t_{1/2} = 0.346\,\text{ms}}$$

7.24



t < 0



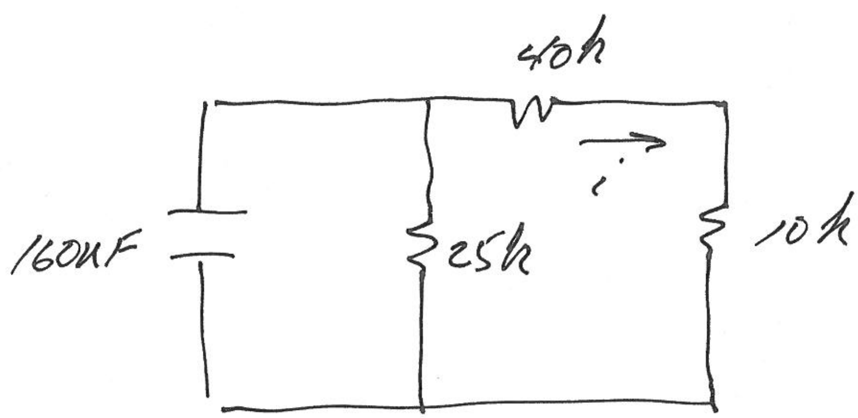
$$v_C(0) = 120V\left(\frac{10k}{10k+5k}\right)$$

(VOLTAGE DIV)

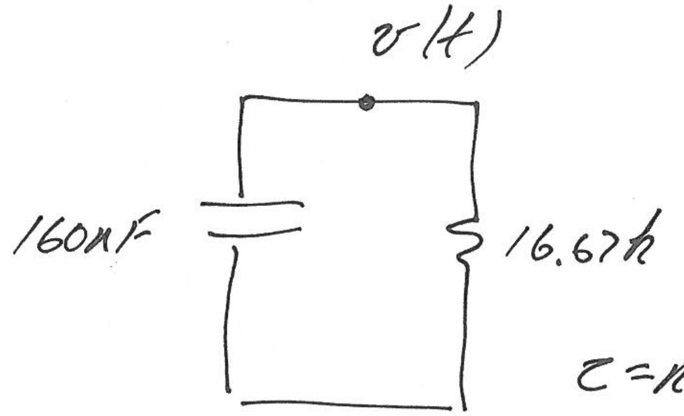
$$\underline{\underline{v(0) = 80\ V}}$$

$$W_C(0) = \frac{1}{2}\ C\ v^2(0) = 0.512\ mJ$$

t ≥ 0



7.24, CONT'D



$\tau = RC = 2.667 \times 10^{-3}\,s$

$$v(t) = v(0)\, e^{-t/\tau}$$

$$v(t) = 80 e^{-375t}\ V \quad t \geq 0$$

$$i(t) = \frac{v(t)}{50k} = 1.6 e^{-375t}\ mA \quad t \geq 0^+$$

(NOTE THAT $i(t) = 0$ FOR $t = 0^-$)

