Ans.1

a) $x(t) = -2\sin(100\pi t - 135^\circ)$

$$2\cos(100\pi t - 45) = \boxed{2e^{-j\pi/4}}$$

b) $x(t) = 12\sin(100\pi t + 135^\circ) + 5\cos(100\pi t + 60^\circ)$

$$\Rightarrow 12\cos(100\pi t + 45^\circ) + 5\cos(100\pi t + 60^\circ)$$

$$\boxed{12e^{j\pi/4} + 5e^{j\pi/3}}$$

c) No phasor representation as frequencies are different.

Ans.2

a) $\underline{X} = 4-3j$, $w = 70K$ rad/s

$$x(t) = Re\{\underline{X}e^{j\omega t}\} \Rightarrow Re\{(4-3j)(\cos\omega t + j\sin\omega t)\}$$

$$\Rightarrow Re\{4\cos\omega t + 4j\sin\omega t - 3j\cos\omega t + 3\sin\omega t\}$$

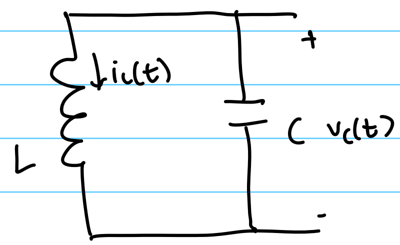
$$\Rightarrow 4\cos\omega t + 3\sin\omega t \Rightarrow \boxed{4\cos(70000t) + 3\sin(70000t)}$$

b) $\underline{X} = -8e^{-j\pi/6}$, $\omega = 100$ rad/s

$$x(t) = Re\{\underline{X}e^{j\omega t}\} = Re\{-8e^{j(\omega t - \pi/6)}\} = -8\cos(\omega t - \pi/6)$$

$$\Rightarrow \boxed{-8\cos(100t - \pi/6)}$$

Ans.3

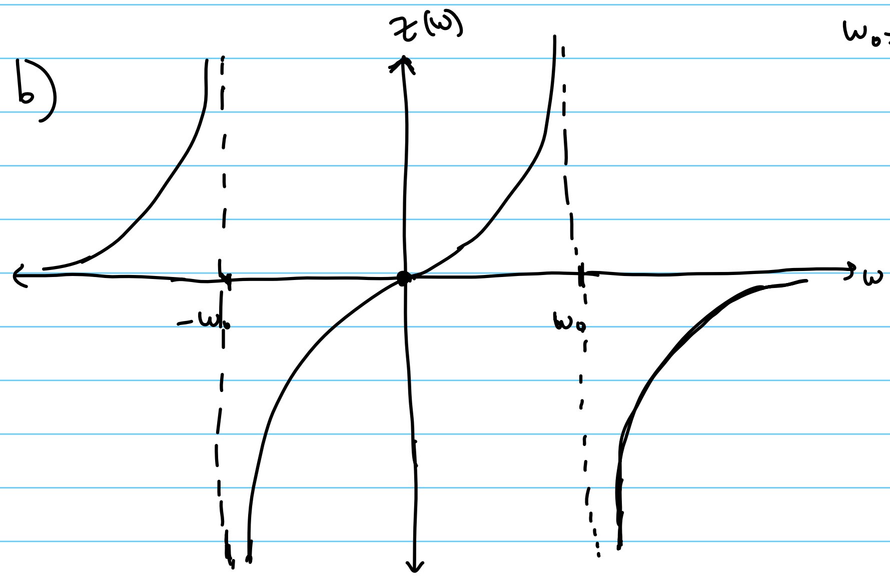


$$Z = \left(\frac{1}{j\omega C}\right) \parallel j\omega L$$

$$\Rightarrow \frac{\frac{1}{j\omega C} \times j\omega L}{\frac{1}{j\omega C} + j\omega L} \Rightarrow \frac{\frac{L}{C} \times j\omega C}{1 + j^2\omega^2 LC}$$

$$Z \Rightarrow \frac{j\omega L}{1 - \omega^2 LC}$$

b)

