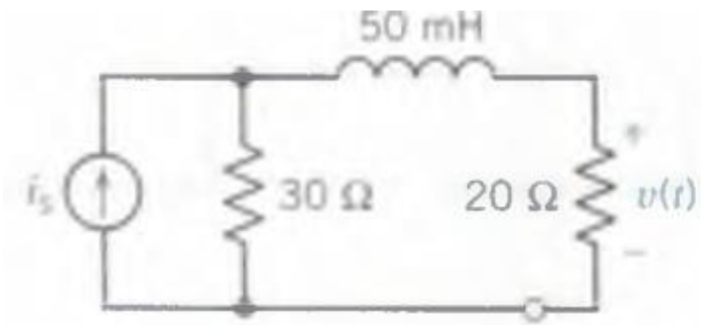
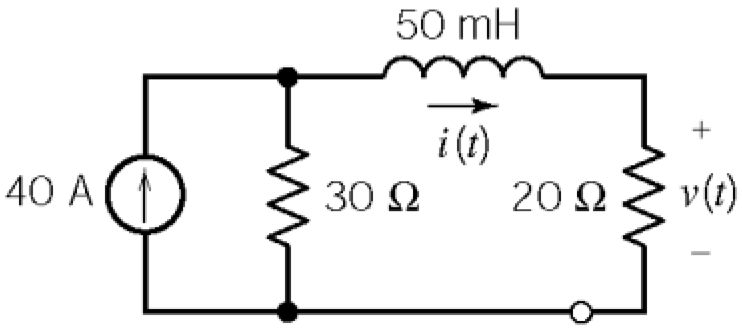


plot $v(t)$ for $0 < t < 0.3$ s.

$i_s(t) = 40\,[u(t) - u(t - t_0)]$ A, where $t_0 = 1$ ms.

Assume that the circuit is at steady state before $t = 0$. Then the initial inductor current is $i(0^-) = 0$ A.

For $0 < t < 1$ ms:



The steady state inductor current will be

$$i(\infty) = \lim_{t\to\infty} i(t) = \frac{30}{30+20}(40) = 24 \text{ A}$$

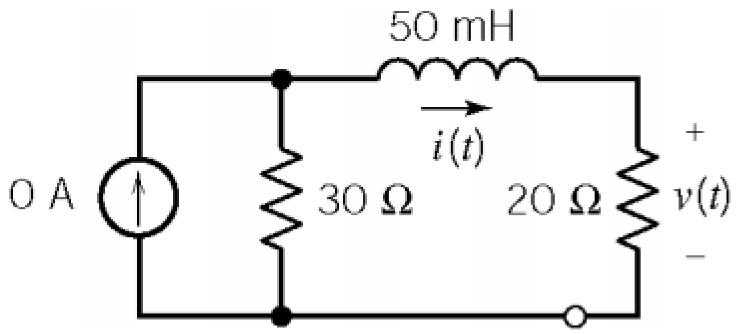
The time constant will be

$$\tau = \frac{50\times10^{-3}}{30+20} = 10^{-3} = \frac{1}{1000} \text{ s}$$

The inductor current is $i(t) = 24\left(1 - e^{-1000\,t}\right)$ A

In particular, $i(0.001) = 24\left(1 - e^{-1}\right) = 15.2\ \text{A}$

For t > 1 ms

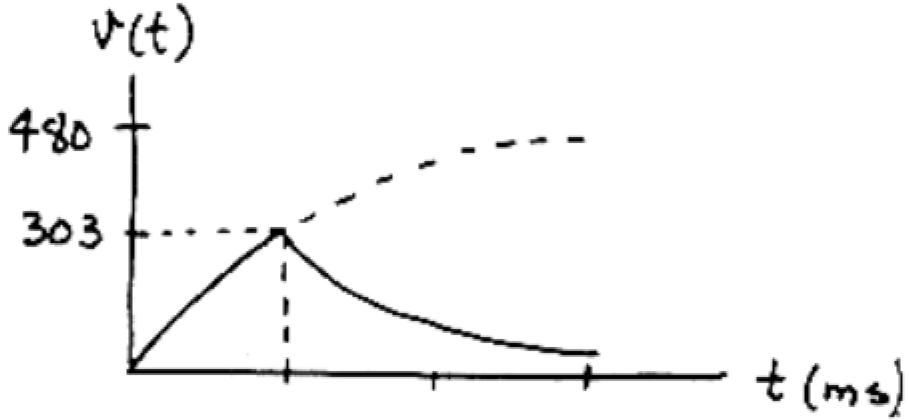


Now the initial current is $i(0.001) = 15.2$ A and the steady state current is 0 A. As before, the time constant is 1 ms. The inductor current is

