P7.3-4

$$v(t)=\frac{1}{C}\int_0^t i(\tau)\,d\tau+v(0)=\frac{1}{2\times10^{-12}}\int_0^t i(\tau)\,d\tau-10^{-3}$$

$0<t<2\times10^{-9}$ $\quad i_s(t)=0 \;\Rightarrow\; v(t)=\dfrac{1}{2\times10^{-12}}\displaystyle\int_0^t 0\,d\tau-10^{-3}=-10^{-3}$

$2\times10^{-9}<t<3\times10^{-9}$ $\quad i_s(t)=4\times10^{-6}$ A

$$\Rightarrow\; v(t)=\frac{1}{2\times10^{-12}}\int_{2\text{ns}}^t\left(4\times10^{-6}\right)d\tau-10^{-3}=-5\times10^{-3}+\left(2\times10^{6}\right)t$$

In particular, $v\left(3\times10^{-9}\right)=-5\times10^{-3}+\left(2\times10^{6}\right)\left(3\times10^{-9}\right)=10^{-3}$

$3\times10^{-9}<t<5\times10^{-9}$ $\quad i_s(t)=-2\times10^{-6}$ A

$$\Rightarrow\; v(t)=\frac{1}{2\times10^{-12}}\int_{3\text{ns}}^t\left(-2\times10^{-6}\right)d\tau+10^{-3}=4\times10^{-3}-\left(10^{6}\right)t$$

In particular, $v\left(5\times10^{-9}\right)=4\times10^{-3}-\left(10^{6}\right)\left(5\times10^{-9}\right)=-10^{-3}$ V

$5\times10^{-9}<t$ $\quad i_s(t)=0 \;\Rightarrow\; v(t)=\dfrac{1}{2\times10^{-12}}\displaystyle\int_{5\text{ns}}^t 0\,d\tau-10^{-3}=-10^{-3}$ V

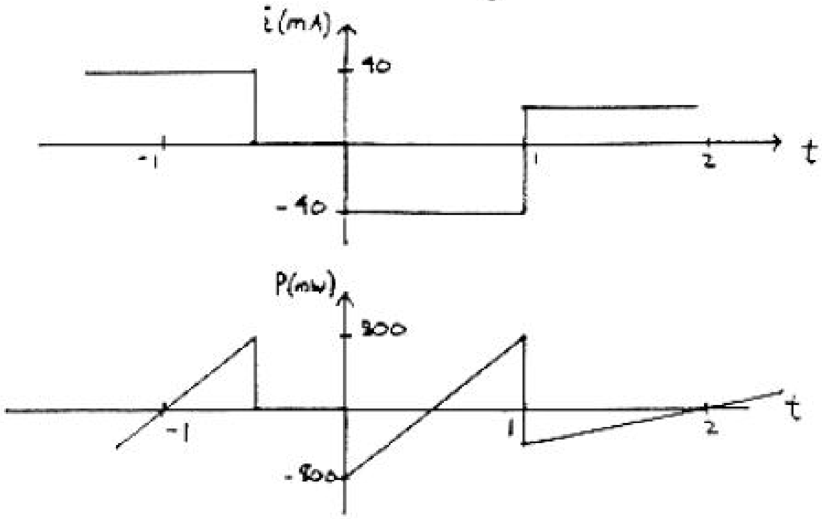
P7.3-7

$$v(t)=v(0)+\frac{1}{C}\int_0^t i(\tau)\,d\tau=25+2.5\times10^{4}\int_0^t\left(6\times10^{-3}\right)e^{-6\tau}\,d\tau$$

$$=\;25\;+\;150\int_0^t e^{-6\tau}\,d\tau$$

$$=\;25+150\left[-\frac{1}{6}e^{-6\tau}\right]_0^t=\;\underline{50\;-\;25e^{-6t}\text{ V}}$$

P7.4–3



$$i(t) = C\,\frac{dv_c}{dt} \text{ so read off slope of } v_c(t) \text{ to get } i(t)$$

$$p(t) = v_c(t)\,i(t) \text{ so multiply } v_c(t) \;\&\; i(t) \text{ curves to get } p(t)$$

P7.4-5

$$\text{Max. charge on capacitor} = C\,v = \left(10\times10^{-6}\right)\,(6) = 60\ \mu\text{C}$$

$$\Delta t = \frac{\Delta q}{i} = \frac{60\times10^{-6}}{10\times10^{-6}} = \underline{6\text{ sec}} \text{ to charge}$$

$$\text{stored energy} = \mathscr{W} = \frac{1}{2}C\,v^2 = \frac{1}{2}\left(10\times10^{-6}\right)(6)^2 = \underline{180\ \mu\text{J}}$$