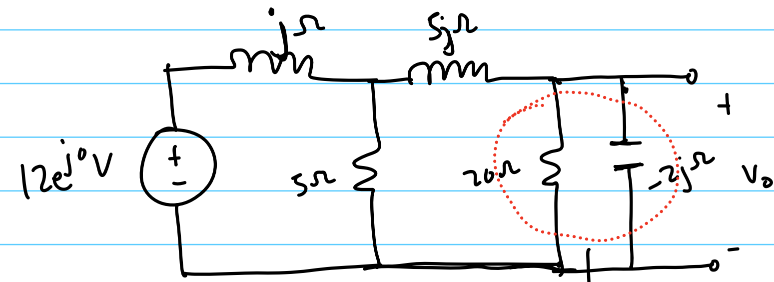


$$\omega_0 = \frac{1}{\sqrt{LC}}$$

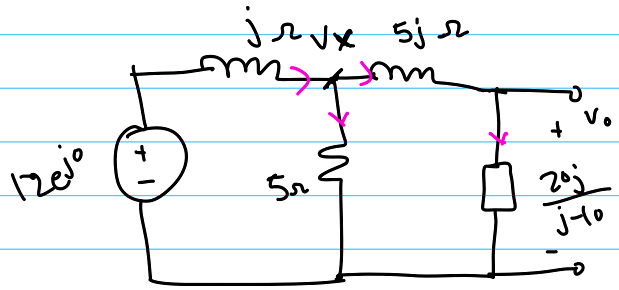
c) $$\omega_0 = \frac{1}{\sqrt{LC}} \Rightarrow \frac{1}{\sqrt{125\times10^{-9} \times 5\times10^{-9}}} \Rightarrow \frac{1}{25}\times10^{9} \Rightarrow \underline{\underline{40\times10^{6}\ \text{rad/s}}}$$

$$\text{freq} = \frac{1}{2\pi} \times 40\times10^{6} \Rightarrow \underline{\underline{6.366\times10^{6}\ \text{Hz}}}$$

Ans.3



$$\frac{20 \times -2j}{20-2j} \Rightarrow \frac{-20j}{10-j} \Rightarrow \frac{20j}{j-10}$$



$$\frac{12 - V_x}{j} = \frac{V_x}{5} + \frac{V_x - V_o}{5j} \quad — \ (1)$$

$$\frac{V_x - V_o}{5j} = \frac{V_o(j-10)}{20j} \quad — \ (2)$$

from (2)

$$V_x - V_o = \frac{V_o}{4}(j-10)$$

$$4V_x - 4V_o = V_o(j-10)$$

$$V_x = V_o + \frac{V_o(j-10)}{4} \Rightarrow -1.5V_o + j0.25V_o$$

from (1)

$$-12j + jV_x = \frac{V_x}{5} + \frac{(V_0 - V_x)j}{5}$$

$$-12j + jV_x - \frac{V_x}{5} + \frac{V_x}{5}j = j\frac{V_0}{5}$$

$$-12 + V_x + j\frac{V_x}{5} + \frac{V_x}{5} = \frac{V_0}{5}$$

$$V_0 = -60 + 5V_x + jV_x + V_x$$

$$V_0 = -60 + (6+j)V_x \Rightarrow -60 + (6+j)(-1.5V_0 + j0.25V_0)$$

$$V_0 = -60 + [-9V_0 + j\cancel{1.5}V_0 - 1.\cancel{5j}V_0 - 0.25V_0]$$

$$10.25V_0 = -60$$

$$\boxed{V_0 = -\frac{60}{10.25} \Rightarrow -5.8536}$$

b) Current delivered by independent source $\Rightarrow \dfrac{12 - V_x}{j} \Rightarrow \dfrac{12 - (-1.5V_0 + j0.25V_0)}{j}$

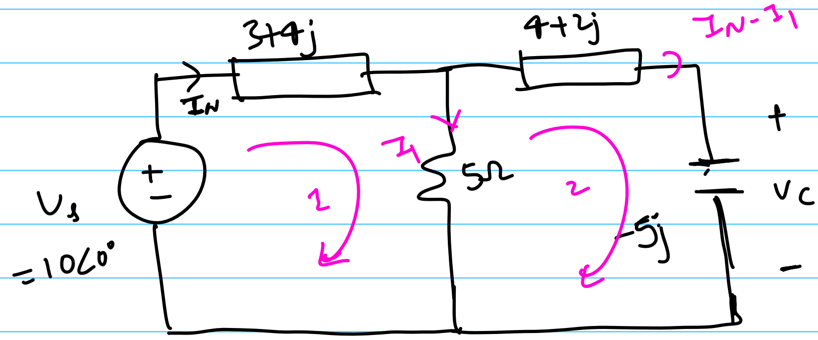
$$\Rightarrow \frac{12 + 1.5V_0 - j0.25V_0}{j}$$

