1. a) \[ Z_1 = 1 + 2j \]
   
   Modulus = \[ \sqrt{1^2 + 2^2} = \sqrt{5} = 2.236 \]
   
   Phase = \[ \tan^{-1} \left( \frac{2}{1} \right) = 63.43^\circ \]
   
   \[ \Rightarrow Z_1 = \sqrt{5} / 63.43^\circ \]

b) \[ Z_2 = 2 + 3j \]
   
   Modulus = \[ \sqrt{2^2 + 3^2} = \sqrt{13} = 3.605 \]
   
   Phase = \[ \tan^{-1} \left( \frac{3}{2} \right) = 56.3^\circ \]
   
   \[ \Rightarrow Z_2 = \sqrt{13} / 56.3^\circ \]

c) \[ Z_3 = 1 - j \]
   
   Modulus = \[ \sqrt{1^2 + (-1)^2} = \sqrt{2} = 1.414 \]
   
   Phase = \[ \tan^{-1} \left( \frac{-1}{1} \right) = -45^\circ \]
   
   \[ \Rightarrow Z_3 = \sqrt{2} / -45^\circ \]

1
2) a) \( z_1 \cdot z_2 \cdot z_3 = (z_1 \cdot z_2) \cdot z_3 = \left( (1+2j) (2+3j) \right)(1-j) \)
\[ = (2+3j+4j-6)(1-j) = (-4+7j)(1-j) \]
\[ = -4+4j+7j-4j + 7 = 3+11j = \sqrt{130} \angle 74.74^\circ = 11.4 \angle 74.74^\circ \]

b) \( z_1 \cdot z_2 \cdot z_3 = \left( \sqrt{5} \angle 63.43^\circ \right) \left( \sqrt{13} \angle 56.3^\circ \right) \left( \sqrt{2} \angle -45^\circ \right) \)
\[ = \sqrt{5 \cdot 13 \cdot 2} \angle (63.43^\circ + 56.3^\circ - 45^\circ) = \sqrt{130} \angle 74.74^\circ \]
\[ = 11.4 \angle 74.74^\circ \]

3) a) \( \frac{z_1}{z_2} = \frac{1+2j}{2+3j} = \frac{\sqrt{5} \angle 63.43^\circ}{\sqrt{13} \angle 56.3^\circ} = \left( \frac{\sqrt{5}}{\sqrt{13}} \right) \angle (63.43^\circ - 56.3^\circ) \)
\[ = 0.62 \angle 7.13^\circ = 0.615 + j0.0769 \]

b) \( \frac{z_1}{z_2} = \frac{1+2j}{2+3j} = \frac{(1+2j)(2-3j)}{4+9} = \frac{2-3j+4j+6}{13} \)
\[ = \frac{8+j}{13} = 0.615 + j0.0769 = 0.62 \angle 7.13^\circ \]
(4) a) $\frac{Z_1}{Z_2} = 0.62 \angle 7.13^\circ \Rightarrow \text{Modulus} = 0.62$ (from 3 part b)

b) $\left| \frac{Z_1}{Z_2} \right| = \frac{|Z_1|}{|Z_2|} = \frac{\sqrt{5}}{\sqrt{13}} = 0.62$

(5) Problem 9.6 (d):  
\[ y = 100 \cos (wt + 40^\circ) + 100 \cos (wt + 160^\circ) + 100 \cos (wt - 80^\circ) \]

\[ \Rightarrow y = 100 \angle 40^\circ + 100 \angle 160^\circ + 100 \angle -80^\circ \]

\[ = 76.6 + j64.27 - 93.96 + j34.2 + 17.36 - j98.4 \Rightarrow y = 0 \Rightarrow y = 0 \]

The three phasors exactly cancel, because they have the same magnitude and they are 120° apart.