$$p = i^2(t) R = (1.6 e^{-375t}\ mA)^2\, 40k\Omega$$

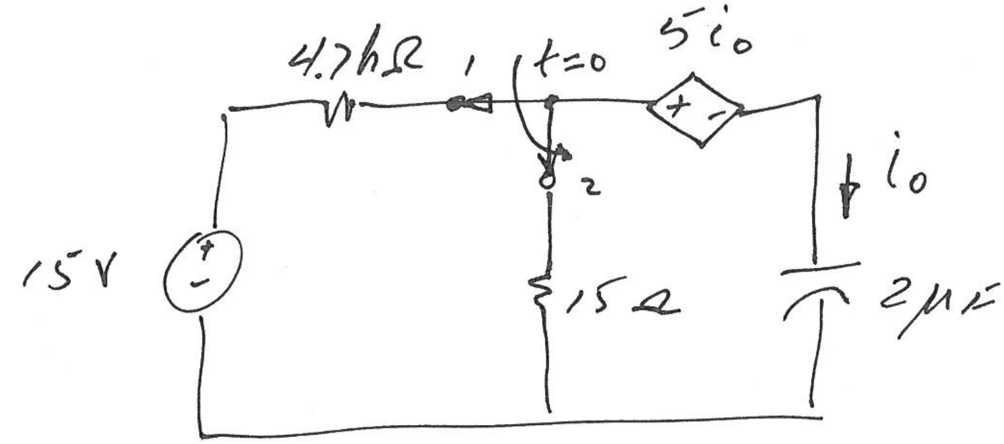
$$= 0.1024 e^{-750t}$$

$$w_{40k}(\infty) = \int_0^{\infty} p(t)\,dt = \frac{0.1024}{-750} e^{-750t}\Big|_0^{\infty}$$

$$w_{40k}(\infty) = 0.1024/750 = 0.1365\,mJ$$

(26.67% OF ENERGY INITIALLY STORED IN CAP)

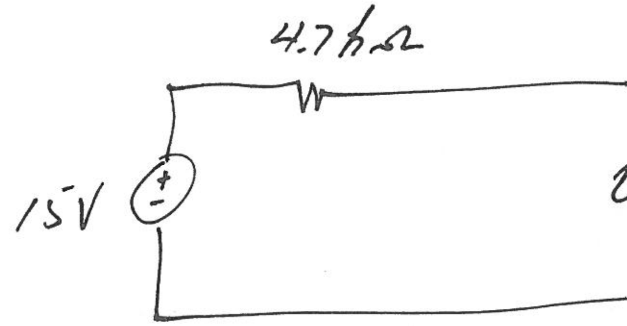
7.28
~~7.30~~



AT $t=0$ SWITCH MOVED FROM POSITION 1 TO POSITION 2

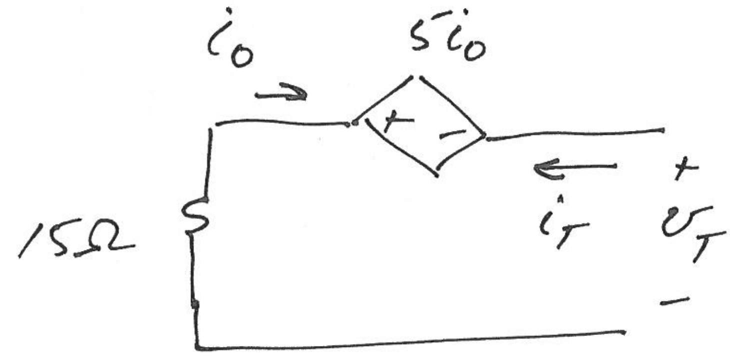
FIND $i_o(t)$ FOR $t \geq 0^+$

$t < 0$



$v_c(0^-) = 15V$

FOR $t \geq 0$, THÉVENIN EQ SEEN BY CAPACITOR



7.28

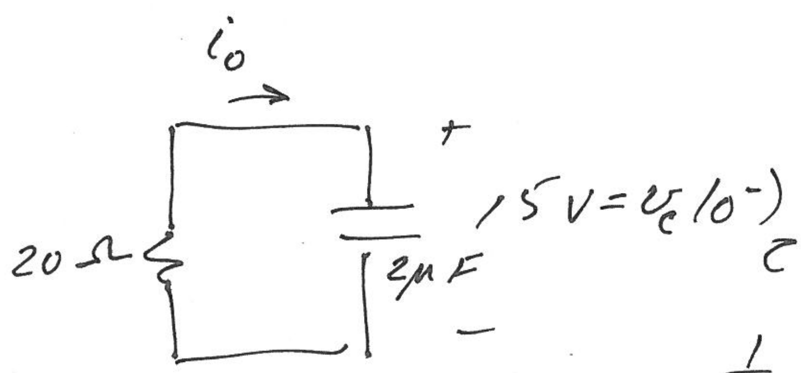
~~7.30~~, CONT'D.