$$\Rightarrow -j(12 + 1.5V_0) - 0.25V_0$$

$$-j(12 - 8.7804) - 0.25 \times (-5.8536)$$

$$\boxed{I = -3.2196j + 1.4634}$$

Ans.4



KVL in loop ①

$$10 - I_N(3+4j) - 5I_1 \Rightarrow 0 \qquad -①$$

KVL in loop ②

$$5I_1 - (4+2j)(I_N - I_1) + 5j(I_N - I_1) \Rightarrow 0 \qquad -②$$

from ①

$$\boxed{5I_1 + (3+4j)I_N = 10} \qquad -③$$

from ②

$$I_1[5+4+2j-5j] + I_N(-4-2j+5j] = 0$$

$$\boxed{I_1[9-3j] + I_N[-4+3j] = 0} \qquad -④$$

$$\hookrightarrow I_1 = -\frac{I_N[-4+3j]}{9-3j} \Rightarrow \frac{I_N[4-3j]}{9-3j}$$

$$I_1 \Rightarrow I_N\left[\frac{1}{2} - \frac{1}{6}j\right]$$

Substituting this in (3)

$$5 I_N \left[\frac{1}{2} - \frac{j}{6} \right] + (3+4j) I_N = 10$$

$$I_N \left[\frac{5}{2} - \frac{5j}{6} + 3 + 4j \right] \Rightarrow 10$$

$$I_N \left[5.5 + \frac{19}{6} j \right] = 10 \quad ; \quad \boxed{I_N \Rightarrow \frac{198}{145} - \frac{114}{145} j}$$

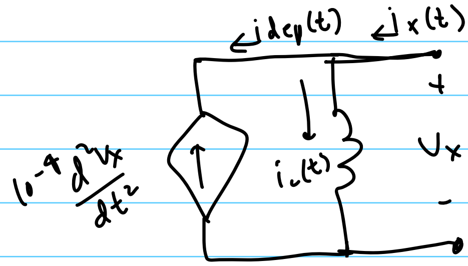
$$V_C \Rightarrow (I_N - I_1)(-5j)$$

$$\left[I_N - \frac{I_N}{2} + \frac{j I_N}{6} \right] (-5j)$$

$$I_N \left[\frac{1}{2} + \frac{j}{6} \right] (-5j) \Rightarrow I_N \left[-\frac{5}{2} j + \frac{5}{6} \right]$$

$$\boxed{V_C = -\frac{24}{29} - \frac{118}{29} j}$$

Ans. 5

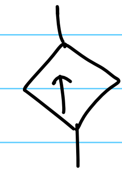


a) $V_x = V_0 \cos(w_0 t)$

dep c.s $\Rightarrow$ $10^{-4} \frac{d^2 V_x}{dt^2}$

dep C.S $\Rightarrow$ $-10^{-4} V_o \omega^2 \cos(\omega_o t)$ for $\omega = 10$ rad/s

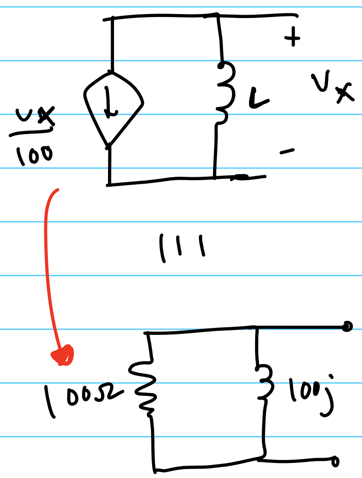
$-10^{-2} V_o \cos(\omega_o t) \Rightarrow \boxed{-\frac{V_o}{100}} \longrightarrow$



b)

