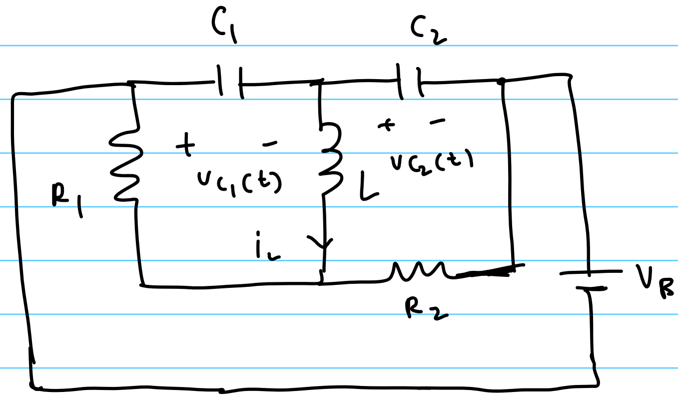
Ans.1



$R_1 = 1k\Omega$

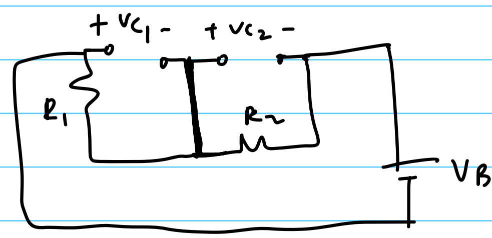
$R_2 = 4k\Omega$

$L = 1nH$

$C_1 = 1nF$

$C_2 = 1nF$

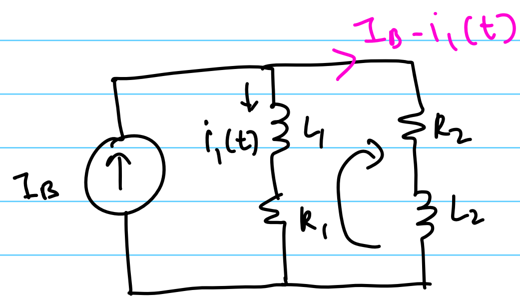
$V_B = 3V$



$V_{C_1}(t)$ in steady state $\Rightarrow -\frac{R_1}{R_1+R_2} \times V_B = -\frac{1}{5} \times 3 \Rightarrow \underline{-0.6V}$

$I_L(t)$ in steady state $= \underline{0A}$

Ans.2



$I_B = 4mA$

$R_1 = 2k\Omega$

$R_2 = 6k\Omega$

$L_1 = 4mH$

$L_2 = 2mH$

a) Applying KVL in the loop,

$$i_1 R_1 + L_1 \frac{di_1}{dt} - (I_B - i_1) R_2 - L_2 \frac{d(I_B - i_1)}{dt} = 0$$

Setting $I_B = 0$, to get the characteristic eq^n,

$$i_1 R_1 + L_1 \frac{di_1}{dt} + i_1 R_2 + L_2 \frac{di_1}{dt} = 0$$

$$i_1(R_1+R_2) + (L_1+L_2)\frac{di_1}{dt} \Rightarrow 0$$

Characteristic eq^n has a first order differential term, hence it is a first order circuit.

b) $$\tau = \frac{L_1+L_2}{R_1+R_2} \Rightarrow \frac{(4+2)\,mH}{(2+6)\,k\Omega} \Rightarrow \underline{0.75\,\mu s}$$

c) $$i_1(0) = \frac{I_B L_2}{L_1+L_2} \rightarrow \frac{4}{3}\,mA \qquad i_1(\infty) = \frac{I_B R_2}{R_1+R_2} \rightarrow 3\,mA, \qquad \tau = \frac{L_1+L_2}{R_1+R_2} = 0.75\,\mu$$

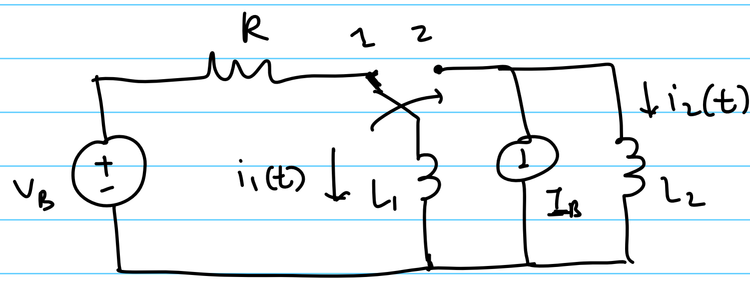
@ $t = 0^+$ $(L_1 I_1 = L_2 I_2)$

$$i_1(t) = i_1(0) + \left[i_1(\infty) - i_1(0)\right]\left(1 - e^{-t/\tau}\right)$$

$$i_1(t) = \frac{4}{3} + \left[3 - \frac{4}{3}\right]\left(1 - e^{-t/\tau}\right)$$

$$i_1(t) = \frac{4}{3} + \left(\frac{5}{3}\right)\left(1 - e^{-t/\tau}\right) \Rightarrow \left(3 - \frac{5}{3}e^{-t/\tau}\right) mA$$

Ans. 3



$V_B = 3V$

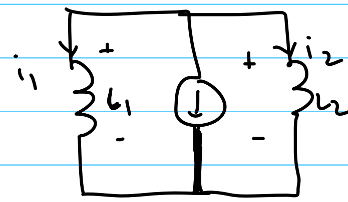
$I_B = 4\,mA$

$R = 1\,k\Omega$

$L_1 = 1\,mH$, $L_2 = 2\,mH$

a) $i_1(t=0^-) = \frac{V_B}{R} \Rightarrow \frac{3}{1K} \Rightarrow \underline{3mA}$ $\quad i_2(t=0^-) = \underline{-4mA}$

b)



