Chapter 7, Solution 2.

$\tau = R_{th}C$

where R_{th} is the Thevenin equivalent at the capacitor terminals.

$$R_{th} = 120 \parallel 80 + 12 = 60\ \Omega$$
$$\tau = 60 \times 200 \times 10^{-3} = \mathbf{12\ s}.$$

Chapter 7, Solution 7.

Assuming that the switch in Fig. 7.87 has been in position A for a long time and is moved to position B at t=0. Then at t = 1second, the switch moves from B to C. Find $v_C(t)$ for $t \geq 0$.

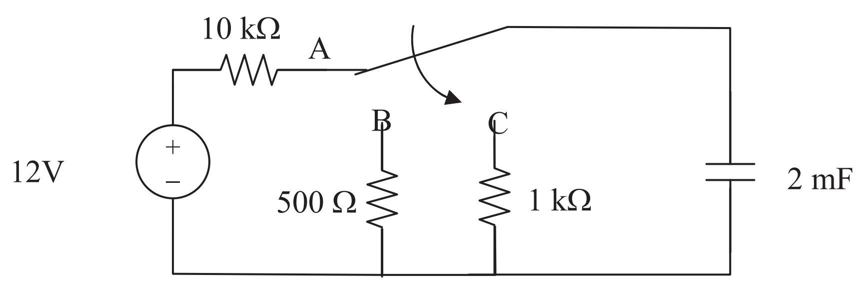


Figure 7.87
For Prob. 7.7

Solution

Step 1. Determine the initial voltage on the capacitor. Clearly it charges to 12 volts when the switch is at position A because the circuit has reached steady state.

This then leaves us with two simple circuits, the first a 500 **Ω** resistor in series with a 2 mF capacitor and an initial charge on the capacitor of 12 volts. The second circuit which exists from t = 1 sec to infinity. The initial condition for the second circuit will be $v_C(1)$ from the first circuit. The time constant for the first circuit is (500)(0.002) = 1 sec and the time constant for the second circuit is (1,000)(0.002) = 2 sec. $v_C(\infty) = 0$ for both circuits.

Step 1.

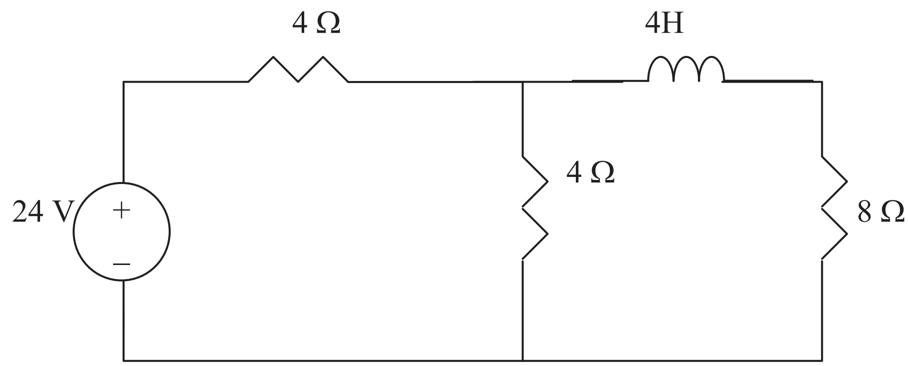
$v_C(t) = \mathbf{12e^{-t}}$ **volts** for $0 < t < 1$ sec and $= 12e^{-1}e^{-2(t-1)}$ at t = 1 sec, and

$= \mathbf{4.415e^{-2(t-1)}}$ **volts** for 1 sec $< t < \infty$.

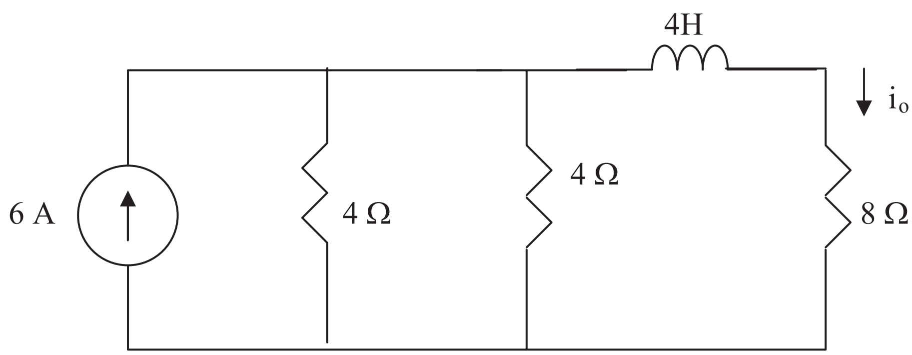
$\mathbf{12e^{-t}}$ **volts** for $0 < t < 1$ sec, $\mathbf{4.415e^{-2(t-1)}}$ **volts** for 1 sec $< t < \infty$.

Chapter 7, Solution 11.

For $t<0$, we have the circuit shown below.