$L = 10H$

$\underline{\omega = 10 \text{ rad/s}}$



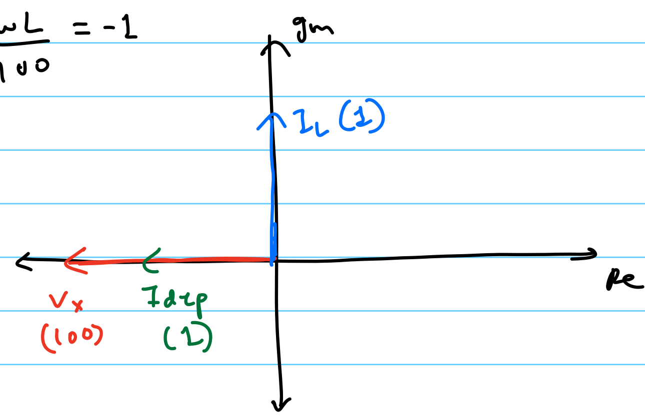
$$z = \frac{100j \times 100}{100 + 100j} \Rightarrow \frac{100j}{1+j}$$

$$\boxed{Z_{eq} \Rightarrow 50 + 50j}$$

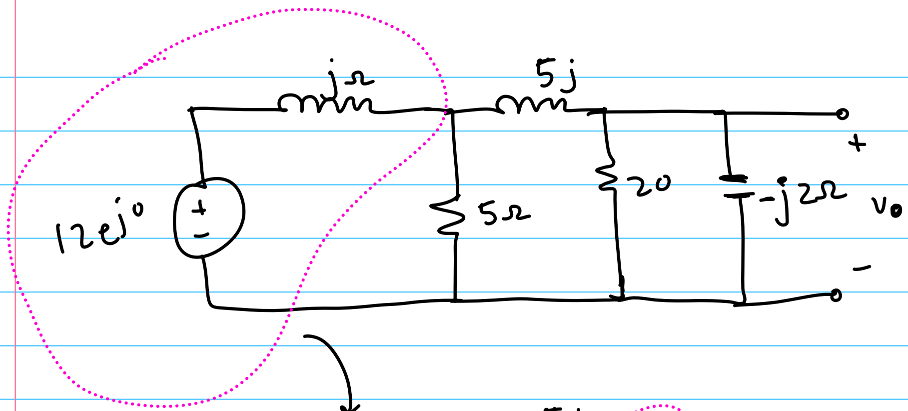
c) $I_L \Rightarrow \dfrac{V_x}{j\omega L} = -j\dfrac{V_x}{\omega L}$

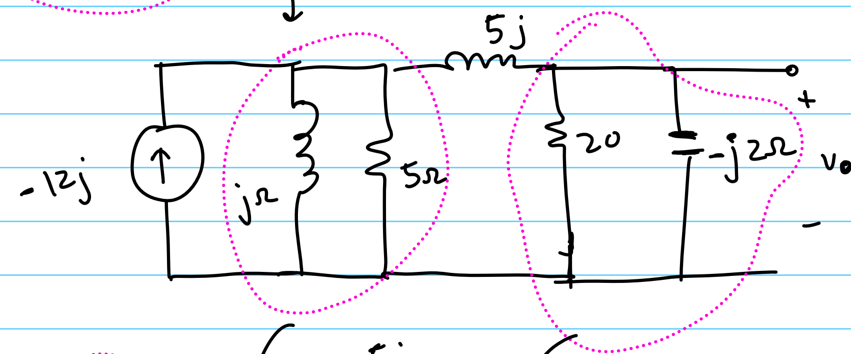
If $I_L = j \Rightarrow V_x = -\omega L = -100$

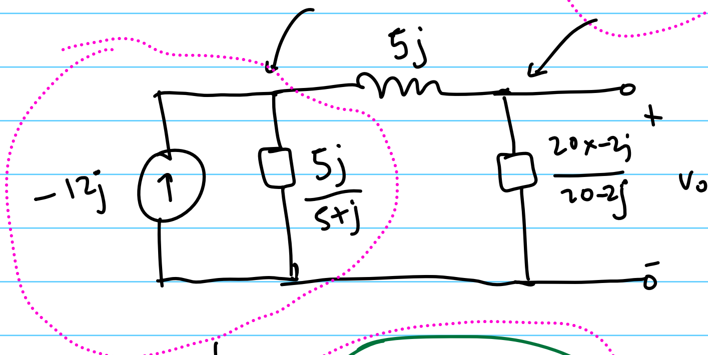
$I_{dep} \Rightarrow \dfrac{V_x}{100} = -\dfrac{\omega L}{100} = -1$



