Chapter 7, Solution 1.

Applying KVL to Fig. 7.1.

$$\frac{1}{C}\int_{-\infty}^{t} i\,dt + Ri = 0$$

Taking the derivative of each term,

$$\frac{i}{C} + R\frac{di}{dt} = 0$$

or $$\frac{di}{i} = -\frac{dt}{RC}$$

Integrating,

$$\ln\left(\frac{i(t)}{I_0}\right) = \frac{-t}{RC}$$

$$i(t) = I_0 e^{-t/RC}$$

$$v(t) = Ri(t) = RI_0 e^{-t/RC}$$

or $$\underline{\mathbf{v(t) = V_0 e^{-t/RC}}}$$

Chapter 7, Solution 2.

$\tau = R_{th}C$

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

$$R_{th} = 120 \parallel 80 + 12 = 60\ \Omega$$

$$\tau = 60 \times 0.5 \times 10^{-3} = \underline{\mathbf{30\ ms}}$$

Chapter 7, Solution 3.

(a) $R_{Th} = 10//10 = 5k\Omega, \quad \tau = R_{Th}C = 5x10^3 x2x10^{-6} = \underline{10\text{ ms}}$

(b) $R_{Th} = 20//(5+25) + 8 = 20\Omega, \quad \tau = R_{Th}C = 20x0.3 = \underline{6\text{s}}$

Chapter 7, Solution 4.

$\tau = R_{eq}C_{eq}$

where $C_{eq} = \dfrac{C_1C_2}{C_1+C_2}, \qquad R_{eq} = \dfrac{R_1R_2}{R_1+R_2}$

$$\tau = \underline{\mathbf{\frac{R_1R_2C_1C_2}{(R_1+R_2)(C_1+C_2)}}}$$

Chapter 7, Solution 5.

$$v(t) = v(4)\,e^{-(t-4)/\tau}$$

where $v(4) = 24$, $\tau = RC = (20)(0.1) = 2$

$$v(t) = 24\,e^{-(t-4)/2}$$

$$v(10) = 24\,e^{-6/2} = \underline{\mathbf{1.195\ V}}$$

Chapter 7, Solution 6.

$$v_o = v(0) = \frac{2}{10+2}(24) = 4\,V$$

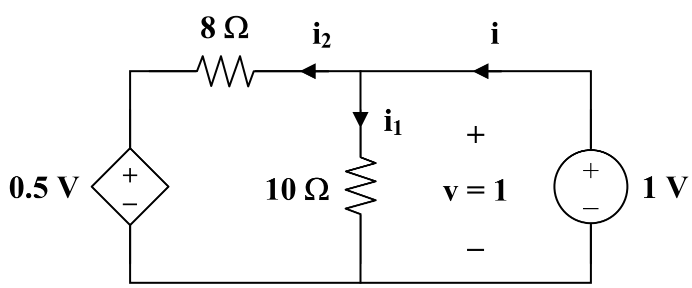
$$v(t) = v_o e^{-t/\tau},\ \ \tau = RC = 40x10^{-6}x2x10^{3} = \frac{2}{25}$$

$$v(t) = \underline{4e^{-12.5t}V}$$

Chapter 7, Solution 7.

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

where R_{th} is the Thevenin resistance across the capacitor. To determine R_{th}, we insert a 1-V voltage source in place of the capacitor as shown below.



$$i_1 = \frac{1}{10} = 0.1, \qquad i_2 = \frac{1-0.5}{8} = \frac{1}{16}$$

$$i = i_1 + i_2 = 0.1 + \frac{1}{16} = \frac{13}{80}$$

$$R_{th} = \frac{1}{i} = \frac{80}{13}$$

$$\tau = R_{th}C = \frac{80}{13}\times 0.1 = \frac{8}{13}$$

$$v(t) = \underline{20\,e^{-13t/8}\ V}$$

Chapter 7, Solution 8.

(a) $\tau = RC = \frac{1}{4}$

$-i = C\frac{dv}{dt}$

$-0.2e^{-4t} = C(10)(-4)e^{-4t} \longrightarrow C = \underline{\mathbf{5\ mF}}$

$R = \frac{1}{4C} = \underline{\mathbf{50\ \Omega}}$

(b) $\tau = RC = \frac{1}{4} = \underline{\mathbf{0.25\ s}}$

(c) $w_C(0) = \frac{1}{2}CV_0^2 = \frac{1}{2}(5\times10^{-3})(100) = \underline{\mathbf{250\ mJ}}$

(d) $w_R = \frac{1}{2}\times\frac{1}{2}CV_0^2 = \frac{1}{2}CV_0^2\left(1 - e^{-2t_0/\tau}\right)$

$0.5 = 1 - e^{-8t_0} \longrightarrow e^{-8t_0} = \frac{1}{2}$

or $e^{8t_0} = 2$

$t_0 = \frac{1}{8}\ln(2) = \underline{\mathbf{86.6\ ms}}$

Chapter 7, Solution 9.

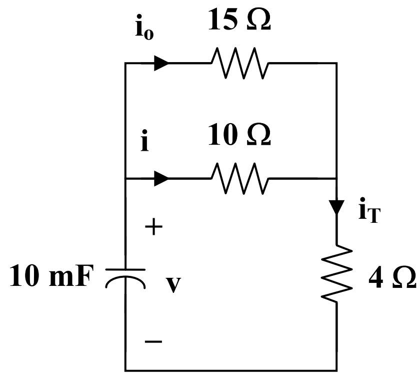
$v(t) = v(0)e^{-t/\tau}, \qquad \tau = R_{eq}C$

$R_{eq} = 2 + 8 \,||\, 8 + 6 \,||\, 3 = 2 + 4 + 2 = 8\ \Omega$

$\tau = R_{eq}C = (0.25)(8) = 2$

$v(t) = \underline{\mathbf{20e^{-t/2}\ V}}$

Chapter 7, Solution 10.



$$15 i_o = 10 i \longrightarrow i_o = \frac{(10)(3)}{15} = 2 \text{ A}$$

i.e. if $i(0) = 3$ A, then $i_o(0) = 2$ A

$i_T(0) = i(0) + i_o(0) = 5$ A

$v(0) = 10i(0) + 4i_T(0) = 30 + 20 = 50$ V

across the capacitor terminals.

$$R_{th} = 4 + 10 \,||\, 15 = 4 + 6 = 10\,\Omega$$

$$\tau = R_{th} C = (10)(10 \times 10^{-3}) = 0.1$$

$$v(t) = v(0)\,e^{-t/\tau} = 50\,e^{-10t}$$

$$i_C = C\frac{dv}{dt} = (10 \times 10^{-3})(-500\,e^{-10t})$$

$$i_C = -5\,e^{-10t} \text{ A}$$

By applying the current division principle,

$$i(t) = \frac{15}{10+15}(-i_C) = -0.6 i_C = \underline{\mathbf{3\,e^{-10t}\ A}}$$

Chapter 7, Solution 11.