$i_1 + i_2 \Rightarrow 4mA$

$i_2 = 4m - i_1$

$$L_1 \frac{di_1}{dt} = L_2 \frac{di_2}{dt}$$

$L_1 \Delta i_1 = L_2 \Delta i_2$

$\Delta i_1 = 2 i\Delta_2$

$i_1 + i_2 = -4mA$

$3 + \Delta i_1 - 4 + \Delta i_2 = -4$

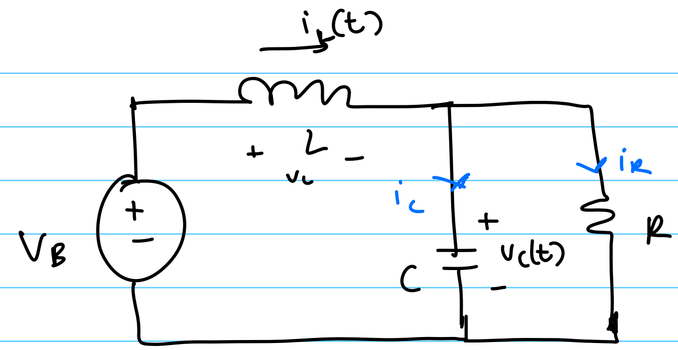
$\Delta i_1 + \Delta i_2 = -3$

$\Delta i_1 + \frac{\Delta i_1}{2} = -3$

$\frac{3}{2} \Delta i_1 = -3$; $\boxed{\Delta i_1 = -2}$

$\boxed{i_1(0^+) = 3 - 2 = 1mA}$

Ans 4



$V_B = 2V$

$L = 16\,mH$

$C = 1nF$

$R = 2.5k\Omega$

$v_c(0^+) = 5V, \; i_L(0^+) = 4mA$

a) $i_L = i_c + i_R$

$$\frac{1}{L}\int v_L\,dt = C\frac{dv_c}{dt} + \frac{v_c}{R}$$

differentiate.

$$\frac{v_L}{L} = C\frac{d^2v_c}{dt^2} + \frac{1}{R}\frac{dv_c}{dt}$$

$$\frac{V_B - v_c}{L} = C\frac{d^2v_c}{dt^2} + \frac{1}{R}\frac{dv_c}{dt} \quad ; \quad V_B = 0 \text{ (for chracteristic eq}^n\text{)}$$

$$\boxed{\frac{d^2v_c}{dt^2} + \frac{1}{LC}v_c + \frac{1}{RC}\frac{dv_c}{dt} = 0}$$

b) $$\zeta = \frac{1}{2}\frac{\sqrt{L/C}}{R} \Rightarrow \frac{\sqrt{16m/1n}}{2\times 2.5K} \Rightarrow \frac{4\times10^3}{2\times2.5K} \Rightarrow \frac{4}{5}$$

$$\boxed{\zeta = \frac{4}{5} = 0.8 < 1}$$

underdamped

c) $v_c(t) = e^{-6t}(A\cos wt + B\sin wt) + K_3$

$$\omega_0 \Rightarrow \frac{1}{\sqrt{LC}} \Rightarrow \frac{1}{\sqrt{16\times10^{-3}\times 1\times10^{-9}}} \Rightarrow \frac{1}{4}\times10^{6} \Rightarrow 0.25\times10^{6} \Rightarrow \underline{25\times10^{4}\,Hz}$$

$$\sigma = \xi\omega_0$$

$$\sigma = 0.8\times25\times10^{4} \Rightarrow 2{,}00{,}000 \Rightarrow \underline{2\times10^{5}}$$

$$\omega = \left(\sqrt{1-\xi^2}\right)\omega_0 \Rightarrow \left(\sqrt{1-0.8^2}\right)\times25\times10^{4} \Rightarrow \underline{15\times10^{4}\,Hz}$$

$$v_c(\infty) = 2 \Rightarrow k_3 = 2$$

$$v_c(0) = 5 \Rightarrow A = 3$$

$$v_c(t) = e^{-\sigma t}(3\cos\omega t + B\sin\omega t) + 2$$

At $t = 0^+$,

$$i_L = i_c + i_R$$

$$4m = i_c + \frac{5V}{2.5k} \Rightarrow \underline{i_c = 2mA}$$

$$C\left.\frac{dv_c}{dt}\right|_{t=0^+} = 2mA$$

$$C\left[-\sigma e^{-\sigma t}(3\cos\omega t + B\sin\omega t) + e^{-\sigma t}(-3\omega\sin\omega t + B\omega\cos\omega t)\right]\Big|_{t=0^+} = 2m$$

$$C[-\sigma(3) + B\omega] = 2m$$

$$\ln\left[-36 + B\omega\right] = 2m$$

$$-36 + B\omega = 2\times10^6$$

$$-6\times10^5 + B\times15\times10^4 = 2\times10^6$$

$$15B\times10^4 = 2.6\times10^6$$

$$\boxed{B \Rightarrow \frac{260}{15} \Rightarrow \frac{52}{3} = 17.33}$$

$$\boxed{V_c(t) \Rightarrow e^{-2\times10^5 t}\left(3\cos(15\times10^4 t) + 17.33\sin(15\times10^4 t)\right) + 2}$$

d) Need to reduce R to make the circuit critically damped ($\xi = 1$)