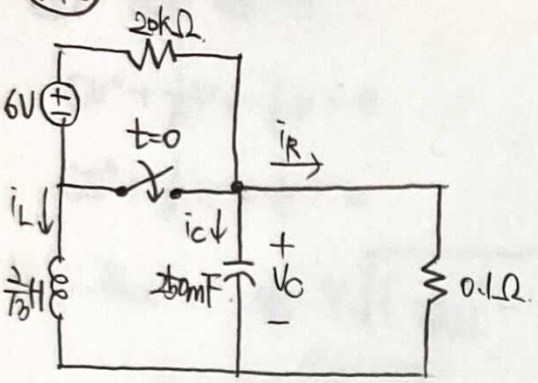
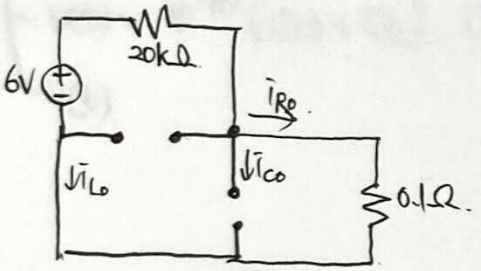
9.12



- $t<0$일 때,

< capacitor – open (full-charged)
  inductor – short (full-charged)



$$- V_C(0^-) = i_R(0^-) \times 0.1$$

$$= \frac{6}{20\times10^3 + 0.1} \times 0.1$$

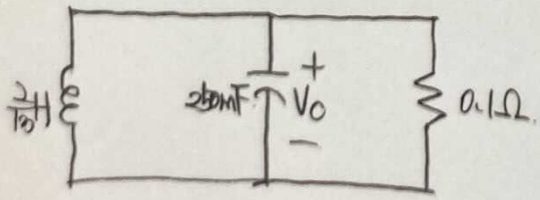
$$= 30\times10^{-6} V$$

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

$$= -\frac{6}{20\times10^3+0.1} = -300\times10^{-6} A$$

이때, $V_C(0^-) = V_C(0^+)$, $i_L(0^-) = i_L(0^+)$ 이다.

- $t \geq 0$ 일 때,



$$\cdot\ \alpha = \frac{1}{2RC} = \frac{1}{2\times0.1\times250\times10^{-3}} = 20\,s^{-1}$$

$$\cdot\ \omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{\frac{2}{13}\times250\times10^{-3}}} = 5.1\,rad/s$$

- $V_C(t)$의 일반해

$$V_C(t) = A_1 e^{s_1 t} + A_2 e^{s_2 t}$$

$$\begin{cases} s_1 = -\alpha + \sqrt{\alpha^2 + \omega_0^2} = -0.66\,s^{-1} \\ s_2 = -\alpha - \sqrt{\alpha^2 - \omega_0^2} = -39.34\,s^{-1} \end{cases}$$

⇒ A_1과 A_2를 찾기 위해서는 두개의 초기조건 필요.

$V_C(0^+)$과 $i_C(0^+)$ 이용

i) $V_C(0^+) = 30\times10^{-6} V$ 에서,

$$V_C(0^+) = A_1 e^{-0.66\times0} + A_2 e^{-39.34\times0}$$

$$= A_1 + A_2 = 30\times10^{-6} \quad \cdots ⑦$$

ii) $I_C(0^+) = -300\times10^{-6} A$ 에서,

$$V_C'(t) = -0.66 A_1 e^{-0.66t} - 39.34 A_2 e^{-39.34t}$$

① $\frac{dV_C}{dt} = \frac{i_C(t)}{C}$, ② $i_C(t) = -i_L(t) - i_R(t)$

③ $i_R(t) = \frac{V_C(t)}{R}$ 를 이용하면,

$$\frac{-i_L(0) - \frac{V_C(0)}{R}}{C} = \frac{-(-300\times10^{-6}) - \frac{30\times10^{-6}}{0.1}}{250\times10^{-6}}$$

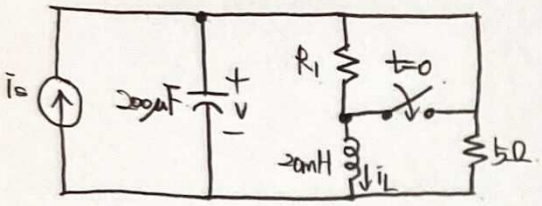
$$= 0 = -0.66 A_1 - 39.34 A_2 \quad \cdots ⑧$$

iii) ⑦, ⑧을 연립하면,

$$\begin{cases} A_1 = 30.5\times10^{-6} \\ A_2 = -0.51\times10^{-6} \end{cases}$$

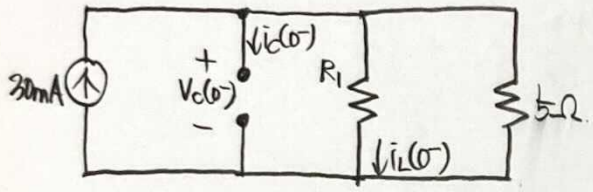
$$\therefore V_C(t) = 30.5 e^{-0.66t} - 0.51 e^{-39.34t}\ \mu V$$

9.26



- $t<0$ 일 때,

  < capacitor - open (full-charged)
  inductor - short (full-charged)



(a) $V_c(0^-) = V_c(0^+)$ 에서.