Applying KCL to the RL circuit,

$$\frac{1}{L}\int v\,dt + \frac{v}{R} = 0$$

Differentiating both sides,

$$\frac{v}{L} + \frac{1}{R}\frac{dv}{dt} = 0 \longrightarrow \frac{dv}{dt} + \frac{R}{L}v = 0$$

$$v = A\,e^{-Rt/L}$$

If the initial current is I_0, then

$$v(0) = I_0 R = A$$

$$v = I_0 R\, e^{-t/\tau}, \qquad \tau = \frac{L}{R}$$

$$i = \frac{1}{L}\int_{-\infty}^{t} v(t)\, dt$$

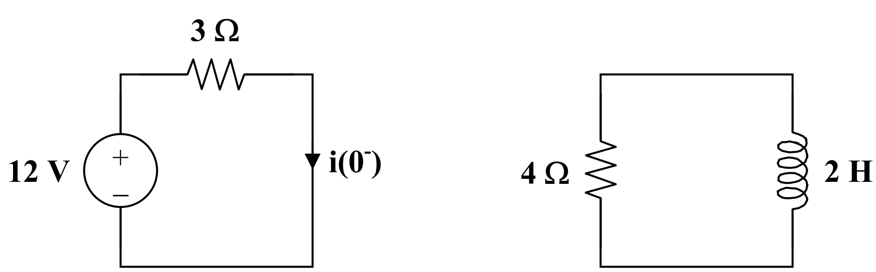
$$i = \frac{-\tau I_0 R}{L} e^{-t/\tau}\Big|_{-\infty}^{t}$$

$$i = -I_0 R\, e^{-t/\tau}$$

$$\underline{\mathbf{i(t) = I_0\, e^{-t/\tau}}}$$

Chapter 7, Solution 12.

When t < 0, the switch is closed and the inductor acts like a short circuit to dc. The 4 Ω resistor is short-circuited so that the resulting circuit is as shown in Fig. (a).



(a) (b)

$$i(0^-) = \frac{12}{3} = 4\text{ A}$$

Since the current through an inductor cannot change abruptly,

$$i(0) = i(0^-) = i(0^+) = 4\text{ A}$$

When t > 0, the voltage source is cut off and we have the RL circuit in Fig. (b).

$$\tau = \frac{L}{R} = \frac{2}{4} = 0.5$$

Hence,

$$i(t) = i(0)\, e^{-t/\tau} = \underline{\mathbf{4\, e^{-2t}\ A}}$$

Chapter 7, Solution 13.

$$\tau = \frac{L}{R_{th}}$$

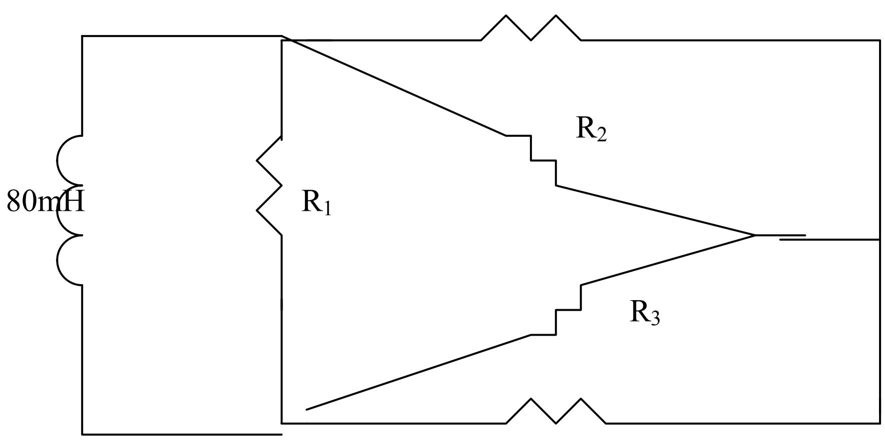
where R_{th} is the Thevenin resistance at the terminals of the inductor.

$$R_{th} = 70 \parallel 30 + 80 \parallel 20 = 21 + 16 = 37\ \Omega$$

$$\tau = \frac{2 \times 10^{-3}}{37} = \underline{\mathbf{81.08\ \mu s}}$$

Chapter 7, Solution 14

Converting the wye-subnetwork to delta gives



$$R_1 = \frac{10x20 + 20x50 + 50x10}{20} = 1700/20 = 85\Omega, \quad R_2 = \frac{1700}{50} = 34\Omega, \quad R_3 = \frac{1700}{10} = 170\Omega$$

30//170 = (30x170)/200 = 25.5 Ω, 34//16=(34x16)/50 =10.88 Ω

$$R_{Th} = 85//(25.5 + 10.88) = \frac{85x36.38}{121.38} = 25.476\Omega, \quad \tau = \frac{L}{R_{Th}} = \frac{80x10^{-3}}{25.476} = \underline{3.14\ ms}$$

Chapter 7, Solution 15

(a) $R_{Th} = 12 + 10 // 40 = 20\Omega, \qquad \tau = \dfrac{L}{R_{Th}} = 5/20 = \underline{0.25s}$

(b) $R_{Th} = 40 // 160 + 8 = 40\Omega, \qquad \tau = \dfrac{L}{R_{Th}} = (20x10^{-3})/40 = \underline{0.5\ \text{ms}}$

Chapter 7, Solution 16.

$$\tau = \frac{L_{eq}}{R_{eq}}$$

(a) $L_{eq} = L$ and $R_{eq} = R_2 + \dfrac{R_1 R_3}{R_1 + R_3} = \dfrac{R_2(R_1 + R_3) + R_1 R_3}{R_1 + R_3}$

$$\tau = \underline{\mathbf{\frac{L(R_1 + R_3)}{R_2(R_1 + R_3) + R_1 R_3}}}$$

(b) where $L_{eq} = \dfrac{L_1 L_2}{L_1 + L_2}$ and $R_{eq} = R_3 + \dfrac{R_1 R_2}{R_1 + R_2} = \dfrac{R_3(R_1 + R_2) + R_1 R_2}{R_1 + R_2}$

$$\tau = \underline{\mathbf{\frac{L_1 L_2 (R_1 + R_2)}{(L_1 + L_2)(R_3(R_1 + R_2) + R_1 R_2)}}}$$

Chapter 7, Solution 17.

