Homework-01 EEE 117 Due date 02/07/2022

Questions 1-5 2 points each **Questions 6-11 15 points each**

Q- 1 The rms value of $v(t) = V_{max}\cos(\omega t + \delta)$ is given by
(a) V_{max} (b) $V_{max}/\sqrt{2}$ (c) $2\ V_{max}$ (d) $\sqrt{2}\ V_{max}$

Q-2 If the rms phasor of a voltage is given by $V = 120\underline{/60^\circ}$ volts, then the corresponding $v(t)$ is given by
(a) $120\sqrt{2}\cos(\omega t + 60^\circ)$ (b) $120\cos(\omega t + 60^\circ)$
(c) $120\sqrt{2}\sin(\omega t + 60^\circ)$

Q-3 If a phasor representation of a current is given by $I = 70.7\underline{/45^\circ}$ A, it is equivalent to
(a) $100\ e^{j45^\circ}$ (b) $100 + j100$
(c) $50 + j50$

Q-4 With sinusoidal steady-state excitation, for a purely resistive circuit, the voltage and current phasors are
(a) in phase
(b) perpendicular with each other with V leading I
(c) perpendicular with each other with I leading V.

Q-5 For a purely inductive circuit, with sinusoidal steady-state excitation, the voltage and current phasors are
(a) in phase
(b) perpendicular to each other with V leading I
(c) perpendicular to each other with I leading V.

Q-6 Consider the sinusoidal voltage

$$v(t) = 25\cos(400\pi t + 60^\circ)\ \text{V}.$$

a) What is the maximum amplitude of the voltage?
b) What is the frequency in hertz?
c) What is the frequency in radians per second?
d) What is the phase angle in radians?
e) What is the phase angle in degrees?
f) What is the period in milliseconds?
g) What is the first time after $t = 0$ that $v = 0$ V?

Q-7 Use the concept of the phasor to combine the following sinusoidal functions into a single trigonometric expression:

a) $y = 30\cos(200t - 160^\circ) + 15\cos(200t + 70^\circ)$,

b) $y = 90\sin(50t - 20^\circ) + 60\cos(50t - 70^\circ)$,

c) $y = 50\cos(5000t - 60^\circ) + 25\sin(5000t + 110^\circ) - 75\cos(5000t - 30^\circ)$,

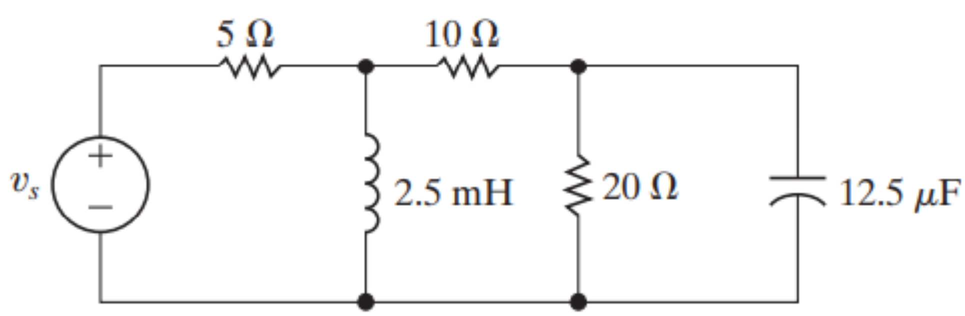
d) $y = 10\cos(\omega t + 30^\circ) + 10\sin\omega t + 10\cos(\omega t + 150^\circ)$.

Q-8 A 25 Ω resistor and a 10 mH inductor are connected in parallel. This parallel combination is also in parallel with the series combination of a 30 Ω resistor and a 10 μF capacitor. These three parallel branches are driven by a sinusoidal current source whose current is $125\sin(2500t + 60^\circ)$ A.

a) Find total impedance.
b) Analyze the circuit and find current and voltage for each component.

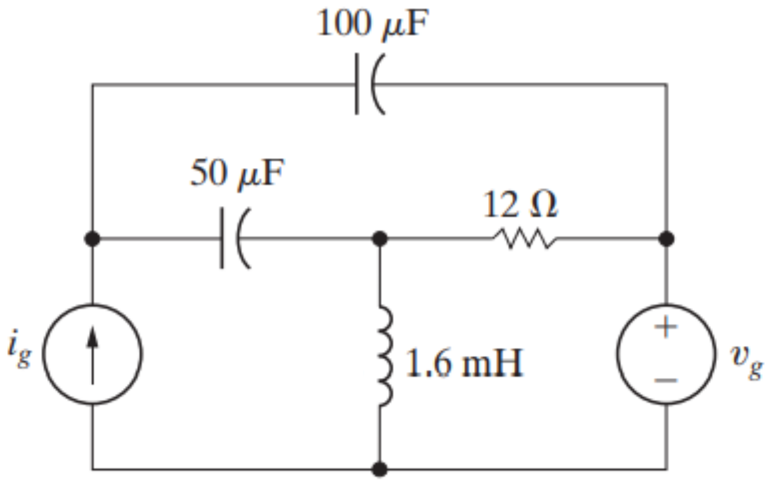
Q-9 For the circuit shown below.