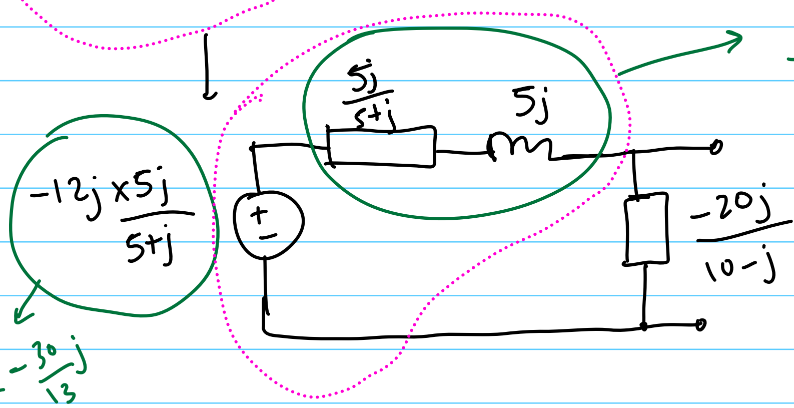
Ans. 6



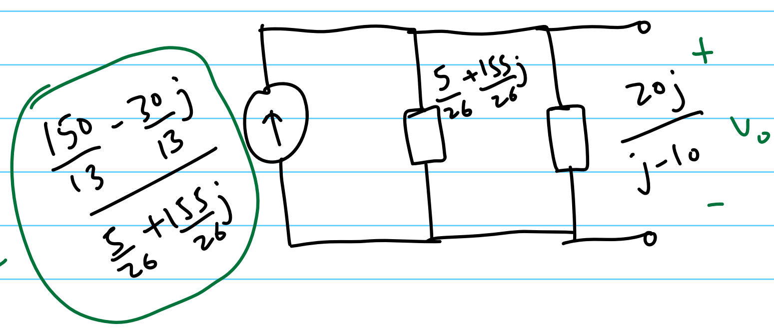




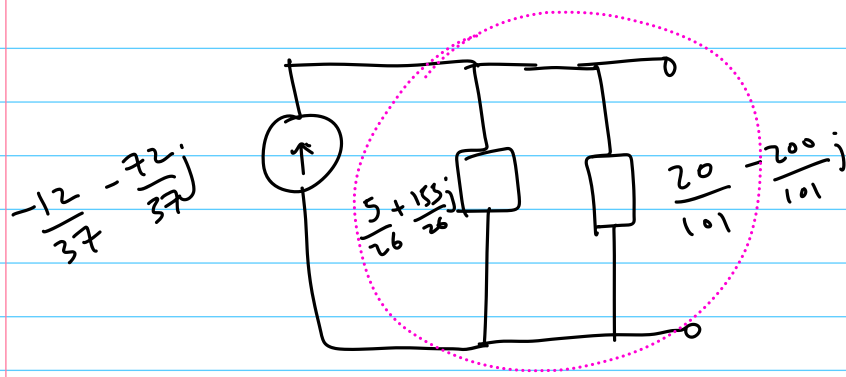
$$\frac{5j}{5+j} + 5j \Rightarrow \frac{5}{26} + \frac{155}{26}j$$

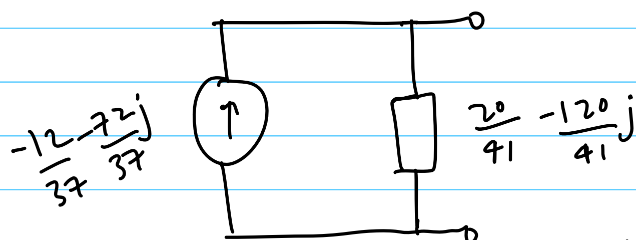


$$\frac{150}{13} - \frac{30}{13}j$$



$$-\frac{12}{37} - \frac{72}{37}j$$

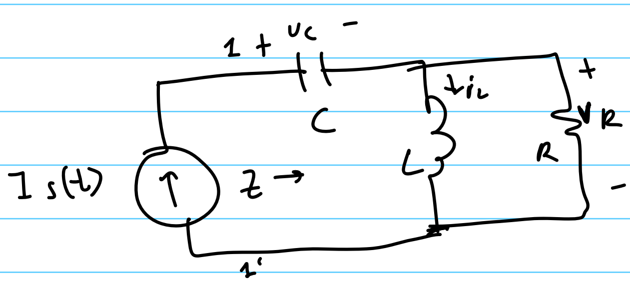




$V_o = -\left(\frac{12}{37} + \frac{72}{37}j\right)\left(\frac{20-120j}{41}\right)$