$i(t) = i(0)\,e^{-t/\tau}, \qquad \tau = \dfrac{L}{R_{eq}} = \dfrac{1/4}{4} = \dfrac{1}{16}$

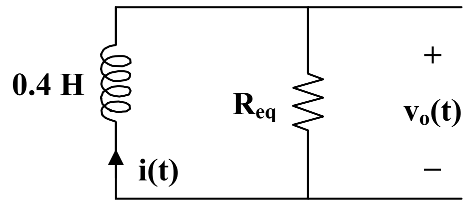
$i(t) = 2\,e^{-16t}$

$v_o(t) = 3i + L\dfrac{di}{dt} = 6\,e^{-16t} + (1/4)(-16)\,2\,e^{-16t}$

$v_o(t) = \underline{\mathbf{-\,2\,e^{-16t}\ V}}$

Chapter 7, Solution 18.

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

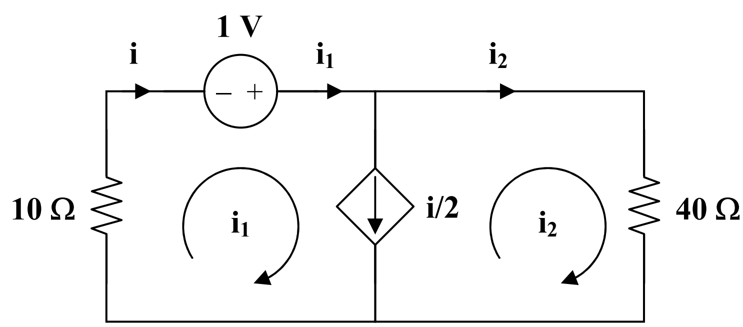


$$R_{eq} = 2 \parallel 3 = \frac{6}{5}, \qquad \tau = \frac{L}{R} = \frac{2}{5} \times \frac{5}{6} = \frac{1}{3}$$

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

$$v_o(t) = -L\frac{di}{dt} = \frac{-2}{5}(-3)\,e^{-3t} = \underline{\mathbf{1.2\,e^{-3t}\ V}}$$

Chapter 7, Solution 19.



To find R_{th} we replace the inductor by a 1-V voltage source as shown above.

$$10i_1 - 1 + 40i_2 = 0$$

But $\quad i = i_2 + i/2 \quad$ and $\quad i = i_1$

i.e. $\quad i_1 = 2i_2 = 2i$

$$10i - 1 + 20i = 0 \longrightarrow i = \frac{1}{30}$$

$$R_{th} = \frac{1}{i} = 30\,\Omega$$

$$\tau = \frac{L}{R_{th}} = \frac{6}{30} = 0.2\ \text{s}$$

$$i(t) = \underline{\mathbf{2\,e^{-5t}\ A}}$$

Chapter 7, Solution 20.

(a). $\tau = \dfrac{L}{R} = \dfrac{1}{50} \longrightarrow R = 50L$

$-v = L\dfrac{di}{dt}$

$-150e^{-50t} = L(30)(-50)e^{-50t} \longrightarrow L = \underline{\mathbf{0.1\ H}}$

$R = 50L = \underline{\mathbf{5\,\Omega}}$

(b). $\tau = \dfrac{L}{R} = \dfrac{1}{50} = \underline{\mathbf{20\ ms}}$

(c). $w = \dfrac{1}{2}Li^2(0) = \dfrac{1}{2}(0.1)(30)^2 = \underline{\mathbf{45\ J}}$

(d). Let p be the fraction

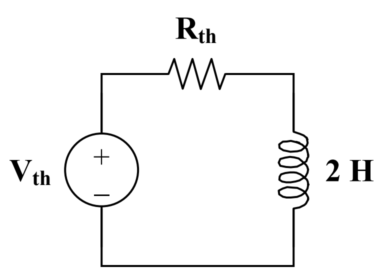
$\dfrac{1}{2}LI_0 \cdot p = \dfrac{1}{2}LI_0\left(1 - e^{-2t_0/\tau}\right)$

$p = 1 - e^{-(2)(10)/50} = 1 - e^{-0.4} = 0.3296$

i.e. $p = \underline{\mathbf{33\%}}$

Chapter 7, Solution 21.

The circuit can be replaced by its Thevenin equivalent shown below.



$V_{th} = \dfrac{80}{80+40}(60) = 40\ V$

$R_{th} = 40 \,\|\, 80 + R = \dfrac{80}{3} + R$

$I = i(0) = i(\infty) = \dfrac{V_{th}}{R_{th}} = \dfrac{40}{80/3 + R}$

$w = \dfrac{1}{2}LI^2 = \dfrac{1}{2}(2)\left(\dfrac{40}{R + 80/3}\right)^2 = 1$

$\dfrac{40}{R + 80/3} = 1 \longrightarrow R = \dfrac{40}{3}$

$R = \underline{\mathbf{13.33\,\Omega}}$

Chapter 7, Solution 22.

$$i(t) = i(0)\,e^{-t/\tau}, \qquad \tau = \frac{L}{R_{eq}}$$

$$R_{eq} = 5 \,||\, 20 + 1 = 5\,\Omega, \qquad \tau = \frac{2}{5}$$

$$i(t) = \underline{\mathbf{10\,e^{-2.5t}\ A}}$$

Using current division, the current through the 20 ohm resistor is

$$i_o = \frac{5}{5+20}(-i) = \frac{-i}{5} = -2\,e^{-2.5t}$$

$$v(t) = 20\,i_o = \underline{\mathbf{-40\,e^{-2.5t}\ V}}$$

Chapter 7, Solution 23.