P7.5-3

$$C \text{ in series with } C = \frac{C\cdot C}{C+C} = \frac{C}{2}$$

$$C \parallel C \parallel \frac{C}{2} = \frac{5}{2}C$$

$$C \text{ in series with } \frac{5}{2}C = \frac{C\cdot\frac{5}{2}C}{C+\frac{5}{2}C} = \frac{5}{7}C$$

$$(25\times10^{-3})\cos 250t = \left(\frac{5}{7}C\right)\frac{d}{dt}(14\sin 250t) = \left(\frac{5}{7}C\right)(14)(250)\cos 250t$$

$$\text{so } 25\times10^{-3} = 2500\,C \Rightarrow C = 10\times10^{-6} = 10\ \mu\text{F}$$

P7.6-3

(a)

$$v(t) = L\frac{d}{dt}i(t) = \begin{cases} 0 & 0 < t < 1 \\ 4 & 1 < t < 2 \\ -4 & 2 < t < 3 \\ 0 & 3 < t \end{cases}$$

(b)

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

For $0 < t < 1$, $v(t) = 0$ V so $i(t) = \int_0^t 0\,d\tau + 0 = 0$ A

For $1 < t < 2$, $v(t) = (4t - 4)$ V so

$$i(t) = \int_0^t (4\tau - 4)\,d\tau + 0 = \left(2\tau^2 - 4\tau\right)\Big|_1^t = 2t^2 - 4t + 2 \text{ A}$$

$i(2) = 4\left(2^2\right) - 4\left(2\right) + 2 = 2$ A

For $2 < t < 3$, $v(t) = -4t + 12$ V so

$$i(t) = \int_2^t (-4\tau + 12)\,d\tau + 2 = \left(-2\tau^2 + 12\tau\right)\Big|_2^t + 2 = \left(-2t^2 + 12t - 14\right) \text{ A}$$

$i(3) = -2\left(3^2\right) + 12\left(3\right) - 14 = 4$ A

For $3 < t$, $v(t) = 0$ V so $i(t) = \int_3^t 0\,d\tau + 4 = 4$ A

P7.7-2

$$\begin{aligned} p(t) = v(t)\ i(t) &= \left[5\,\frac{d}{dt}(4\sin 2t)\right](4\sin 2t) \\ &= 5\ (8\cos 2t)\ (4\sin 2t) \\ &= 80\ [2\cos 2t\ \sin 2t] \\ &= 80\ [\sin(2t+2t) + \sin(2t-2t)] = 80\ \sin 4t \text{ W} \end{aligned}$$

$$\mathcal{W}(t) = \int_0^t p(\tau)\,d\tau = 80\int_0^t \sin 4\tau\ \mathrm{d}\tau = -\frac{80}{4}\ [\cos 4\tau\ |_0^t] = 20\ (1 - \cos 4t)$$

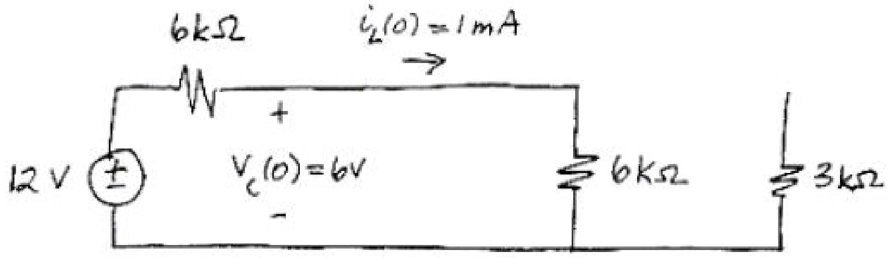
P7.8-2

$4 \text{ mH} + 4 \text{ mH} = 8 \text{ mH}$, $8\text{mH} \parallel 8\text{mH} = \dfrac{\left(8\times10^{-3}\right)\times\left(8\times10^{-3}\right)}{8\times10^{-3} + 8\times10^{-3}} = 4 \text{ mH}$

and $4 \text{ mH} + 4 \text{ mH} = 8 \text{ mH}$

$$v(t) = (8\times10^{-3})\ \frac{d}{dt}\ (5 + 3e^{-250t}) = (8\times10^{-3})\,(0 + 3\,(-250)\ e^{-250t}) = -6\ e^{-250t} \text{ V}$$