c) Find total impedance.
d) Analyze the circuit and find current and voltage for each component. if vs = 25 sin 4000t V.

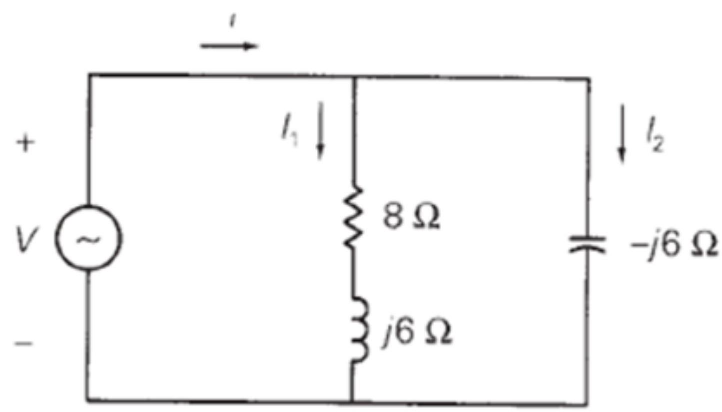


Q-10 Analyze the circuit and find current and voltage for each component.

if $i_g = 5\cos 2500t$ A and $v_g = 20\cos(2500t + 90°)$ V.



Q-11 In the figure shown below, $\bar{I} = 10\angle 0\ A$, compute the phasors $\bar{I}_1$, $\bar{I}_2$ and $\bar{V}$.



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Q1 b.

Q2 b.

Q3 c.

Q4 a.

Q5 b.

Q6 $v(t) = V_m \cos(\omega t + \phi)$

(a) $V_m = 25\ V$

(b) $\omega = 2\pi f \longrightarrow f = \frac{\omega}{2\pi} = \frac{400\pi}{2\pi} = 200\ Hz$

(c) $\omega = 400\pi$

(d) $\phi = 60^\circ = \pi/3\ rad$

(e) $\phi = 60^\circ$

(f) $\omega = 2\pi/T \longrightarrow T = \frac{2\pi}{\omega} = \frac{2\pi}{400\pi} = 5\times10^{-3}\ s \approx 5\ ms$

(g) @ $v = 0$: $0 = 25\cos(400\pi t + 60^\circ)$

$90^\circ = 400\pi t + 60^\circ$

$\pi/6 = 400\pi t$

$t = 4.17\times10^{-4}\ s \approx 0.417\ ms$

Q7 (a) $y = (30\angle-160^\circ) + (15\angle70^\circ)$

$= (-28.19 - j10.26) + (5.13 + j14.10)$

$= -23.06 + j3.84$

$= 23.38\angle170.55^\circ$

$\boxed{= 23.38\cos(200t + 170.55^\circ)}$

(b) $y = 90\cos(50t - 110^\circ) + 60\cos(50t - 70^\circ)$

$= (-30.78 - j84.57) + (20.52 - j56.38)$

$= -10.26 - j140.95$

$\boxed{= 141.32\cos(50t - 94.16^\circ)}$

(c) $y = 50\cos(5000t - 60^\circ) + 25\cos(5000t + 20) - 75\cos(5000t - 30^\circ)$

$y = (25 - j43.30) + (23.49 + j8.55) - (64.95 - j37.5)$

$= -16.46 + j2.75$

$\boxed{= 16.67\cos(5000t + 170.51^\circ)}$

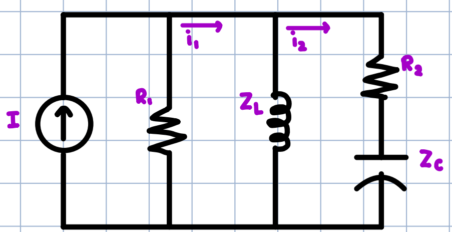
(d) $y = (10\angle30^\circ) + (10\angle-90^\circ) + (10\angle150^\circ)$