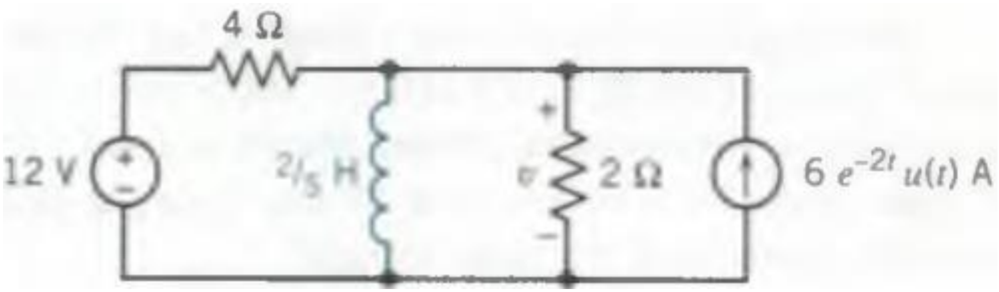
$$i(t) = 15.2\, e^{-1000(t-0.001)}\ \text{A}$$

The output voltage is

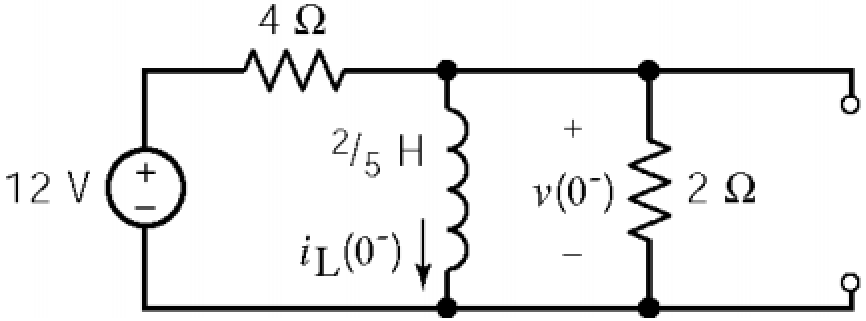
$$v(t) = 20\, i(t) = \begin{cases} 480\left(1 - e^{-1000t}\right)\ \text{V} & t < 1\ \text{ms} \\ 303\, e^{-1000(t-0.001)}\ \text{V} & t > 1\ \text{ms} \end{cases}$$



$v(t)$ for $t > 0$



Assume that the circuit is at steady state before $t = 0$:

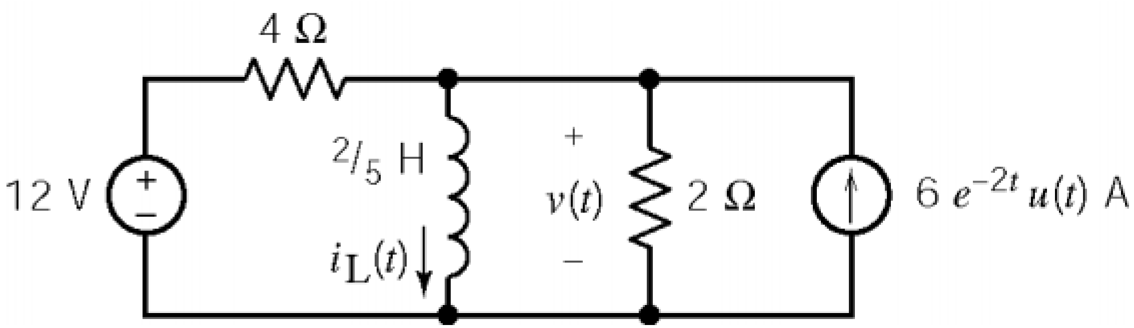


$$i_L(0^+) = i_L(0^-) = \frac{12}{4} = 3 \text{ A}$$

After $t = 0$:

KCL : $\dfrac{v(t)-12}{4} + i_L(t) + \dfrac{v(t)}{2} = 6\,e^{-2t}$

also : $v(t) = (2/5)\,\dfrac{di_L(t)}{dt}$



$$i_L(t) + \frac{3}{4}\left[(2/5)\,\frac{di_L(t)}{dt}\right] = 3 + 6\,e^{-2t}$$

$$\frac{di_L(t)}{dt} + \frac{10}{3}\,i_L(t) = 10 + 20\,e^{-2t}$$

$\therefore i_n(t) = Ae^{-(10/3)t}$, try $i_f(t) = B + Ce^{-2t}$, substitute into the differential equation,

and then equating like terms $\Rightarrow B{=}3,\ C{=}15 \Rightarrow i_f(t){=}3{+}15\,e^{-2t}$

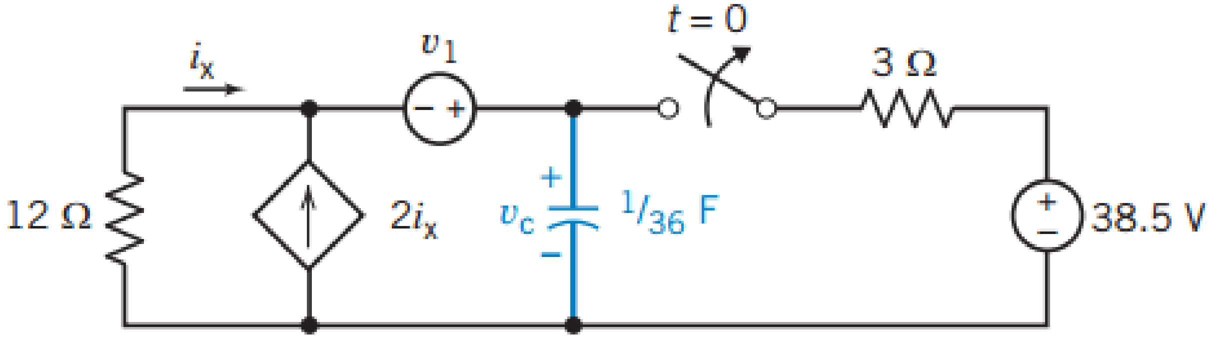
$\therefore i_L(t){=}i_n(t){+}i_f(t) = Ae^{-(10/3)t}\ {+}3{+}15e^{-2t}$, $\quad i_L(0) = 3 = A + 3 + 15 \Rightarrow A = -15$

$$\therefore i_L(t) = -15e^{-(10/3)t} + 3 + 15e^{-2t}$$

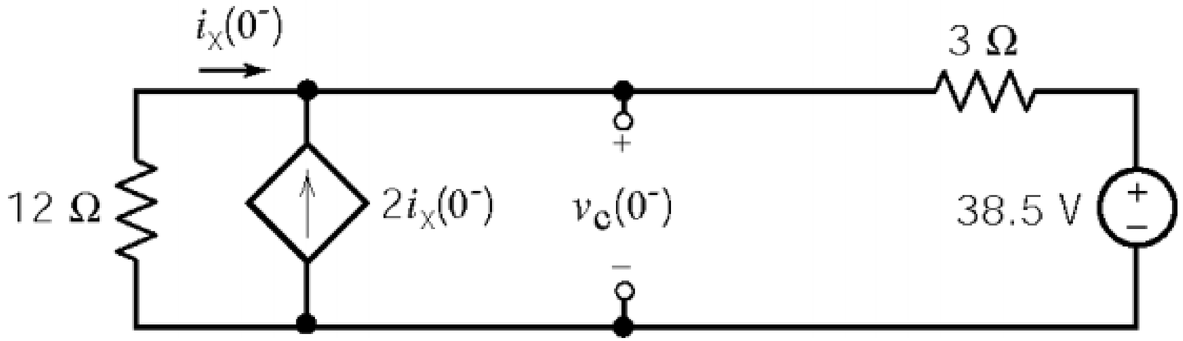
Finally, $\underline{v(t) = (2/5)\,\dfrac{di_L}{dt} = 20\,e^{-(10/3)t} - 12\,e^{-2t}\ \text{V}}$

