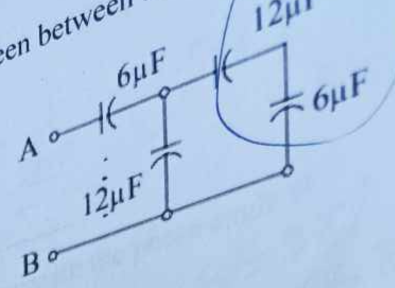
8

**Question # 2 (10 points)**

a. For the circuit shown below, find the equivalent capacitance $C_{eq}$ seen between term[inals]



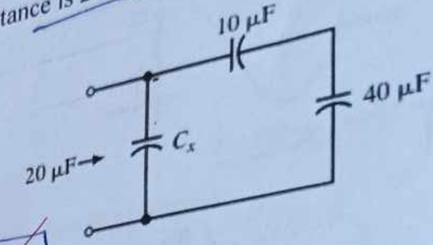

series : $\frac{1}{6\mu F} + \frac{1}{12\mu F} \rightarrow 4\mu F$

Parallel : $(12+4)\mu F = 16\mu F$

series : $\left(\frac{1}{16\mu F} + \frac{1}{6\mu F}\right) \rightarrow$ $\boxed{4.36\ \mu F}$ Ceq

2

b. For the circuit shown below, determine $C_x$ if the equivalent capacitance is 20 μF.




~~series: $(10+40)\mu F = 50\mu F$~~

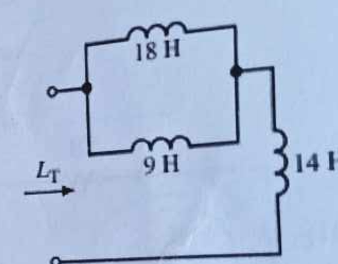
~~$\frac{1}{50\mu F} + \frac{1}{C_x} = 20\mu F$~~

series $= \frac{1}{40} + \frac{1}{10} \rightarrow 8$

Parallel $C_x + 8 = 20 \rightarrow$ $\boxed{C_x = 12\ \mu F}$

2

c. For the circuit shown below, find the equivalent inductance $L_T$.



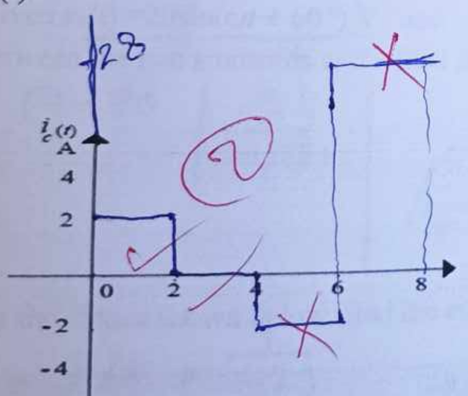

Parallel: $\left(\frac{1}{9} + \frac{1}{18}\right)\frac{1}{H} \Rightarrow 6H$

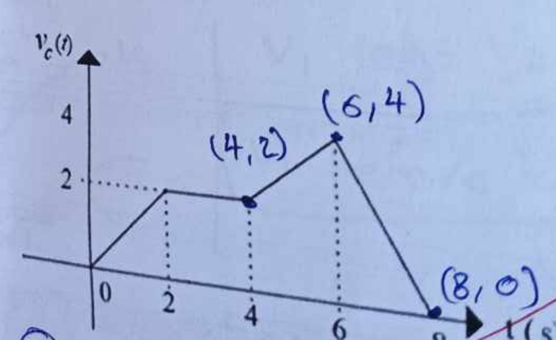
series: $L_t = 6 + 14 = 20H$

✓ 2

d. If the voltage across a 2F capacitor is shown below, draw the waveform for the capacitor current $i_c(t)$.