$= (5\sqrt{3} + j5) + (0 - j10) + (-5\sqrt{3} + j5)$

$= 0 + j0$

$\boxed{y = 0}$

Q8



$I = 125\sin(2500t + 60^\circ)\ A$

$= 125\cos(2500t - 30^\circ)\ A$

$= 125\angle-30^\circ\ A$

$R1 = 25\ \Omega$

$L = 10\ mH \approx 0.01\ H$

$R2 = 30\ \Omega$

$C = 10\ \mu F \approx 10\times10^{-6}\ F$

$Z_L = j\omega L = j(2500)(0.01)$

$= j25\ \Omega$

$Z_C = \frac{-j}{\omega C} = \frac{-j}{(2500)(10\times10^{-6})}$

$= -j40\ \Omega$

(a) $\frac{1}{Z_{eq}} = \frac{1}{R_1} + \frac{1}{Z_L} + \frac{1}{R_2 + Z_C}$

$= \frac{1}{25} + \frac{1}{j25} + \frac{1}{30 - j40}$

$= \frac{1}{25} - \frac{j}{25} + \frac{3 + j4}{10(9 + 16)}$

$= \frac{1 - j}{25} + \frac{3 + j4}{10(25)} = \frac{13 - j6}{250}$

$Z_{eq} = \frac{250}{13 - j6} = \frac{250(13 + j6)}{205}$

$= \frac{650}{41} + j\frac{300}{41}\ \Omega$

$= \boxed{17.46\angle24.78^\circ\ \Omega}$

(b) $V = IZ$

$I = \boxed{125\angle-30^\circ\ A}$

$= (125\angle-30^\circ)(17.46\angle24.78^\circ)$

$= \boxed{2182.5\angle-5.22^\circ\ V}$

$i_2 = \frac{V}{R_2 + Z_C} = \frac{2182.5\angle-5.22^\circ}{30 - j40}$

$= \frac{2182.5\angle-5.22^\circ}{50\angle-53.13^\circ} = 43.65\angle47.91^\circ$

$V_{R1} = V = \boxed{2182.5\angle-5.22^\circ\ V}$

$I_{R1} = V/R_1 = \frac{2182.5\angle-5.22^\circ}{25\angle0^\circ} = \boxed{87.3\angle-5.22^\circ\ A}$

$V_{Z_L} = V = \boxed{2182.5\angle-5.22^\circ\ V}$

$I_{Z_L} = V/Z_L = \frac{2182.5\angle-5.22^\circ}{25\angle90^\circ} = \boxed{87.3\angle-95.22^\circ\ A}$

$V_{R_2} = i_2 R_2 = (43.65\angle47.91^\circ)(30\angle0^\circ)$

$= \boxed{1309.5\angle47.91^\circ\ V}$

$I_{R_2} = i_2 = \boxed{43.65\angle47.91^\circ\ A}$

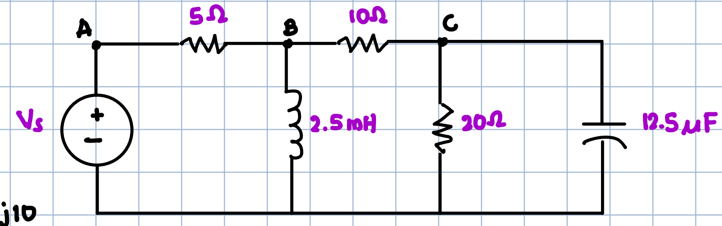
$V_{Z_C} = i_2 Z_C = (43.65\angle47.91^\circ)(40\angle-90^\circ)$

$= \boxed{1746\angle-42.09^\circ\ V}$

$I_{Z_C} = i_2 = \boxed{43.65\angle47.91^\circ\ A}$

Q9

$$Z_L = j\omega L = j(4000)(2.5\times10^{-3})$$
$$= j10\ \Omega$$
$$Z_C = \frac{-j}{\omega C} = \frac{-j}{(4000)(12.5\times10^{-6})} = j20\Omega$$



(c) • $20\Omega \,//\, 12.5\,\mu F$: $\dfrac{1}{\frac{1}{20}+\frac{1}{j20}} = \dfrac{1}{\frac{1+j}{j20}} = \dfrac{j20}{1+j} = 10+j10$

• $10\Omega + (20\Omega \,//\, 12.5\,\mu F)$: $10 + (10+j10) = 20+j10$

• $2.5\,mH \,//\, [10\Omega + (20\Omega \,//\, 12.5\,\mu F)]$: $\dfrac{1}{\frac{1}{j10}+\frac{1}{20+j10}} = \dfrac{1}{\frac{3+j}{j25}} = 2.5+j7.5$