Since the 2 Ω resistor, 1/3 H inductor, and the (3+1) Ω resistor are in parallel, they always have the same voltage.

$$-i = \frac{2}{2} + \frac{2}{3+1} = 1.5 \longrightarrow i(0) = -1.5$$

The Thevenin resistance R_{th} at the inductor's terminals is

$$R_{th} = 2 \,||\, (3+1) = \frac{4}{3}, \qquad \tau = \frac{L}{R_{th}} = \frac{1/3}{4/3} = \frac{1}{4}$$

$$i(t) = i(0)\,e^{-t/\tau} = -1.5\,e^{-4t}, \quad t > 0$$

$$v_L = v_o = L\frac{di}{dt} = -1.5(-4)(1/3)\,e^{-4t}$$

$$v_o = \underline{\mathbf{2\,e^{-4t}\ V,\quad t > 0}}$$

$$v_x = \frac{1}{3+1}v_L = \underline{\mathbf{0.5\,e^{-4t}\ V,\quad t > 0}}$$

Chapter 7, Solution 24.

(a) $v(t) = \underline{\mathbf{-5\,u(t)}}$

(b) $i(t) = -10\left[u(t) - u(t-3)\right] + 10\left[u(t-3) - u(t-5)\right]$

$$= \underline{\mathbf{-10\,u(t) + 20\,u(t-3) - 10\,u(t-5)}}$$

(c) $x(t) = (t-1)\left[u(t-1) - u(t-2)\right] + \left[u(t-2) - u(t-3)\right]$
$+ (4-t)\left[u(t-3) - u(t-4)\right]$
$= (t-1)u(t-1) - (t-2)u(t-2) - (t-3)u(t-3) + (t-4)u(t-4)$
$= \underline{\mathbf{r(t-1) - r(t-2) - r(t-3) + r(t-4)}}$

(d) $y(t) = 2u(-t) - 5\left[u(t) - u(t-1)\right]$
$= \underline{\mathbf{2u(-t) - 5u(t) + 5u(t-1)}}$

Chapter 7, Solution 25.

$\underline{\mathbf{v(t) = [u(t) + r(t-1) - r(t-2) - 2u(t-2)]\ V}}$

Chapter 7, Solution 26.

(a) $v_1(t) = u(t+1) - u(t) + \left[u(t-1) - u(t)\right]$
$v_1(t) = \underline{\mathbf{u(t+1) - 2u(t) + u(t-1)}}$

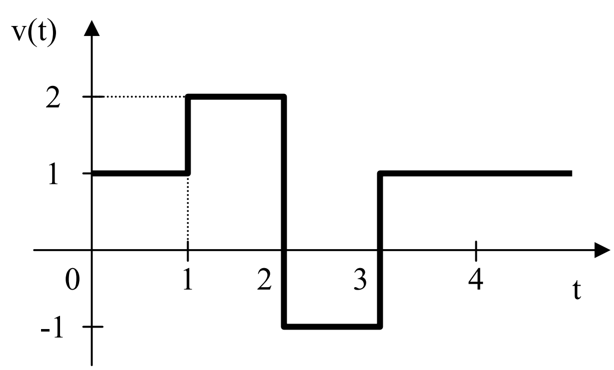
(b) $v_2(t) = (4-t)\left[u(t-2) - u(t-4)\right]$
$v_2(t) = -(t-4)u(t-2) + (t-4)u(t-4)$
$v_2(t) = \underline{\mathbf{2u(t-2) - r(t-2) + r(t-4)}}$

(c) $v_3(t) = 2\left[u(t-2) - u(t-4)\right] + 4\left[u(t-4) - u(t-6)\right]$
$v_3(t) = \underline{\mathbf{2u(t-2) + 2u(t-4) - 4u(t-6)}}$

(d) $v_4(t) = -t\left[u(t-1) - u(t-2)\right] = -t\,u(t-1) + t\,u(t-2)$
$v_4(t) = (-t+1-1)u(t-1) + (t-2+2)u(t-2)$
$v_4(t) = \underline{\mathbf{-r(t-1) - u(t-1) + r(t-2) + 2u(t-2)}}$

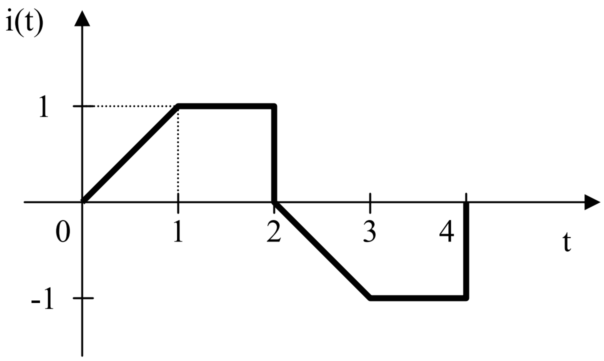
Chapter 7, Solution 27.

v(*t*) is sketched below.



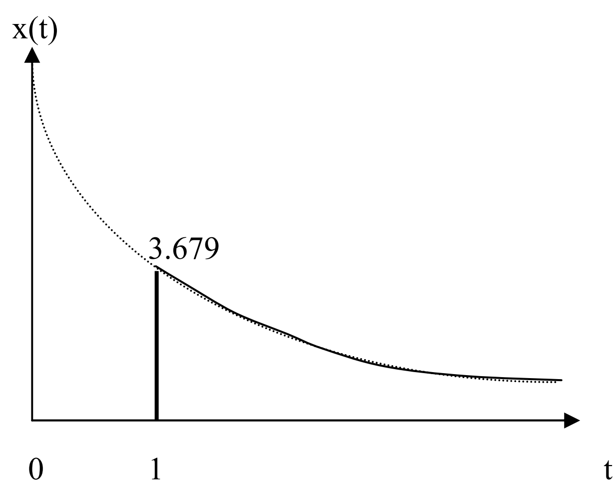
Chapter 7, Solution 28.

i(*t*) is sketched below.