$v_c(t)$ for $t > 0$

$v_1 = 8e^{-5t}u(t)$



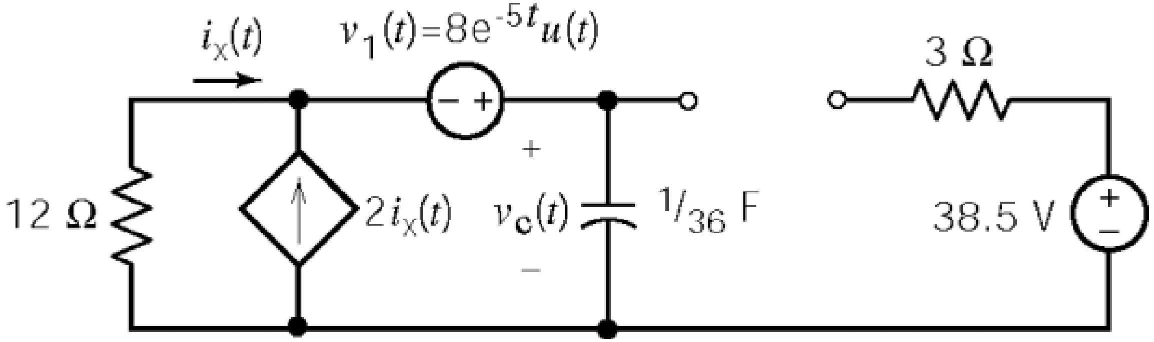
Assume that the circuit is at steady state before $t = 0$:



KVL : $12i_x + 3(3\,i_x) + 38.5 = 0 \quad \Rightarrow \quad i_x = -1.8\bar{3}$ A

Then $\underline{v_c(0^-) = -12\,i_x = 22 \text{ V} = v_c(0^+)}$

After $t = 0$:



$$\text{KVL : } 12i_x(t) - 8e^{-5t} + v_c(t) = 0$$

$$\text{KCL : } -i_x(t) - 2i_x(t) + (1/36)\,\frac{dv_c(t)}{dt} = 0 \;\Rightarrow\; i_x(t) = \frac{1}{108}\frac{dv_c(t)}{dt}$$

$$\therefore\; 12\left[\frac{1}{108}\frac{dv_c(t)}{dt}\right] - 8e^{-5t} + v_c(t) = 0$$

$$\frac{dv_c(t)}{dt} + 9v_c(t) = 72e^{-5t} \;\Rightarrow\; v_{cn}(t) = Ae^{-9t}$$

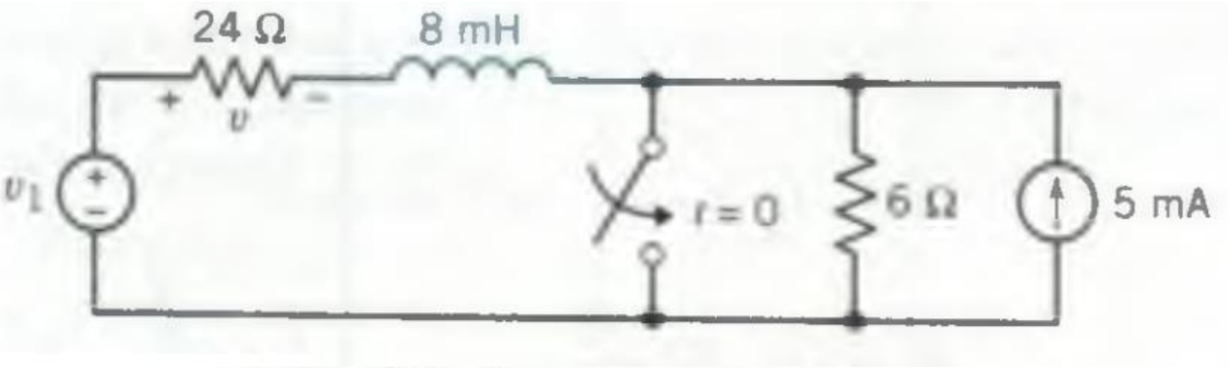
Try $v_{cf}(t) = Be^{-5t}$ & substitute into the differential equation $\Rightarrow B = 18$