$$v_T + 5i_o + 15i_o = 0$$

$$i_o = -i_T$$

$$v_T = 5i_T + 15i_T = 20i_T$$

$$\Rightarrow R_T = 20\,\Omega$$



$$\tau = RC = 40\,\mu s$$

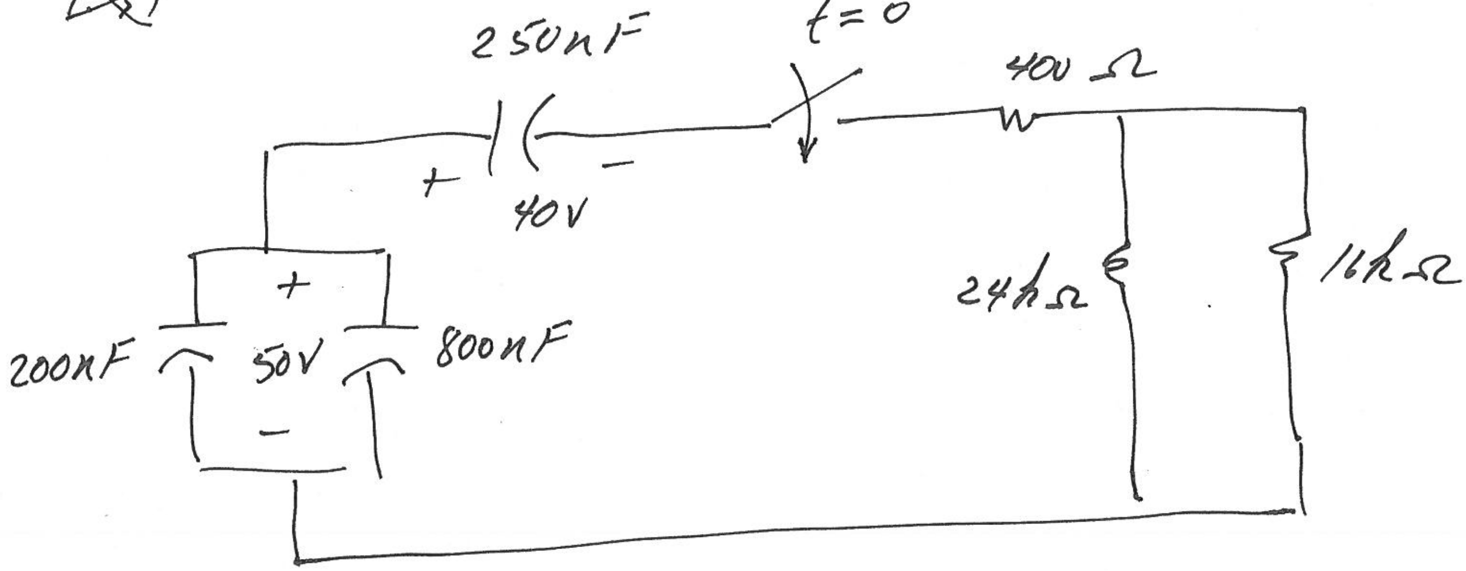
$$\frac{1}{\tau} = 25{,}000\ s^{-1}$$

$$v_c(t) = v_c(0^-)e^{-25{,}000t}$$

$$i_o(t) = -\frac{v_c(t)}{20\,\Omega}$$

$$\boxed{i_o(t) = -0.75e^{-25{,}000t}\ A,\ t \geq 0^+}$$

7.34
~~2.31~~

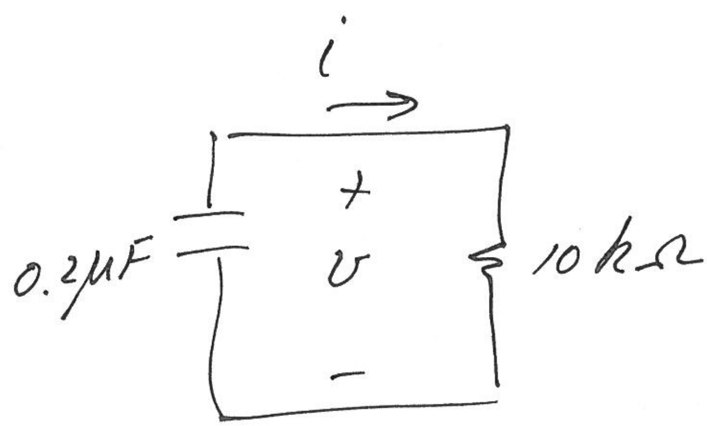


$$w_c(0) = \frac{1}{2} C V_0^2$$

$$w_c(0) = \frac{1}{2}(50)^2(200nF + 800nF) + \frac{1}{2}(40)^2(250nF)$$

$$\boxed{w_c(0) = 1.45\,mJ}$$

$t \geq 0$



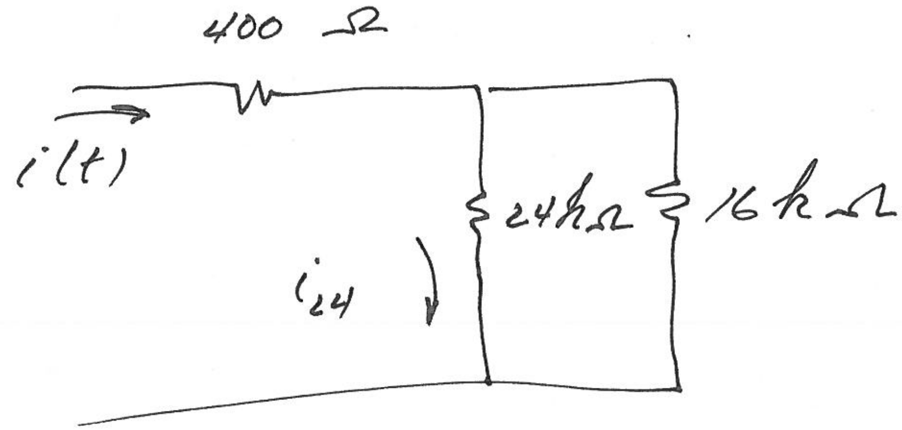
$v(0) = 10V$

$RC = 2ms = \tau$

$$v(t) = v(0)e^{-500t} = 10e^{-500t}\ V$$

7.34

~~7.31~~, CONT'D. $i(t) = \frac{v(t)}{10\,k\Omega} = 1 e^{-500t}$ mA



$$i_{24}(t) = i(t)\frac{16}{16+24} = 0.4\, i(t)$$