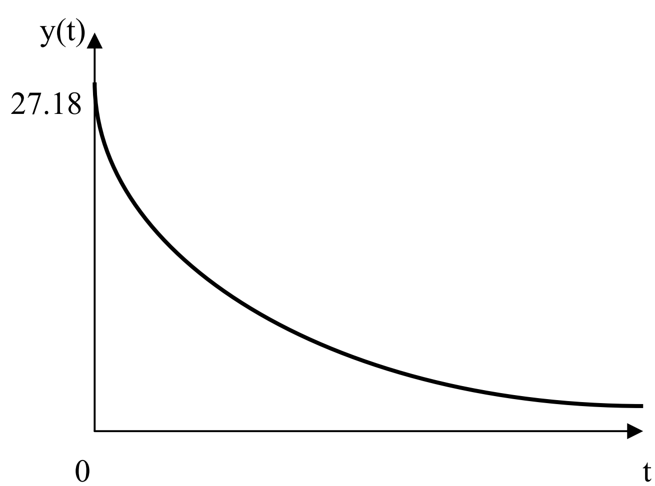


Chapter 7, Solution 29

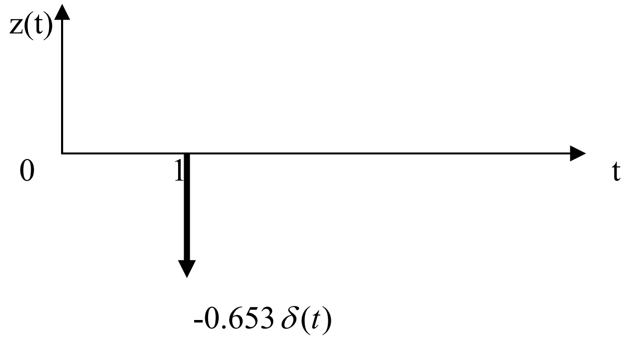
(a)



(b)



(c) $z(t) = \cos 4t\delta(t-1) = \cos 4\delta(t-1) = -0.6536\delta(t-1)$, which is sketched below.



Chapter 7, Solution 30.

(a) $\int_0^{10} 4t^2\,\delta(t-1)\,dt = 4t^2\Big|_{t=1} = \underline{\mathbf{4}}$

(b) $\int_{-\infty}^{\infty} \cos(2\pi t)\,\delta(t-0.5)\,dt = \cos(2\pi t)\Big|_{t=0.5} = \cos\pi = \underline{\mathbf{-1}}$

Chapter 7, Solution 31.

(a) $\int_{-\infty}^{\infty}\left[e^{-4t^2}\,\delta(t-2)\right]dt = e^{-4t^2}\Big|_{t=2} = e^{-16} = \underline{\mathbf{112\times10^{-9}}}$

(b) $\int_{-\infty}^{\infty}\left[5\delta(t) + e^{-t}\,\delta(t) + \cos 2\pi t\,\delta(t)\right]dt = \left(5 + e^{-t} + \cos(2\pi t)\right)\Big|_{t=0} = 5+1+1 = \underline{\mathbf{7}}$

Chapter 7, Solution 32.

(a) $\int_1^t u(\lambda)d\lambda = \int_1^t 1d\lambda = \lambda\Big|_1^t = \underline{t-1}$

(b) $\int_0^4 r(t-1)dt = \int_0^1 0dt + \int_1^4 (t-1)dt = \frac{t^2}{2} - t\Big|_1^4 = \underline{4.5}$

(c) $\int_1^5 (t-6)^2\,\delta(t-2)dt = (t-6)^2\Big|_{t=2} = \underline{16}$

Chapter 7, Solution 33.

$$i(t) = \frac{1}{L}\int_0^t v(t)\,dt + i(0)$$

$$i(t) = \frac{10^{-3}}{10\times10^{-3}}\int_0^t 20\,\delta(t-2)\,dt + 0$$

$$i(t) = \underline{\mathbf{2\,u(t-2)\ A}}$$

Chapter 7, Solution 34.

(a)
$$\frac{d}{dt}\left[u(t-1)\,u(t+1)\right] = \delta(t-1)u(t+1) +$$
$$u(t-1)\delta(t+1) = \delta(t-1)\bullet 1 + 0\bullet\delta(t+1) = \underline{\delta(t-1)}$$

(b)
$$\frac{d}{dt}\left[r(t-6)\,u(t-2)\right] = u(t-6)u(t-2) +$$
$$r(t-6)\delta(t-2) = u(t-6)\bullet 1 + 0\bullet\delta(t-2) = \underline{u(t-6)}$$

(c)
$$\frac{d}{dt}\left[\sin 4t\,u(t-3)\right] = 4\cos 4t\,u(t-3) + \sin 4t\delta(t-3)$$
$$= 4\cos 4t\,u(t-3) + \sin 4x3\delta(t-3)$$
$$= \underline{4\cos 4t\,u(t-3) - 0.5366\delta(t-3)}$$

Chapter 7, Solution 35.

(a) $v(t) = A\,e^{-5t/3},\ v(0) = A = -2$

$v(t) = \underline{\mathbf{-2\,e^{-5t/3}\ V}}$

(b) $v(t) = A\,e^{2t/3},\ v(0) = A = 5$

$v(t) = \underline{\mathbf{5\,e^{2t/3}\ V}}$

Chapter 7, Solution 36.

(a) $v(t) = A + Be^{-t}, \quad t > 0$

$A = 1, \qquad v(0) = 0 = 1 + B \qquad \text{or} \qquad B = -1$

$v(t) = \underline{\mathbf{1 - e^{-t}\ V, \quad t > 0}}$

(b) $v(t) = A + Be^{t/2}, \quad t > 0$

$A = -3, \qquad v(0) = -6 = -3 + B \qquad \text{or} \qquad B = -3$

$v(t) = \underline{\mathbf{-3\left(1 + e^{t/2}\right) V, \quad t > 0}}$

Chapter 7, Solution 37.