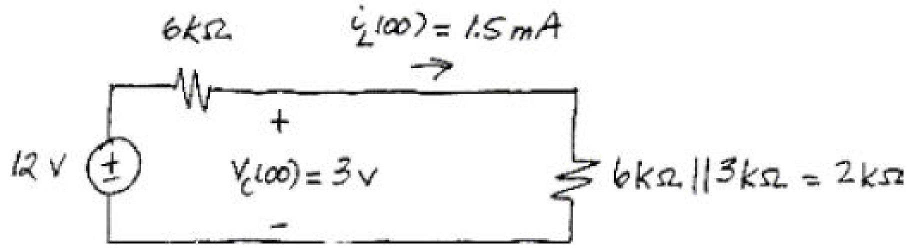
P7.9-2



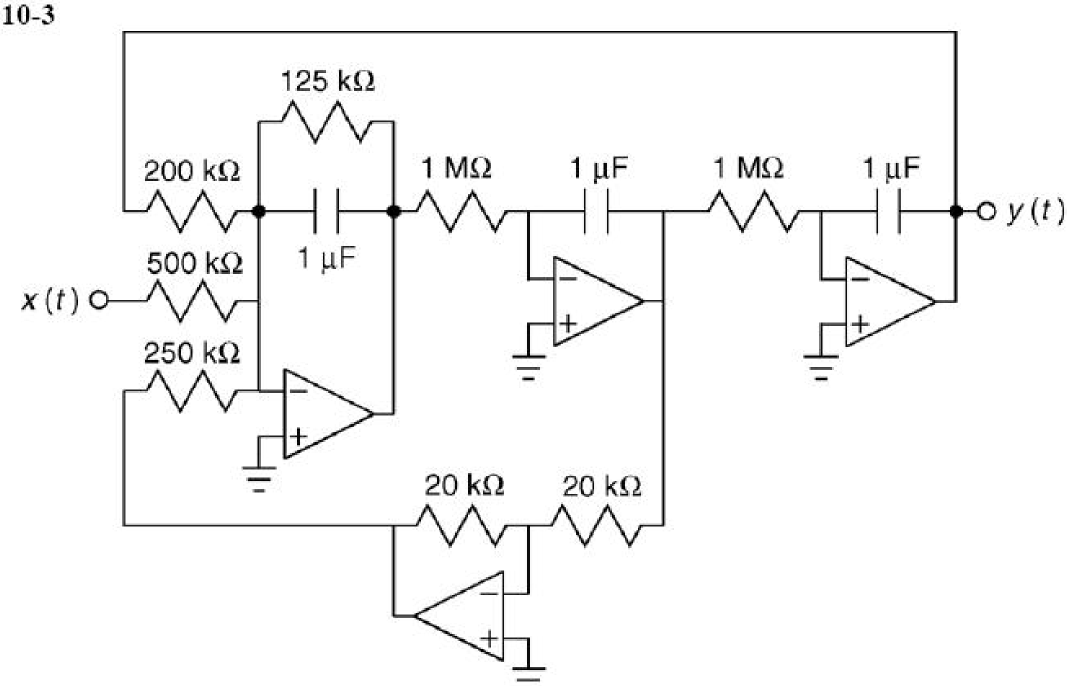
Then

$$i_L\left(0^+\right) = i_L\left(0^-\right) = 1 \text{ mA} \quad \text{and} \quad v_C\left(0^+\right) = v_C\left(0^-\right) = 6 \text{ V}$$

Next

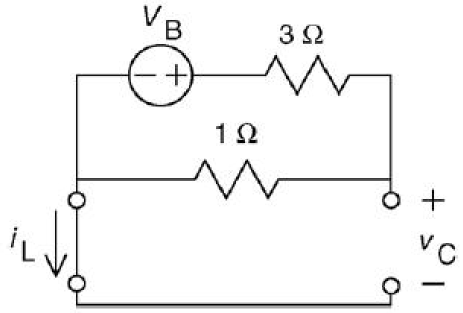


P7.10-3



DP7-4

at $t=0^-$



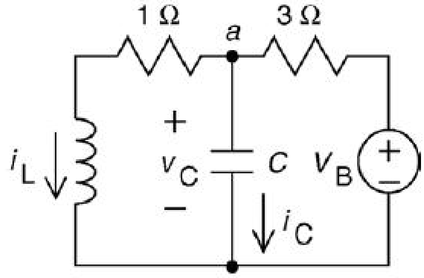
$i_L(0^-) = 0$

By voltage division: $v_C(0^-) = \frac{V_B}{4}$

We require $v_C(0^-) = 3$ V so

$$V_B = 12 \text{ V}$$

at $t=0^+$



Now we will check $\left.\frac{dv_C}{dt}\right|_{t=0^+}$

First:

$$i_L(0^+) = i_L(0^-) = 0$$

and

$$v_C(0^+) = v_C(0^-) = 3 \text{ V}$$

Apply KCL at node a:

$$i_L(0^+) + i_C(0^+) = \frac{V_B - v_C(0^+)}{3}$$

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

Finally

$$\left.\frac{dv_C}{dt}\right|_{t=0^+} = \frac{i_C(0^+)}{C} = \frac{3}{0.125} = 24 \ \frac{\text{V}}{\text{s}}$$

as required.

DP7-5

We require $\frac{1}{2} L\, i_L^2 = \frac{1}{2} C\, v_C^2$ where i_L and v_c are the steady state inductor current and capacitor voltage. At steady state, $i_L = \frac{v_C}{R}$. Then

$$L\left(\frac{v_C}{R}\right)^2 = C\, v_C^2 \quad \Rightarrow \quad C = \frac{L}{R^2} \quad \Rightarrow \quad R = \sqrt{\frac{L}{C}} = \sqrt{\frac{10^{-2}}{10^{-6}}} = \sqrt{10^4} = 10^2 \ \Omega$$

so $R = 100\ \Omega$.