$$i_{24}(t) = 0.4\, e^{-500} \text{ mA}$$

$$\omega_{24}(\infty) = \int_0^\infty i_{24}^2(x)(24\,k\Omega)\,dx$$

$$= (0.4\times10^{-3})^2 (24\times10^{3})\left(\frac{1}{-1000} e^{-1000x}\Big|_0^\infty\right)$$

$$= \frac{(0.4\times10^{-3})^2(24\times10^{3})}{1000}$$

$$\boxed{\omega_{24}(\infty) = 3.84\,\mu J = 0.265\%}$$

7.34

~~7.31~~, CONT'D.

$$i_{16}(t) = i(t)\frac{24}{16+24} = 0.6\,i(t)$$

$$w_{16}(\infty) = \int_0^{\infty} i_{16}^2(t)\,16\,k\Omega\,dt$$

⋮

$$\boxed{w_{16}(\infty) = 5.76\,\mu J = 0.40\%}$$

$$i_{400}(t) = i(t)$$

⋮

$$\boxed{w_{400}(\infty) = 0.4\,\mu J = 0.0276\%}$$

TOTAL DISSIPATED $= 3.84\,\mu J + 5.76\,\mu J + 0.4\,\mu J$

$= 10\,\mu J$

FRACTION OF INITIAL ENERGY TRAPPED

$$= \frac{1.45\,mJ - 10\,\mu J}{1.45\,mJ}$$

$$\boxed{w_c(0)\text{ TRAPPED} = 99.31\%}$$