Let $v = v_h + v_p$, $v_p = 10$.

$$\dot{v}_h + \frac{1}{4} v_h = 0 \quad \longrightarrow \quad v_h = Ae^{-t/4}$$

$$v = 10 + Ae^{-0.25t}$$

$$v(0) = 2 = 10 + A \quad \longrightarrow \quad A = -8$$
$$v = 10 - 8e^{-0.25t}$$

(a) $\tau = \underline{4s}$

(b) $v(\infty) = \underline{10}$ V

(c) $\underline{v = 10 - 8e^{-0.25t}}$

Chapter 7, Solution 38

Let $i = i_p + i_h$

$$\dot{i}_h + 3i_h = 0 \quad \longrightarrow \quad i_h = Ae^{-3t}u(t)$$

Let $i_p = ku(t), \quad \dot{i}_p = 0, \quad 3ku(t) = 2u(t) \quad \longrightarrow \quad k = \frac{2}{3}$

$$i_p = \frac{2}{3}u(t)$$

$$i = (Ae^{-3t} + \frac{2}{3})u(t)$$

If i(0) =0, then A + 2/3 = 0, i.e. A=-2/3. Thus

$$\underline{i = \frac{2}{3}(1 - e^{-3t})u(t)}$$

Chapter 7, Solution 39.

(a) Before t = 0,

$$v(t) = \frac{1}{4+1}(20) = \underline{\mathbf{4\ V}}$$

After t = 0,

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

$$\tau = RC = (4)(2) = 8, \quad v(0) = 4, \qquad v(\infty) = 20$$

$$v(t) = 20 + (8 - 20)e^{-t/8}$$

$$v(t) = \underline{\mathbf{20 - 12e^{-t/8}\ V}}$$

(b) Before t = 0, $v = v_1 + v_2$, where v_1 is due to the 12-V source and v_2 is due to the 2-A source.

$$v_1 = 12\ V$$

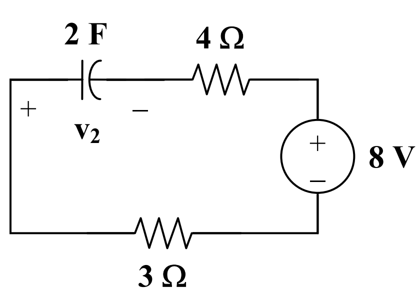
To get v_2, transform the current source as shown in Fig. (a).

$$v_2 = -8\ V$$

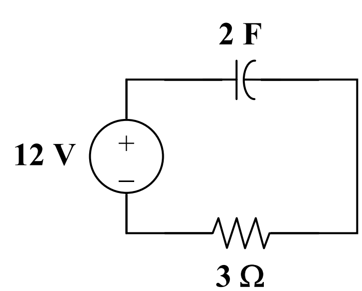
Thus,

$$v = 12 - 8 = \underline{\mathbf{4\ V}}$$

After t = 0, the circuit becomes that shown in Fig. (b).



(a)



(b)

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

$$v(\infty) = 12, \qquad v(0) = 4, \qquad \tau = RC = (2)(3) = 6$$

$$v(t) = 12 + (4 - 12)\, e^{-t/6}$$

$$v(t) = \underline{\mathbf{12 - 8e^{-t/6}\ V}}$$

Chapter 7, Solution 40.

(a) Before $t = 0$, $v = \underline{\mathbf{12\ V}}$.

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

$$v(\infty) = 4, \qquad v(0) = 12, \qquad \tau = RC = (2)(3) = 6$$

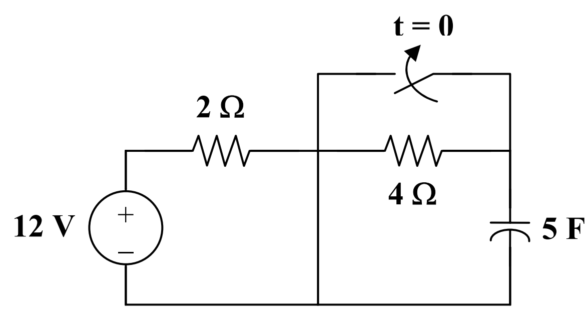
$$v(t) = 4 + (12 - 4)\, e^{-t/6}$$

$$v(t) = \underline{\mathbf{4 + 8e^{-t/6}\ V}}$$

(b) Before $t = 0$, $v = \underline{\mathbf{12\ V}}$.

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

After transforming the current source, the circuit is shown below.



$$v(0) = 12, \qquad v(\infty) = 12, \qquad \tau = RC = (2)(5) = 10$$

$$v = \underline{\mathbf{12\ V}}$$

Chapter 7, Solution 41.

$$v(0) = 0, \qquad v(\infty) = \frac{30}{16}(12) = 10$$

$$R_{eq}C = (6 \parallel 30)(1) = \frac{(6)(30)}{36} = 5$$

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

$$v(t) = 10 + (0 - 10)\, e^{-t/5}$$

$$v(t) = \underline{\mathbf{10(1 - e^{-0.2t})\ V}}$$

Chapter 7, Solution 42.

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

$$v_o(0) = 0, \qquad v_o(\infty) = \frac{4}{4+2}(12) = 8$$

$$\tau = R_{eq}C_{eq}, \qquad R_{eq} = 2 \,||\, 4 = \frac{4}{3}$$

$$\tau = \frac{4}{3}(3) = 4$$

$$v_o(t) = 8 - 8e^{-t/4}$$

$$v_o(t) = \underline{\mathbf{8(1 - e^{-0.25t})\ V}}$$

(b) For this case, $v_o(\infty) = 0$ so that

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

$$v_o(0) = \frac{4}{4+2}(12) = 8, \qquad \tau = RC = (4)(3) = 12$$

$$v_o(t) = \underline{\mathbf{8e^{-t/12}\ V}}$$

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.