• $5\Omega + 2.5\,mH \,//\, [10\Omega + (20\Omega \,//\, 12.5\,\mu F)]$ $\quad Z_{eq} = 5 + (2.5+j7.5) = 7.5+j7.5$

$$= \boxed{10.61\angle 45^\circ}$$

(d) $V = IZ$ $\qquad V_s = 25\cos(4000t - 90^\circ)\,V = \boxed{25\angle -90^\circ\ V}$

$$I = \frac{V}{Z} = \frac{25\angle -90^\circ}{10.61\angle 45^\circ} = \boxed{2.36\angle -135^\circ}$$

NODE B: $\dfrac{V_B - V_A}{5} + \dfrac{V_B}{j10} + \dfrac{V_B - V_C}{10} = 0$

$$V_B\left(\frac{1}{5}+\frac{1}{j10}+\frac{1}{10}\right) = \frac{-j25}{5} + \frac{V_C}{10}$$
$$V_B\left(3/10 - j/10\right) = -j5 + V_C/10$$

NODE C: $\dfrac{V_C - V_B}{10} + \dfrac{V_C}{20} + \dfrac{V_C}{j20} = 0$

$$V_C\left(\frac{1}{10}+\frac{1}{20}+\frac{1}{j20}\right) = \frac{V_B}{10}$$
$$V_C\left(3/20 - j1/20\right) = V_B/10$$
$$V_C\left(3/2 - j1/2\right) = V_B$$

$$V_B\left(3/10 - j/10\right) = -j5 + V_C/10$$
$$V_C(3/2 - j1/2)(3/10 - j/10) = -j5 + V_C/10$$
$$V_C\left(2/5 - j3/10\right) - V_C/10 = -j5$$
$$V_C = 25/3 - j25/3 = 11.79\angle -45^\circ$$

$$V_B = V_C\left(3/2 - j1/2\right)$$
$$= (25/3 - j25/3)(3/2 - j1/2)$$
$$= \frac{25}{3} - j\frac{50}{3} = 18.63\angle -63.43^\circ$$

$$V_{5\Omega} = V_B - V_S = \left(\frac{25}{3} - j\frac{50}{3}\right) - (-j25)$$
$$= \frac{25}{3} + j\frac{25}{3} = \boxed{11.79\angle 45^\circ\ V}$$
$$I_{5\Omega} = \frac{V_B - V_S}{5} = \frac{\frac{25}{3}+j\frac{25}{3}}{5} = \frac{5}{3}+j\frac{5}{3}$$
$$= \boxed{2.36\angle 45^\circ\ A}$$

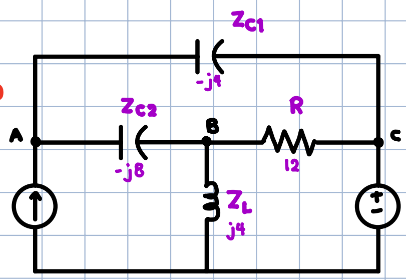
$$V_{Z_L} = V_B = \boxed{18.63\angle -63.43^\circ\ V}$$
$$I_{Z_L} = \frac{V_B}{Z_L} = \frac{18.63\angle -63.43^\circ}{10\angle 90^\circ} = \boxed{1.86\angle -158.43^\circ\ A}$$

$$V_{10\Omega} = V_B - V_C = \left(\frac{25}{3} - j\frac{50}{3}\right) - (25/3 - j25/3)$$
$$= -j25/3 = \boxed{8.33\angle -90^\circ\ V}$$
$$I_{10\Omega} = \frac{V_B - V_C}{10} = \frac{8.33\angle -90^\circ}{10\angle 0^\circ} = \boxed{0.83\angle -90^\circ A}$$

$$V_{20\Omega} = V_C = \boxed{11.79\angle -45^\circ\ V}$$
$$I_{20\Omega} = \frac{V_C}{20} = \frac{11.79\angle -45}{20\angle 0} = \boxed{0.59\angle -45^\circ A}$$

$$V_{Z_C} = V_C = \boxed{11.79\angle -45^\circ\ V}$$
$$I_{Z_C} = \frac{V_C}{Z_C} = \frac{11.79\angle -45^\circ}{20\angle 90^\circ} = \boxed{0.59\angle -135^\circ\ A}$$