$$\therefore\; v_c(t) = Ae^{-9t} + 18\,e^{-5t}$$

$$v_c(0) = 22 = A + 18 \;\Rightarrow\; A = 4$$

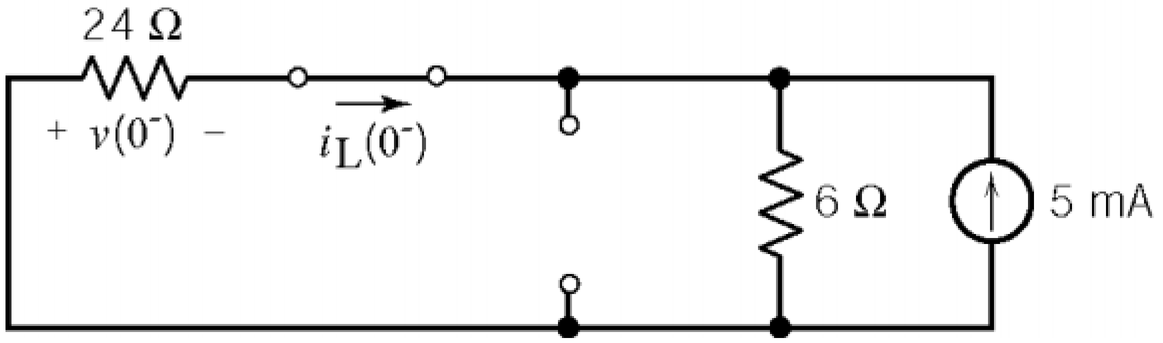
$$\therefore v_c(t) = 4e^{-9t} + 18e^{-5t}\text{ V}$$

$v(t)$ for $t > 0$



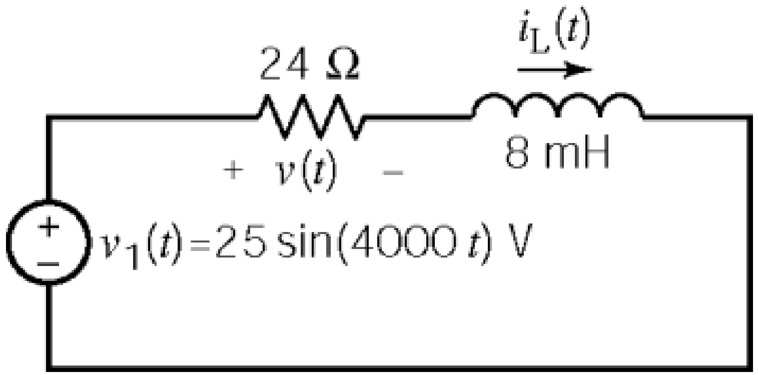
$v_1 = (25 \sin 4000t)u(t)$

Assume that the circuit is at steady state before $t = 0$:



Current division: $i_L(0^-) = -5\left(\dfrac{6}{6+24}\right) = -1 \text{ mA}$

After $t = 0$:



KVL: $-25\sin 4000\,t \;+24i_L(t)+.008\dfrac{di_L(t)}{dt}=0$

$$\frac{di_L(t)}{dt}+3000i_L(t)=\frac{25}{.008}\sin 4000t$$

$i_n(t)=Ae^{-3000t}$, try $i_f(t)=B\cos 4000t+C\sin 4000t$, substitute into the differential equation and equate like terms $\Rightarrow$ $B=-1/2,\ C=3/8 \Rightarrow i_f(t)=-0.5\cos 4000\,t+0.375\sin 4000\,t$

$i_L(t)=i_n(t)+i_f(t)=Ae^{-3000t}\;-0.5\cos 4000\,t+0.375\sin 4000\,t$

$i_L(0^+)=i_L(0^-)=-10^{-3}=A-0.5\Rightarrow A\cong 0.5$

$\therefore\ i_L(t)=0.5e^{-3000t}\;-0.5\cos 4000\,t+0.375\sin 4000\,t$ mA

but $v(t)\;=\;24i_L(t)=12\,e^{-3000t}\;-\;12\cos 4000t\;+\;9\sin 4000t$ V