⇩



4||4= 4x4/8=2
$i_o(0^-) = [2/(2+8)]6 = 1.2$ A

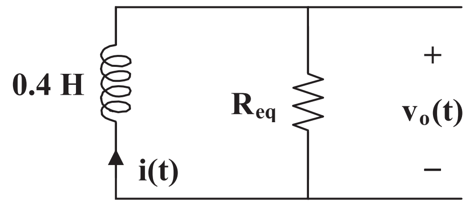
For $t>0$, we have a source-free RL circuit.

$\tau = \frac{L}{R} = \frac{4}{4+8} = 1/3$ thus,

$$i_o(t) = \mathbf{1.2e^{-3t}}\ \mathbf{A}.$$

Chapter 7, Solution 18.

If $v(t) = 0$, the circuit can be redrawn as shown below.



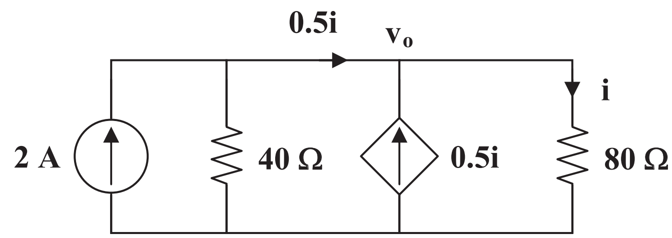
$$R_{eq} = 2 \,\|\, 3 = \frac{6}{5}, \qquad \tau = \frac{L}{R} = \frac{2}{5} \times \frac{5}{6} = \frac{1}{3}$$

$$i(t) = i(0)\,e^{-t/\tau} = 5e^{-3t}$$

$$v_o(t) = -L\frac{di}{dt} = \frac{-2}{5}(-3)5e^{-3t} = \mathbf{6\,e^{-3t}}\ V$$

Chapter 7, Solution 43.

Before t = 0, the circuit has reached steady state so that the capacitor acts like an open circuit. The circuit is equivalent to that shown in Fig. (a) after transforming the voltage source.



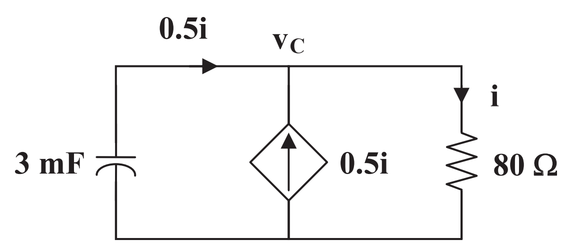
(a)

$$0.5i = 2 - \frac{v_o}{40}, \qquad i = \frac{v_o}{80}$$

Hence, $\frac{1}{2}\frac{v_o}{80} = 2 - \frac{v_o}{40} \longrightarrow v_o = \frac{320}{5} = 64$

$$i = \frac{v_o}{80} = \underline{\mathbf{0.8\ A}}$$

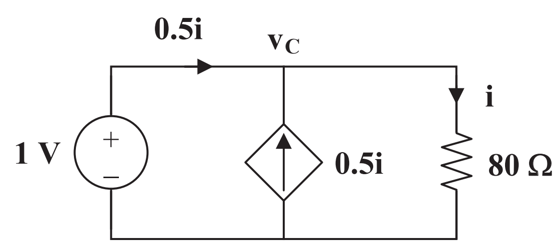
After t = 0, the circuit is as shown in Fig. (b).



(b)

$$v_C(t) = v_C(0)\,e^{-t/\tau}, \qquad \tau = R_{th}C$$

To find R_{th}, we replace the capacitor with a 1-V voltage source as shown in Fig. (c).



(c)

$$i = \frac{v_C}{80} = \frac{1}{80}, \qquad i_o = 0.5\,i = \frac{0.5}{80}$$

$$R_{th} = \frac{1}{i_o} = \frac{80}{0.5} = 160\,\Omega, \qquad \tau = R_{th}C = 480$$

$$v_C(0) = 64\text{ V}$$

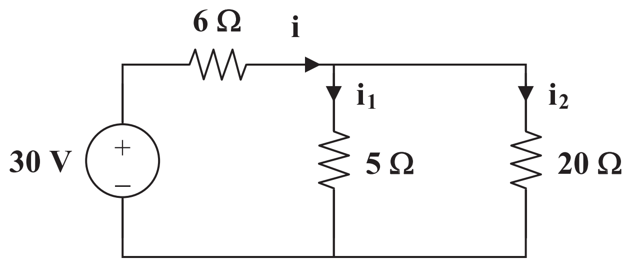
$$v_C(t) = 64\,e^{-t/480}$$

$$0.5\,i = -i_C = -C\frac{dv_C}{dt} = -3\left(\frac{1}{480}\right)64\,e^{-t/480}$$

$$i(t) = \boldsymbol{800\,e^{-t/480}u(t)\ mA}$$

Chapter 7, Solution 57.