Q10



$$Z_{C1} = \frac{-j}{\omega C} = \frac{-j}{(2500)(100\times10^{-6})} = -j4$$

$$Z_{C2} = \frac{-j}{\omega C} = \frac{-j}{(2500)(50\times10^{-6})} = -j8$$

$$Z_L = j\omega L = j(2500)(1.6\times10^{-3}) = j4$$

NODE A: $\dfrac{V_A - V_C}{Z_{C1}} + \dfrac{V_A - V_B}{Z_{C2}} = 5\angle 0°$

$$V_A\left(\frac{1}{-j4} + \frac{1}{-j8}\right) = 5 + \frac{V_C}{-j4} + \frac{V_B}{-j8}$$

$$V_A\left(-\frac{3}{j8}\right) = 5 + \frac{j20}{-j4} + \frac{V_B}{-j8}$$

$$V_A\left(-\frac{3}{j8}\right) = 5 - 5 + \frac{V_B}{-j8}$$

$$V_A = V_B/3 \longrightarrow V_A = \frac{-8+j4}{3} = -\frac{8}{3} + j\frac{4}{3}$$

$$\approx 2.98\angle 153.43°$$

NODE B: $\dfrac{V_B - V_A}{Z_{C2}} + \dfrac{V_B - V_C}{R} + \dfrac{V_B}{Z_L} = 0$

$$V_B\left(\frac{1}{-j8} + \frac{1}{12} + \frac{1}{j4}\right) - \frac{V_A}{-j8} = \frac{j20}{12}$$

$$V_B\left(\frac{1}{-j8} + \frac{1}{12} + \frac{1}{j4}\right) - \frac{V_B}{-j24} = \frac{j20}{12}$$

$$V_B\left(\frac{1}{12} - j\frac{1}{6}\right) = \frac{j20}{12}$$

$$V_B = -8+j4 \approx 8.94\angle 153.43°$$

VOLTAGE ACROSS i_g: $V_A = \boxed{2.98\angle 153.43°\ V}$

$$V_{C1} = V_A - V_C = \left(-\frac{8}{3} + j\frac{4}{3}\right) - j20 = -8/3 - j\,56/3$$

$$= \boxed{18.86\angle -98.13°\ V}$$

$$I_{C1} = \frac{V_A - V_C}{Z_{C1}} = \frac{-8/3 - j\,56/3}{-j4} = \frac{14}{3} - j\frac{2}{3}$$

$$= \boxed{4.71\angle -8.13\ A}$$

$$V_{C2} = V_A - V_B = \left(-\frac{8}{3} + j\frac{4}{3}\right) - (-8+j4) = \frac{16}{3} - j\frac{8}{3}$$

$$= \boxed{5.96\angle 153.43°\ V}$$

$$I_{C2} = \frac{V_A - V_B}{Z_{C2}} = \frac{\frac{16}{3} - j\frac{8}{3}}{-j8} = \frac{1}{3} + j\frac{2}{3}$$

$$= \boxed{0.75\angle 63.43°\ A}$$

$$V_R = V_B - V_C = (-8+j4) - j20 = -8 - j16$$

$$= \boxed{17.89\angle -116.57°\ V}$$

$$I_R = \frac{V_B - V_C}{R} = \frac{-8-j16}{12} = -\frac{2}{3} - j\frac{4}{3}$$

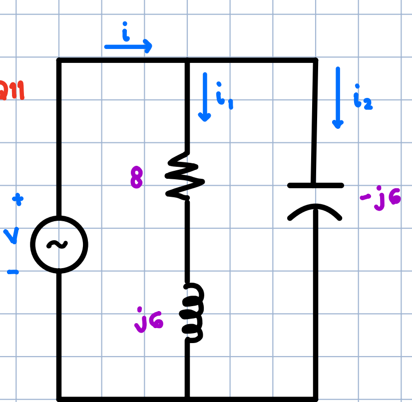
$$= \boxed{1.49\angle -116.57°\ A}$$

$$V_L = V_B = \boxed{8.94\angle 153.43°\ V}$$

$$I_L = \frac{V_B}{Z_L} = \frac{-8+j4}{-j4} = -1-j2$$

$$= \boxed{2.24\angle -116.57°\ A}$$

Q11



$$I = 10\angle 0\ A$$
$$= 10$$

$$I_1 = I\left(\frac{-j6}{8+j6-j6}\right)$$
$$= 10\left(-j6/8\right)$$
$$= -j7.5$$
$$\approx \boxed{7.5\angle -90°\ A}$$

$$I_2 = I\left(\frac{8+j6}{8+j6-j6}\right)$$
$$= 10\left(\frac{8+j6}{8}\right)$$
$$= 10 + j7.5$$
$$\approx \boxed{12.5\angle 36.87°\ A}$$

$$V = I_2 Z_c$$
$$= (10+j7.5)(-j6)$$
$$= 45 - j60$$
$$\approx \boxed{75\angle -53.13°\ V}$$