$$\boxed{\underline{V_o} = -\frac{240}{41} = -5.8536}$$

Ans.7



$C = 10\,pF$

$L = 1\,nH$

$R = 10\,\Omega$

a) $Z = \frac{1}{j\omega C} + \frac{j\omega L \times R}{R + j\omega L} \Rightarrow \frac{1}{j\omega C} + \frac{j\omega LR}{R + j\omega L}$

$$\Rightarrow \frac{R + j\omega L - \omega^2 RLC}{j\omega CR - \omega^2 LC}$$

b) $\omega = 1 \times 10^9$

$$Z = \frac{10 + j\,10^9 \times 1 \times 10^{-9} - 10^{18} \times 10 \times 1 \times 10^{-9} \times 10 \times 10^{-12}}{j\,10^9 \times 10 \times 10^{-12} \times 10 - 10^{18} \times 1 \times 10^{-9} \times 10 \times 10^{-12}}$$

$$Z = \frac{10 + j - 0.1}{0.1j - 0.01} = \frac{9.9 + j}{0.1j - 0.01} \Rightarrow \underset{\substack{\downarrow \\ \text{capacitive}}}{\underline{0.099 - 99i}}$$

c) $I_s = 2e^{-j\pi/6}$

$$V_c \Rightarrow I_s \frac{1}{j\omega C} \Rightarrow 2e^{-j\pi/6} e^{-j\pi/2} \times \frac{1}{1\times10^{10} \times 10\times10^{-12}}$$

$$\Rightarrow \underline{20 e^{-j2\pi/3}}$$

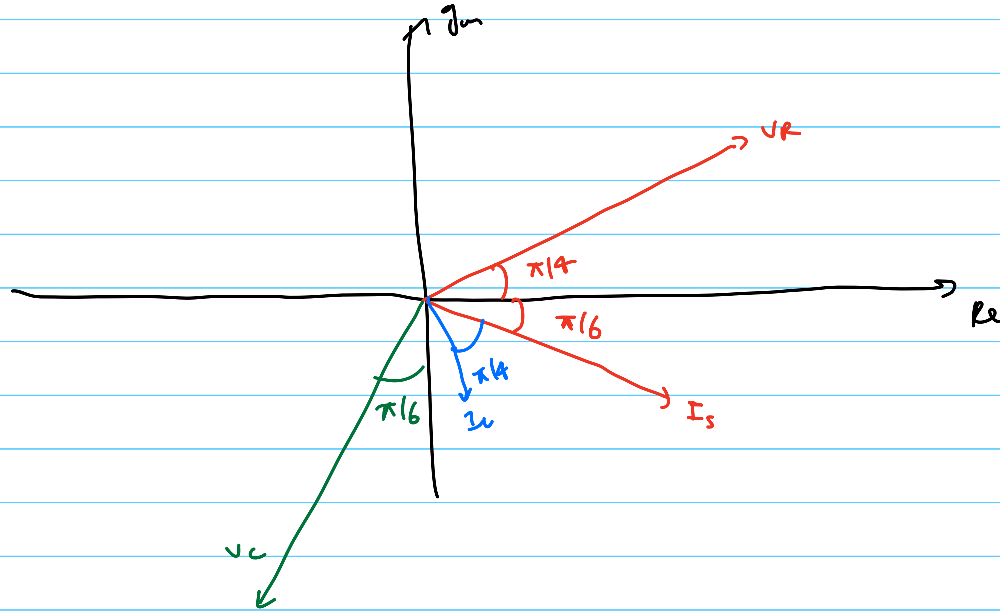
$$I_R \Rightarrow \frac{j\omega L}{R + j\omega L} \times I_s \Rightarrow \frac{j \times 10^{10} \times 10^{-9}}{10 + j\times10^{10}\times1\times10^{-9}} \times I_s$$