At $t = 0^-$, the circuit has reached steady state so that the inductors act like short circuits.



$$i = \frac{30}{6 + (5 \| 20)} = \frac{30}{10} = 3, \qquad i_1 = \frac{20}{25}(3) = 2.4, \qquad i_2 = 0.6$$

$$i_1(0) = 2.4 \text{ A}, \qquad i_2(0) = 0.6 \text{ A}$$

For t > 0, the switch is closed so that the energies in L_1 and L_2 flow through the closed switch and become dissipated in the 5 Ω and 20 Ω resistors.

$$i_1(t) = i_1(0)e^{-t/\tau_1}, \qquad \tau_1 = \frac{L_1}{R_1} = \frac{2.5}{5} = \frac{1}{2}$$

$$i_1(t) = \mathbf{2.4e^{-2t}u(t)\ A}$$

$$i_2(t) = i_2(0)e^{-t/\tau_2}, \qquad \tau_2 = \frac{L_2}{R_2} = \frac{4}{20} = \frac{1}{5}$$

$$i_2(t) = \mathbf{600e^{-5t}u(t)\ mA}$$

Chapter 7, Solution 69.

Let v_x be the capacitor voltage.
For t < 0, $v_x(0) = 0$

For t > 0, the 20 kΩ and 100 kΩ resistors are in series and together, they are in parallel with the capacitor since no current enters the op amp terminals.
As $t \to \infty$, the capacitor acts like an open circuit so that

$$v_o(\infty) = \frac{-4}{10}(20+100) = -48$$

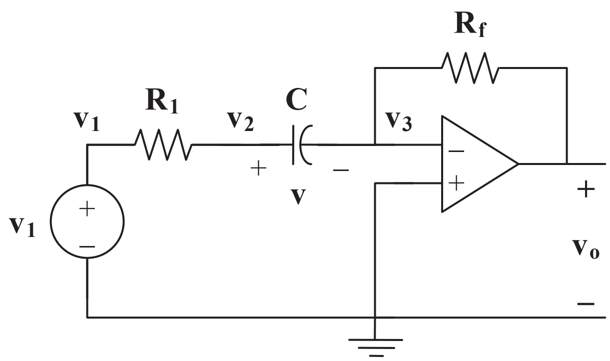
$$R_{th} = 20+100 = 120\text{ k}\Omega, \qquad \tau = R_{th}C = (120\times10^3)(25\times10^{-3}) = 3000$$

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

$$v_o(t) = -48\left(1 - e^{-t/3000}\right)V = \mathbf{48(e^{-t/3000}-1)u(t)V}$$

Chapter 7, Solution 73.

Consider the circuit below.



At node 2,

$$\frac{v_1 - v_2}{R_1} = C\frac{dv}{dt} \qquad (1)$$

At node 3,

$$C\frac{dv}{dt} = \frac{v_3 - v_o}{R_f} \qquad (2)$$

But $v_3 = 0$ and $v = v_2 - v_3 = v_2$. Hence, (1) becomes

$$\frac{v_1 - v}{R_1} = C\frac{dv}{dt}$$

$$v_1 - v = R_1 C\frac{dv}{dt}$$

or
$$\frac{dv}{dt} + \frac{v}{R_1 C} = \frac{v_1}{R_1 C}$$

which is similar to Eq. (7.42). Hence,

$$v(t) = \begin{cases} v_T & t < 0 \\ v_1 + \left(v_T - v_1\right)e^{-t/\tau} & t > 0 \end{cases}$$

where $v_T = v(0) = 1$ and $v_1 = 4$

$$\tau = R_1 C = (10\times10^3)(20\times10^{-6}) = 0.2$$

$$v(t) = \begin{cases} 1 & t < 0 \\ 4 - 3e^{-5t} & t > 0 \end{cases}$$

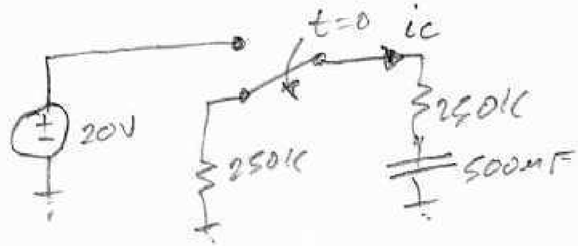
From (2),

$$v_o = -R_f C\frac{dv}{dt} = (20\times10^3)(20\times10^{-6})(15e^{-5t})$$

$$v_o = -6e^{-5t}, \quad t > 0$$

$v_o = \mathbf{-6e^{-5t}\,u(t)\ V}$

Supplemental



Initial Conditions

$t=0^-$	$t=0^+$	$t=\infty$
$I_c = 0$	$I_c = -40mA$	$I_c = 0A$
$V_c = 20V$	$V_c = 20V$	$V_c = 0V$

KVL: $-\frac{1}{C}\int i_c(dt) + 500K\, i_c = 0$

$\Rightarrow 500K\, i_c' - 2K\, i_c = 0 \Rightarrow 250K\, i_c' - i_c = 0$

$\Rightarrow \tau = 250 \quad \Rightarrow i_H(t) = Ce^{-t/\tau}$

General Solution: $i_T(t) = Ce^{-t/\tau} + i_p \Rightarrow i_p = 0A$

$\Rightarrow i(0^+) = 40mA = Ce^0 \Rightarrow C = -40mA$

$\Rightarrow \boxed{i(t) = -40mA\, e^{-t/250}}$

i(t) = C [d v(t) / dt]

==> v(t) = 20e ^(- t/250)

SUPPLEMENTAL (B)