$V_c(0^-) = i_L R_1$

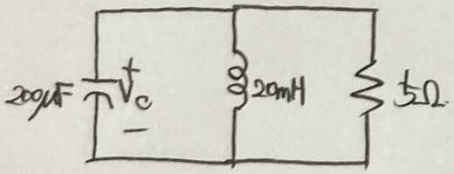
$= 0.03 \times \frac{5}{R_1+5} \times R_1$

→ R_1에 대해 풀면, $\boxed{R_1 = -5.12\Omega}$

(b) $i_L(0^-) = 0.03 \times \frac{5}{5.12+5} = 14.8 \times 10^{-3} A$

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

- $t \geq 0$ 일 때



$\alpha = \frac{1}{2RC} = \frac{1}{2 \times 5 \times 200 \times 10^{-6}} = 500 s^{-1}$

일반해 : $V_c(t) = e^{-500t}(A_1 t + A_2)$

i) $V_c(0^+) = 6 = e^{-500 \times 0}(A_1 \times 0 + A_2)$

$A_2 = 6$

ii) $i_L(0^+) = 14.8 \times 10^{-3} A$ 이므로

$\frac{-i_L(0) - \frac{V_c(0)}{R}}{C} = \frac{-(14.8 \times 10^{-3}) - \frac{6}{5}}{200 \times 10^{-6}} = A_1 - 500A_2$

$A_1 - 500A_2 = -604$

$\therefore A_1 = -304$

$\therefore V_c(t) = e^{-500t}(-304t + 6)$

$t = 2ms$ 에서,

$V_c(2ms) = e^{-500 \times 2 \times 10^{-3}}(-304 \times 2 \times 10^{-3} + 6)$

$= -54.45 \times 10^{-3} V$

$\boxed{V_c(2ms) = -54.45 \times 10^{-3} V}$

c) $t_{min} = 3.9 \times 10^{-3} s$

$V_c(t_{min}) = -0.45V$

$V_c(t_s) = 0.01 V_c(t_{min})$

$\therefore \boxed{t_s = 0.0117s}$

d) $i_L(t) = \frac{1}{L}\int V_c(t)\,dt$ 에서,

$i_L(t) = (304t + 0.0148)e^{-500t} A$

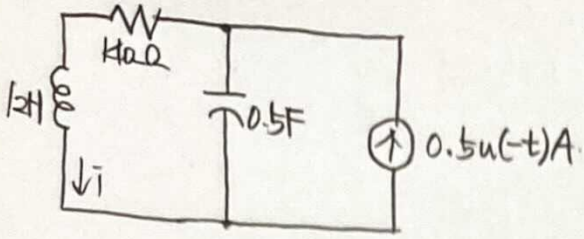
$t_{max} = 0.002s$

$i_L(t_{max}) = 0.22A$

$i_L(t_s) = 0.01\, i_L(t_{max})$

$\therefore \boxed{t_s = 0.0152s}$

9.46



(a) $\alpha = \frac{R}{2L}$

$= \frac{40}{2\times 2} = 5.8333\,s^{-1}$

(b) $\omega_0 = \frac{1}{\sqrt{LC}}$

$= \frac{1}{\sqrt{2\times 0.5}} = 0.707\,rad/s$

(c) $i(0^+) = i(0^-)$ 이므로,

$i(0^+) = 0.5A$

(d) $\frac{di(t)}{dt} = \frac{V_L(t)}{L}$

$t=0$ 일 때, inductor → short

$\therefore \left.\frac{di}{dt}\right|_{0^+} = 0\,A/s$

(e) $\alpha > \omega_0$ (overdamped)

$i(t) = A_1 e^{s_1 t} + A_2 e^{s_2 t}$

$s_{1,2} = -\alpha \pm \sqrt{\alpha^2 - \omega_0^2} = -5.8333 \pm 5.819$

$\therefore i(t) = A_1 e^{-0.014t} + A_2 e^{-11.652t}$

$i(0) = 0.5A \rightarrow A_1 + A_2 = 0.5$

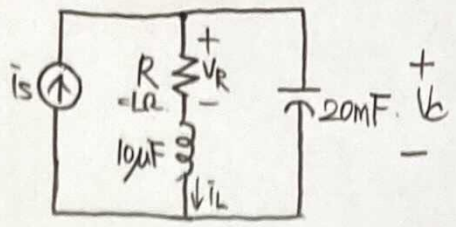
$\frac{di(0)}{dt} = 0 \rightarrow \left.\frac{dv_c(t)}{dt}\right|_{t=0} = \frac{i_L(0)}{L}$

$-0.014A_1 - 11.652A_2 = 0$

$\therefore i(t) = 0.5006e^{-0.014t} - 0.0006e^{-11.652t}$

$\Rightarrow i(6) = 460.261mA$

9.52



(a) $\alpha = \frac{R}{2L}$

$= \frac{1}{2\times(10\times10^{-6})} = 50\times10^3\,s^{-1}$

$\omega_0 = \frac{1}{\sqrt{LC}}$

$= \frac{1}{\sqrt{(10\times10^{-6})(0.020)}} = 2236.1\,rad/s$

(b) $i_s = 2u(-t) + 2u(t)\,mA$

$t=0^+$ 에서, $i_s = 2mA$

capacitor – open
inductor – short

$\boxed{V_R(0^+) = iR = 0.002\times1 = 2mV}$

$\boxed{i_L(0^+) = 2mA}$

$V_c(0^+) = V_R(0^+) + V_L(0^+)$ 에서,

$\boxed{V_c(0^+) = 2mA}$

$V_R(0^+) = V_R(0^-),\ i_L(0^+) = i_L(0^-),\ V_c(0^+) = V_c(0^-)$

$\boxed{i_L(\infty) = 2mA}$

$V_c(\infty) = V_R(inf) + V_L(\infty)$

$= 0.002(1) + 0$

$\boxed{V_c(\infty) = 2mV}$