$$\Rightarrow \frac{10j\, I_s}{10 + 10j} \Rightarrow \frac{j}{j+1} I_s \Rightarrow I_s\left(\frac{1}{2} + \frac{1}{2}j\right)$$

$$\Rightarrow \underline{\frac{I_s e^{j\pi/4}}{\sqrt{2}}}$$

$$\boxed{V_R \Rightarrow 5\sqrt{2} e^{j\pi/4} I_s}$$

$$\boxed{I_L \Rightarrow \frac{V_R}{j\omega L} \Rightarrow \frac{5\sqrt{2} \times e^{-j\pi/4}}{10^{10} \times 1\times10^{-9}} \Rightarrow \frac{1}{\sqrt{2}} e^{-j\pi/4} I_s}$$



d)

$$Z = \frac{R + j\omega L - \omega^2 RLC}{(j\omega CR - \omega^2 LC) \times (-j\omega RC - \omega^2 LC)} \quad (-j\omega RC - \omega^2 LC)$$

Imaginary part of Numerator: $\Rightarrow \dfrac{(-j\omega R^2C - j\omega^3 L^2 C + j\omega^3 R^2 C^2 L)}{\omega^2 R^2 C^2 + \omega^4 L^2 C^2} \Rightarrow \omega j\,(R^2C + \omega^2 L^2 C - \omega^2 R^2 C^2 L)$

$$R^2C + \omega^2 L^2 C - \omega^2 R^2 C^2 L = 0$$

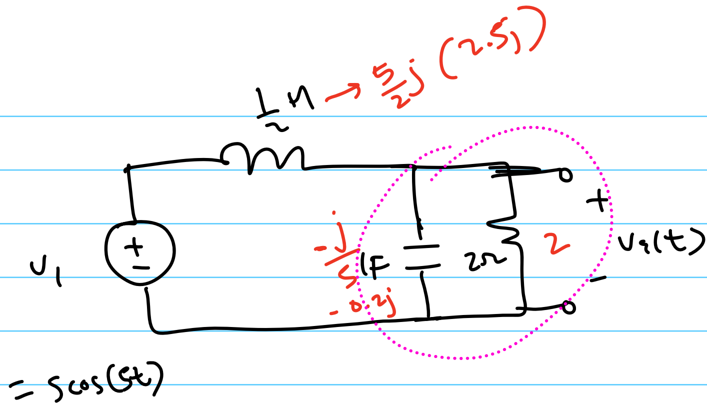
$$\omega^2 (L^2C - R^2C^2L) = -R^2C$$

$$\omega^2 = \frac{R^2 \cancel{C}}{R^2C^2L - L^2\cancel{C}} = \frac{R^2C}{R^2CL - L^2} \Rightarrow \frac{100 \times 10 \times 10^{-12}}{100 \times 10 \times 10^{-12} \times 10^{-9} - 10^{-18}}$$

$$\omega^2 \Rightarrow \frac{10^{-9}}{10^{-18} - 10^{-18}}, \quad \boxed{\omega = \infty}$$

→ No real freq. for which Z is purely resistive.

Ans. 8



$v_1 = 5$

$$\frac{5 - V_a}{2.5j} = \frac{V_a}{-0.2j} + \frac{V_a}{2}$$

$$\frac{5 - V_a}{2.5} = \frac{V_a}{-0.2} + \frac{V_a}{2}j$$

$$2 - \frac{2}{5}V_a = -5V_a + \frac{V_a}{2}j$$

$$2 = \left(-5 + \frac{2}{5}\right)V_a + j\frac{V_a}{2}$$

$$2 = \left(-\frac{23}{5}\right)V_a + j\frac{V_a}{2} \Rightarrow 2 = V_a\left[-\frac{23}{5} + \frac{j}{2}\right]$$

$$V_a \Rightarrow \frac{2}{-\frac{23}{5} + \frac{j}{2}} \Rightarrow -0.4297 - 0.0467j$$

$$\Rightarrow 0.4322\angle -173.79$$

$$V_a(t) = \mathrm{Re}\left\{0.4322e^{-j0.9655\pi} e^{j5t}\right)$$

$$\Rightarrow \boxed{0.4322\cos(5t - 0.9655\pi)}$$