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

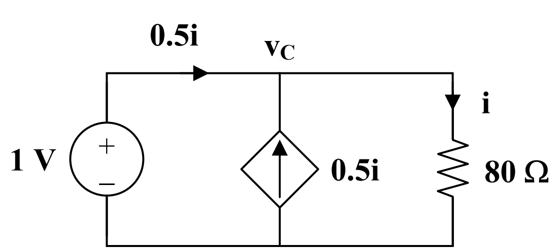
Hence, $$\frac{1}{2}\frac{v_o}{80} = 2 - \frac{v_o}{40} \longrightarrow v_o = \frac{320}{5} = 64$$

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

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

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

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



(c)

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

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

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

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

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

$$i(t) = \underline{\mathbf{0.8\,e^{-t/480}\ A}}$$

Chapter 7, Solution 44.

$$R_{eq} = 6\,||\,3 = 2\,\Omega, \qquad \tau = RC = 4$$

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

Using voltage division,

$$v(0) = \frac{3}{3+6}(30) = 10\text{ V}, \qquad v(\infty) = \frac{3}{3+6}(12) = 4\text{ V}$$

Thus,

$$v(t) = 4 + (10-4)\,e^{-t/4} = 4 + 6\,e^{-t/4}$$

$$i(t) = C\frac{dv}{dt} = (2)(6)\left(\frac{-1}{4}\right)e^{-t/4} = \underline{\mathbf{-3\,e^{-0.25t}\ A}}$$

Chapter 7, Solution 45.

For $t < 0$, $v_s = 5\,u(t) = 0 \longrightarrow v(0) = 0$

For $t > 0$, $v_s = 5$, $\qquad v(\infty) = \frac{4}{4+12}(5) = \frac{5}{4}$

$$R_{eq} = 7 + 4\,||\,12 = 10, \qquad \tau = R_{eq}C = (10)(1/2) = 5$$

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

$$v(t) = \underline{\mathbf{1.25(1 - e^{-t/5})\ V}}$$

$$i(t) = C\frac{dv}{dt} = \left(\frac{1}{2}\right)\left(\frac{-5}{4}\right)\left(\frac{-1}{5}\right)e^{-t/5}$$

$$\underline{i(t) = \mathbf{0.125\,e^{-t/5}\ A}}$$

Chapter 7, Solution 46.

$$\tau = R_{Th}C = (2+6)x0.25 = 2s, \qquad v(0) = 0, \qquad v(\infty) = 6i_s = 6x5 = 30$$

$$v(t) = v(\infty) + [v(0) - v(\infty)]e^{-t/\tau} = \underline{30(1 - e^{-t/2})} \text{ V}$$

Chapter 7, Solution 47.

For $t < 0$, $u(t) = 0$, $\quad u(t-1) = 0$, $\quad v(0) = 0$

For $0 < t < 1$, $\quad \tau = RC = (2+8)(0.1) = 1$

$$v(0) = 0, \qquad v(\infty) = (8)(3) = 24$$
$$v(t) = v(\infty) + \left[\, v(0) - v(\infty) \right] e^{-t/\tau}$$
$$v(t) = 24\left(1 - e^{-t}\right)$$

For $t > 1$, $\qquad v(1) = 24\left(1 - e^{-1}\right) = 15.17$

$$-6 + v(\infty) - 24 = 0 \longrightarrow v(\infty) = 30$$
$$v(t) = 30 + (15.17 - 30)\, e^{-(t-1)}$$
$$v(t) = 30 - 14.83\, e^{-(t-1)}$$

Thus,

$$v(t) = \underline{\begin{cases} \mathbf{24\left(1 - e^{-t}\right) V}, & \mathbf{0 < t < 1} \\ \mathbf{30 - 14.83\, e^{-(t-1)}\ V}, & \mathbf{t > 1} \end{cases}}$$

Chapter 7, Solution 48.

For $t < 0$, $\qquad u(-t) = 1$, $\qquad v(0) = 10$ V

For $t > 0$, $\qquad u(-t) = 0$, $\qquad v(\infty) = 0$

$$R_{th} = 20 + 10 = 30, \qquad \tau = R_{th}C = (30)(0.1) = 3$$
$$v(t) = v(\infty) + \left[\, v(0) - v(\infty) \right] e^{-t/\tau}$$
$$v(t) = \underline{\mathbf{10\, e^{-t/3}\ V}}$$

$$i(t) = C\frac{dv}{dt} = (0.1)\left(\frac{-1}{3}\right) 10\, e^{-t/3}$$

$$i(t) = \underline{\mathbf{\frac{-1}{3} e^{-t/3}\ A}}$$

Chapter 7, Solution 49.

For $0 < t < 1$, $v(0) = 0$, $v(\infty) = (2)(4) = 8$

$$R_{eq} = 4 + 6 = 10, \quad \tau = R_{eq}C = (10)(0.5) = 5$$

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

$$v(t) = 8\left(1 - e^{-t/5}\right) \text{ V}$$

For $t > 1$, $v(1) = 8\left(1 - e^{-0.2}\right) = 1.45$, $v(\infty) = 0$

$$v(t) = v(\infty) + \left[v(1) - v(\infty) \right] e^{-(t-1)/\tau}$$

$$v(t) = 1.45 e^{-(t-1)/5} \text{ V}$$

Thus,

$$v(t) = \begin{cases} \mathbf{8\left(1 - e^{-t/5}\right) V}, & \mathbf{0 < t < 1} \\ \mathbf{1.45 e^{-(t-1)/5} V}, & \mathbf{t > 1} \end{cases}$$

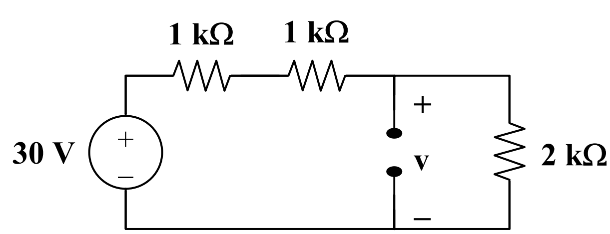
Chapter 7, Solution 50.

For the capacitor voltage,

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

$$v(0) = 0$$

For $t < 0$, we transform the current source to a voltage source as shown in Fig. (a).



