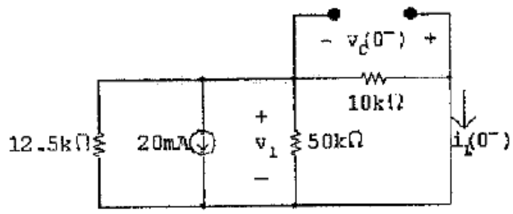
Practice problems solutions:

1)

[a] For $t < 0$:



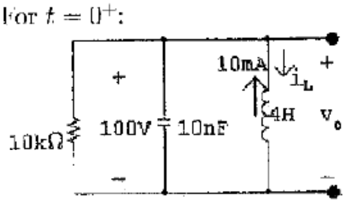
$$\frac{1}{R_e} = \frac{1}{12.5} + \frac{1}{50} + \frac{1}{10} = \frac{1}{5}; \qquad R_e = 5\,\text{k}\Omega$$

$$v_1 = -20(5) = -100\,\text{V}$$

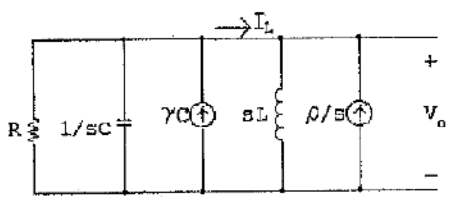
$$i_L(0^-) = \frac{-100}{10} \times 10^{-3} = -10\,\text{mA}$$

$$v_C(0^-) = -v_1 = 100\,\text{V}$$

For $t = 0^+$:



s-domain circuit:



where

$$R = 10\,\text{k}\Omega; \qquad C = 10\,\text{nF}; \qquad \gamma = 100\,\text{V};$$

$$L = 4\,\text{H}; \qquad \text{and} \qquad \rho = 10\,\text{mA}$$

[b] $$\frac{V_o}{R} - V_o sC - \gamma C + \frac{V_o}{sL} - \frac{\rho}{s} = 0$$

$$\therefore\ V_o = \frac{\gamma[s + (\rho/\gamma C)]}{s^2 + (1/RC)s + (1/LC)}$$

$$\frac{\rho}{\gamma C} = \frac{10 \times 10^{-3}}{(100)(10)10^{-9}} = 10^4$$

$$\frac{1}{RC} = \frac{10^9}{10^5} = 10^4$$

$$\frac{1}{LC} = \frac{10^9}{40} = 25 \times 10^6$$

$$V_o = \frac{100(s + 10^4)}{s^2 + 10^4 s + 25 \times 10^6}$$

[c] $$I_L = \frac{V_o}{sL} - \frac{\rho}{s} = \frac{V_o}{4s} - \frac{10 \times 10^{-3}}{s}$$

$$I_L = \frac{25(s + 10^4)}{s(s^2 + 10^4 s + 25 \times 10^6)} - \frac{10^{-2}}{s} = \frac{-0.01(s + 7500)}{(s + 5000)^2}$$

[d] $$V_o = \frac{100(s + 10^4)}{s^2 + 10^4 s + 25 \times 10^6}$$

$$= \frac{100(s + 10^4)}{(s + 5000)^2} = \frac{K_1}{(s + 5000)^2} + \frac{K_2}{s + 5000}$$

$$K_1 = 100(5000) = 5 \times 10^5$$

$$K_2 = \frac{d}{ds}\left[100(s + 10{,}000)\right]_{s=-5000} = 100$$

$$V_o = \frac{5 \times 10^5}{(s + 5000)^2} + \frac{100}{s + 5000}$$

$$v_o = [5 \times 10^5 t e^{-5000t} + 100 e^{-5000t}]u(t)\,\text{V}$$

[e] $$I_L = \frac{-0.01(s + 7500)}{(s + 5000)^2}$$

$$= \frac{K_1}{(s + 5000)^2} + \frac{K_2}{(s + 5000)}$$

$$K_1 = -0.01(2500) = -25$$

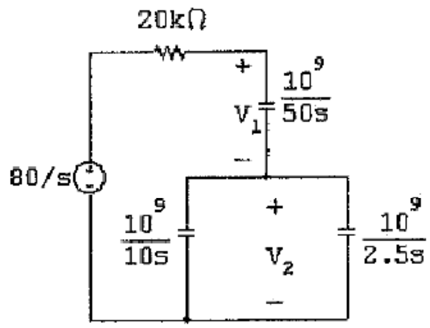
$$K_2 = \frac{d}{ds}[-0.01(s + 7500)]_{s=-5000} = -0.01$$

$$I_L = \left[\frac{-25{,}000}{(s + 5000)^2} - \frac{10}{s + 5000}\right] \times 10^{-3}$$

$$i_L = -[25{,}000t + 10]e^{-5000t}u(t)\,\text{mA}$$

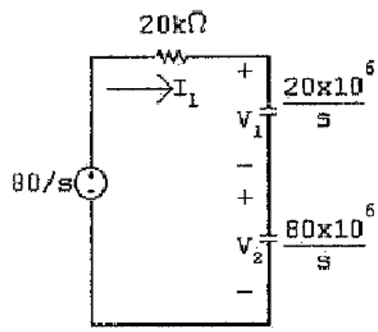
2)

[a]



$$Y_e = \frac{10s}{10^9} + \frac{2.5s}{10^9} = \frac{12.5s}{10^9}$$

$$Z_e = \frac{10^9}{12.5s} = \frac{80 \times 10^6}{s}$$



[b] $I_1 = \dfrac{80/s}{20{,}000 + (100 \times 10^6/s)} = \dfrac{4 \times 10^{-3}}{s + 5000}$

$$V_1 = \frac{4 \times 10^{-3}}{s + 5000} \cdot \frac{20 \times 10^6}{s} = \frac{80{,}000}{s(s + 5000)}$$

$$V_2 = \frac{4 \times 10^{-3}}{s + 5000} \cdot \frac{80 \times 10^6}{s} = \frac{320{,}000}{s(s + 5000)}$$

[c] $i_1(t) = 4e^{-5000t}u(t)$ mA

$$V_1 = \frac{16}{s} - \frac{16}{s + 5000}; \qquad v_1(t) = (16 - 16e^{-5000t})u(t)\ \text{V}$$

$$V_2 = \frac{64}{s} - \frac{64}{s + 5000}; \qquad v_2(t) = (64 - 64e^{-5000t})u(t)\ \text{V}$$