$i_c(t) = C\frac{dv_c}{dt}$




① for (0-2)s

m = 1

y = x → y' = 1

$\frac{2-0}{2-0}$

$i_c(t) = 2 \times 1 = 2A$

② for (2-4)s

m = 0

y = 2 → y' = 0

$i_c(t) = 0\ A$

③ (4-6)s

$m = \frac{4-2}{6-4} = \frac{2}{2} = 1$

$y - 2 = 1(x-4)$

$y = x - 4 + 2 =$ $\boxed{x-2}$

$y' = -1$

$i_c(t) = 2 \times -1 = -2A$

(6-8)

④ $m = \frac{0-4}{8-6} = \frac{-4}{2} = -2$

$y = -2(x-8)$

$y = -2x + 16$

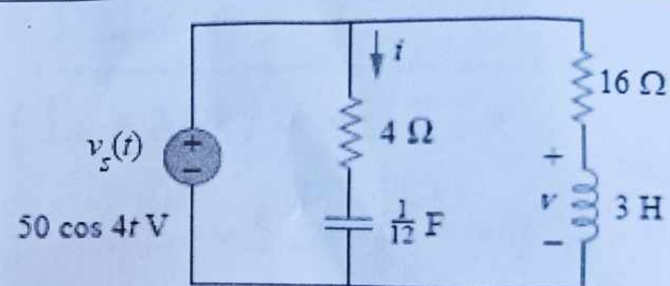
$y = -2 + 16 = 14$

$i_c(t) = 2 \times 14 = 28$

**Question # 5 (8 points)**

For the circuit shown below, find

| | | | | |
|---|---|---|---|---|
| b. | the voltage phasor of the voltage source. | $V_s =$ | $50\angle 0$ | V |
| a. | the impedance of the inductor and capacitor, | $Z_L =$ | $12j$ | Ω |
| | | $Z_C =$ | $-j/16$ | Ω |
| b. | the current phasor and current sinusoid flowing through the 1/12-F capacitor in polar. | $I =$ | | A |
| | | $i(t) =$ | | A |
| c. | the voltage phasor and voltage sinusoid across the 3-H inductor. | $V =$ | | V |
| | | $v(t) =$ | | V |




$Z_L = 12j$

$Z_C = \frac{-j}{16}$

$Z_{C\frac{1}{12}} = \frac{-j}{0.33}$

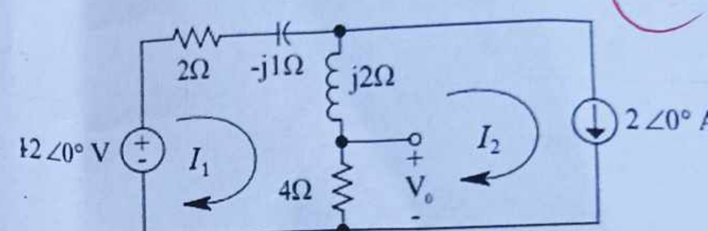
4.5

**Question # 6 (5 points)**

For the circuit shown below, use mesh current analysis to find:

| | | | | |
|---|---|---|---|---|
| a. | the mesh currents $I_1$ and $I_1$. | $I_1 =$ | 3.35 + 0.12j | A |
| | | $I_2 =$ | 2 ∠0 | A |
| b. | the voltage $V_o$ across the 4-Ω resistor. | $V_o =$ | 5.88 | V |

-1/2




$I_1 : 2I_1 - 1jI_1 + (I_1 - 2\angle 0)2j + (I_1 - 2\angle 0)4 = 12\angle 0$

$2I_1 - 1jI_1 + 2jI_1 - 2\angle 0\, 2j + 4I - 2\angle 0 \times 4 - 12\angle 0 =$

$6 + iI_1 = 4j + 8 + 12$

$I_1 = \frac{4j + 20}{6 + j} = 3.35 + 0.12i$

$((3.35 + 0.12) - (2\angle 0)) \times 4 = 5.88 = V_o$

**Question # 3 (15 points)**

a. In a linear circuit, if the voltage source is $v_s(t) = 12\sin(314t + 30^\circ)$ V, find the frequency $f$ and the period $T$ of the voltage waveform.

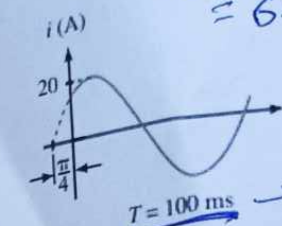
$v_s(t) = 12\cos(314t + 30 - 90)$

$\omega = 314$ r/s $= 2\pi f$

$f = 49.97 \simeq 50$ Hz

$T = \frac{1}{f} = \frac{1}{50} = 0.02$ s

b. Write the equation of the sinusoidal current waveform shown below with the phase angle $\theta$ expressed in degrees.