(a)

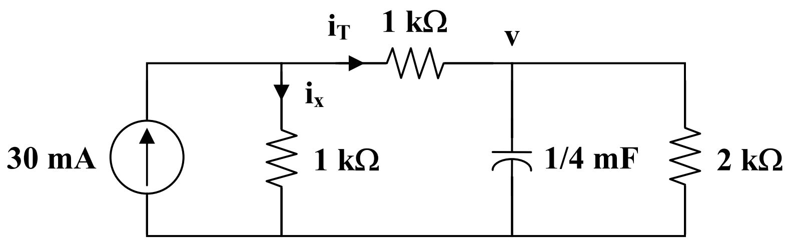
$$v(\infty) = \frac{2}{2+1+1}(30) = 15 \text{ V}$$

$$R_{th} = (1+1) \parallel 2 = 1 \text{ k}\Omega$$

$$\tau = R_{th}C = 10^3 \times \frac{1}{4} \times 10^{-3} = \frac{1}{4}$$

$$v(t) = 15\left(1 - e^{-4t}\right), \quad t > 0$$

We now obtain i_x from v(t). Consider Fig. (b).



(b)

$$i_x = 30 \text{ mA} - i_T$$

But $$i_T = \frac{v}{R_3} + C\frac{dv}{dt}$$

$$i_T(t) = 7.5\left(1 - e^{-4t}\right) \text{ mA} + \frac{1}{4} \times 10^{-3}\ (-15)(-4)e^{-4t}\ \text{A}$$

$$i_T(t) = 7.5\left(1 + e^{-4t}\right) \text{ mA}$$

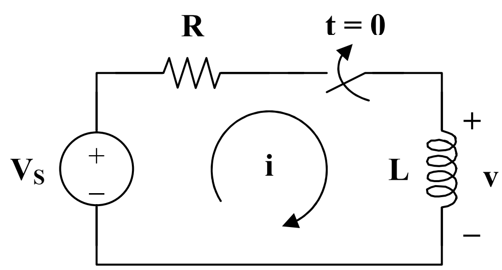
Thus,

$$i_x(t) = 30 - 7.5 - 7.5e^{-4t} \text{ mA}$$

$$i_x(t) = \underline{\mathbf{7.5\left(3 - e^{-4t}\right) mA, \quad t > 0}}$$

Chapter 7, Solution 51.

Consider the circuit below.



After the switch is closed, applying KVL gives

$$V_S = Ri + L\frac{di}{dt}$$

or $$L\frac{di}{dt} = -R\left(i - \frac{V_S}{R}\right)$$

$$\frac{di}{i - V_S/R} = \frac{-R}{L}dt$$

Integrating both sides,

$$\ln\left(i - \frac{V_S}{R}\right)\Bigg|_{I_0}^{i(t)} = \frac{-R}{L}t$$

$$\ln\left(\frac{i - V_S/R}{I_0 - V_S/R}\right) = \frac{-t}{\tau}$$

or $$\frac{i - V_S/R}{I_0 - V_S/R} = e^{-t/\tau}$$

$$\underline{\mathbf{i(t) = \frac{V_S}{R} + \left(I_0 - \frac{V_S}{R}\right)e^{-t/\tau}}}$$

which is the same as Eq. (7.60).

Chapter 7, Solution 52.

$$i(0) = \frac{20}{10} = 2\text{ A}, \qquad i(\infty) = 2\text{ A}$$

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

$$i(t) = \underline{\mathbf{2\ A}}$$

Chapter 7, Solution 53.

(a) Before t = 0, $i = \dfrac{25}{3+2} = \underline{\mathbf{5\ A}}$

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

$$\tau = \frac{L}{R} = \frac{4}{2} = 2, \qquad i(0) = 5$$

$$i(t) = \underline{\mathbf{5e^{-t/2}\ A}}$$

(b) Before t = 0, the inductor acts as a short circuit so that the 2 Ω and 4 Ω resistors are short-circuited.

$$i(t) = \underline{\mathbf{6\ A}}$$

After t = 0, we have an RL circuit.

$$i(t) = i(0)e^{-t/\tau}, \qquad \tau = \frac{L}{R} = \frac{3}{2}$$

$$i(t) = \underline{\mathbf{6e^{-2t/3}\ A}}$$

Chapter 7, Solution 54.

(a) Before t = 0, i is obtained by current division or

$$i(t) = \frac{4}{4+4}(2) = \underline{\mathbf{1\ A}}$$

After t = 0,

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

$$\tau = \frac{L}{R_{eq}}, \qquad R_{eq} = 4 + 4 \,||\, 12 = 7\ \Omega$$

$$\tau = \frac{3.5}{7} = \frac{1}{2}$$

$$i(0) = 1, \qquad i(\infty) = \frac{4\,||\,12}{4 + 4\,||\,12}(2) = \frac{3}{4+3}(2) = \frac{6}{7}$$

$$i(t) = \frac{6}{7} + \left(1 - \frac{6}{7}\right)e^{-2t}$$

$$i(t) = \underline{\mathbf{\frac{1}{7}\left(6 - e^{-2t}\right)\ A}}$$

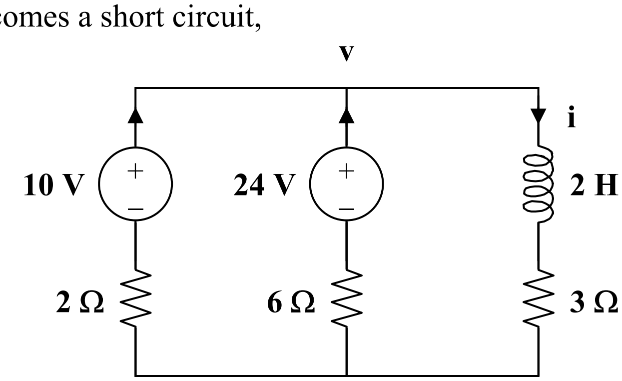
(b) Before t = 0, $i(t) = \frac{10}{2+3} = \underline{\mathbf{2\ A}}$

After t = 0, $R_{eq} = 3 + 6\,||\,2 = 4.5$

$$\tau = \frac{L}{R_{eq}} = \frac{2}{4.5} = \frac{4}{9}$$

$$i(0) = 2$$

To find $i(\infty)$, consider the circuit below, at t = when the inductor becomes a short circuit,



$$\frac{10 - v}{2} + \frac{24 - v}{6} = \frac{v}{3} \longrightarrow v = 9$$

$$i(\infty) = \frac{v}{3} = 3\ A$$

$$i(t) = 3 + (2 - 3)e^{-9t/4}$$

$$i(t) = \underline{\mathbf{3 - e^{-9t/4}\ A}}$$