$\omega = 2\pi f = 62.83$

$f = \frac{1}{100\times10^{-3}} = f = 10$

$20\cos(62.83t \mp 45^\circ)$

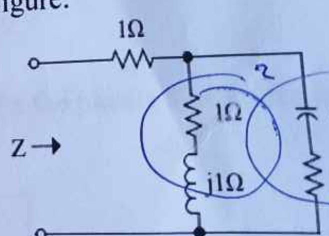
c. Obtain the sinusoidal waveforms corresponding to each of the following phasors:

i. $\overline{V_1} = 60\angle15^\circ\, V,\ \omega = 10$ rad/s $\rightarrow V_1 = 60\cos(10t + 15^\circ)$

ii. $\overline{V_2} = 6 + j8\ V,\ \omega = 40$ rad/sec $\quad V_2 = 10\cos(40t + 53.13)$

$V_2 = 10\angle53.13$

d. Find the frequency domain impedance **Z** shown in the following figure.




Series$_1$ = $1 - j\ \Omega$

Series$_2$ = $1 + j\ \Omega$

Parallel$_{1+2}$ = $\frac{1}{Z} = \frac{1}{1-j} + \frac{1}{1+j} = Z = 1\ \Omega$

$Z_{eq} = 1 + 1 = 2\ \Omega$

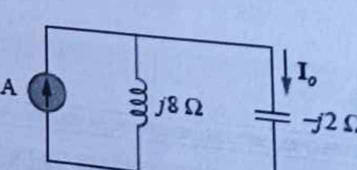
e. Given $v_1(t) = 20\sin(\omega t + 60^\circ)$ V and $v_2(t) = 60\cos(\omega t - 10^\circ)$, determine the phase angle $\theta$ between the two sinusoids and which one lags the other.

$\theta = 70$

$V_1$ lags $V_2$ by $20^\circ$

$V_1$ before $V_2$

f. For the circuit shown below, find the current phasor $\mathbf{I_o}$.




$I = \frac{3\angle0 \times \frac{1}{-2j}}{\frac{1}{-2j} + \frac{1}{8j}} = 4A$

g. A series $RLC$ circuit has $R = 30\ \Omega$, $X_C = 50\ \Omega$, and $X_L = 90\ \Omega$. Find the equivalent impedance $\mathbf{Z_{eq}}$ of the circuit.

$X_C = \frac{1}{\omega C}$ $\quad Z_C \rightarrow -j50$

$X_L = \omega L$ $\quad Z_L = j90$

$Z_{eq} = 30 - 50j + 90j$

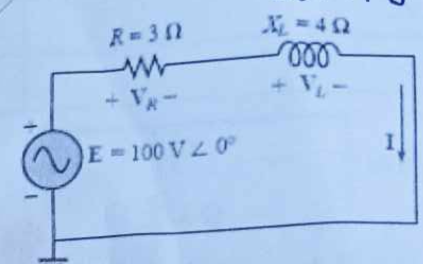
$= 30 + 40j\ \Omega$

**Question # 4 (7 points)**

I. For the circuit shown below, if the voltage source voltage $\mathbf{E} = 100\angle 0^\circ$ V, find

| | | | | |
|---|---|---|---|---|
| a. | the impedance seen by the source in rectangular and polar form. | Z = | 3 + 4j ✓ | Ω |
| | | | 5 ∠ 53.13 ✓ | Ω |
| b. | the current phasor supplied by the source. | I = | 20 ∠ -53.13 ✓ | A |
| c. | the voltage across the 3-Ω resistor *R* and $\mathbf{V}_L$ across the 4-Ω reactor $X_L$. | $\mathbf{V}_R$ = | 60 ∠ -53.13 ✓ | V |
| | | $\mathbf{V}_L$ = | 80 ∠ 36.87 ✓ | V |

$Z_L = 4j$




$Z_{eq} = 3 + 4j$

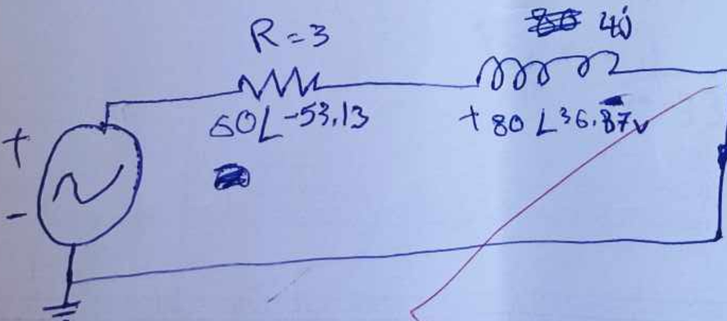
$I = \frac{V}{Z_{eq}} = \frac{100\angle 0}{5\angle 53.13}$

$= 20\angle -53.13$ A

$V_R = I R = 20\angle -53.13 \times 3 = 60\angle -53.13$ V

$V_L = I Z_L = 20\angle -53.13 \times 4j = 80\angle 36.87$ V ✓

II. Draw the phasor diagram showing the phasors **E**, **I**, $\mathbf{V}_R$ and $\mathbf{V}_L$. Take the phasor **E** as a reference.

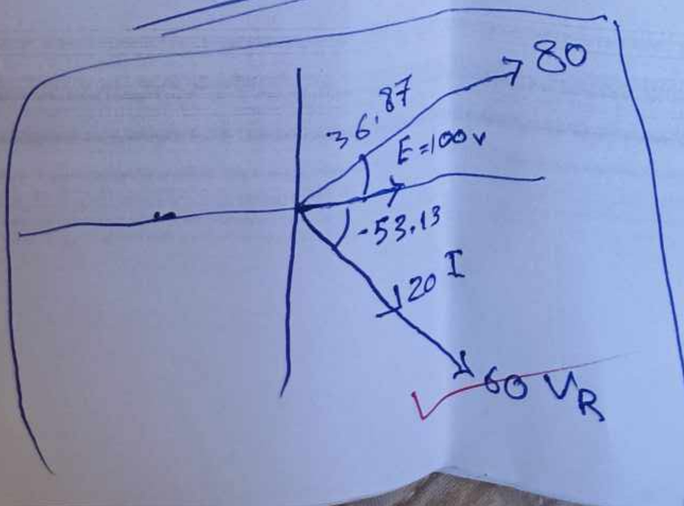



$I = 20\angle -53.13$

$I = 20\cos(wt - 53.13)$

$V_R = 60\cos(wt - 53.13)$

$V_L = [80\cos(wt + 36.87)]$



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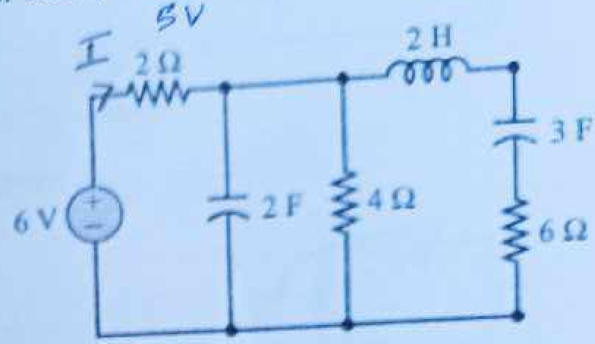
| Question # | Q1 (5) | Q2 (10) | Q3 (15) | Q4 (7) | Q5 (8) | Q6 (5) | Grade |
|---|---|---|---|---|---|---|---|
| Grade: | 0 | 8 | 13 | 7 | 2 | 4.5 | 34.5 /50 |

**Question # 1 (5 points)**

Find the energy stored in each capacitor and inductor, under steady-state conditions, in the circuit shown below.

$E = \frac{1}{2} C V^2$

$2F \rightarrow \frac{1}{2} \times 2 \times (1)^2 = 1$ joul




$V_{2\Omega} = \frac{6 \times 2}{2.4} = 5V$