(6) Problem 9.22)

\[ Z_{ab} \rightarrow 4k\Omega \]

\[ 625 \text{ nF} \]

a) $Z_{ab} = jSw + \frac{\frac{1}{4 \cdot 10^2} - \frac{1}{jw \cdot 625 \cdot 10^{-9}}}{\frac{1}{4 \cdot 10^3} + \frac{1}{jw \cdot 625 \cdot 10^{-9}}} = jSw + \frac{4 \cdot 10^3 (1 - jw2500 \cdot 10^{-6})}{1 + (2500 \cdot 10^{-6} w)^2}$
\[ Z_{ab} = j \omega + \frac{4 \times 10^3 - j 10 \omega}{1 + 6.25 \times 10^{-6} \omega^2} = \frac{4 \times 10^3}{1 + 6.25 \times 10^{-6} \omega^2} + j \left( \omega - \frac{10 \omega}{1 + 6.25 \times 10^{-6} \omega^2} \right) \]

Purely resistive \( \Rightarrow \) \( \text{Im}(Z_{ab}) = 0 \)

\[ \Rightarrow \ \xi \omega = \frac{10 \omega}{1 + 6.25 \times 10^{-6} \omega^2} \Rightarrow \boxed{\omega = 400 \ \text{rad/sec}} \]

b) \[ Z_{ab} (\omega = 400) = \text{Re} (Z_{ab}) = \frac{4 \times 10^3}{1 + 6.25 \times 10^{-6} \omega^2} \bigg|_{\omega = 400} = \frac{4000}{2} = 2 \text{k} \Omega \]
Problem 9.23)

\[ Z_1 = 10 - j40 \text{ \Omega} \]

\[ Z_2 = \frac{(5-j10)(10+j30)}{15+j20} = \frac{50+j150-j100+300}{15+j20} \]

\[ = \frac{350+j50}{15+j20} = \frac{70+j10}{3+j4} = \frac{(70+j10)(3-j4)}{3^2+4^2} \]

\[ = \frac{240-j280+j30+40}{25} = \frac{250-j250}{25} = 10 - j10 \text{ \Omega} \]

\[ Z_3 = \frac{200+j20}{20+j20} = \frac{20j}{1+j} = \frac{20j(1-j)}{1+1} = \frac{20j+20}{2} = 10 + j10 \text{ \Omega} \]
\[ Z_{ab} = Z_1 + Z_2 + Z_3 = 10 - j40 + 10 - j10 + 10 + j10 = 30 - j60 \, \Omega \]
\[ = 50 \angle -83.15^\circ \]

8. Problem 9.29

\( V_g = 150 \cos \left( 8000 \pi t + 20^\circ \right) \, V \)
\( i_g = 30 \sin \left( 8000 \pi t + 38^\circ \right) \, A \)
\[ = 30 \cos \left( 8000 \pi t - 52^\circ \right) \, A \]

a) \[ Z = \frac{V_g}{I_g} = \frac{150 / 20^\circ}{30 / -52^\circ} = 5 / 120^\circ + 52^\circ = 5 / 72^\circ \]
\[ = 1.565 + j 4.75 \, \Omega \]

b) \[ V_g = 150 \cos \left( 8000 \pi t + 20^\circ \right) \, V = 150 \cos \left( 8000 \pi (t - t_{vg}) \right) \, V \]
\[ i_g = 30 \cos \left( 8000 \pi t - 52^\circ \right) \, A = 30 \cos \left( 8000 \pi (t - t_{ig}) \right) \, A \]

where
\[ -8000 \pi (t_{vg}) = 20^\circ \left( \frac{2\pi}{360^\circ} \right) \text{ radians} \Rightarrow t_{vg} = -13.88 \, \mu s \]
\[ -8000 \pi (t_{ig}) = 52^\circ \left( \frac{2\pi}{360^\circ} \right) \text{ radians} \Rightarrow t_{ig} = 36.11 \, \mu s \]

\[ \Rightarrow \Delta t = t_{ig} - t_{vg} = 50 \, \mu s \text{ (} i_g \text{ lags } V_g \text{ by 50} \, \mu s \text{)} \]
(9) Problem 9.25

\[ Z_1 = R_1 + jwL_1 \]

\[ Z_2 = \frac{R_2 (jwL_2)}{R_2 + jwL_2} = \frac{jwR_2 L_2 (R_2 - jwL_2)}{R_2^2 + (wL_2)^2} \]

\[ = \frac{w^2 L_2^2 R_2 + jwL_2 R_2^2}{R_2^2 + w^2 L_2^2} \]

\[ Z_1 = Z_2 \Rightarrow R_1 = \frac{w^2 L_2^2 R_2}{R_2^2 + w^2 L_2^2} \quad \quad \quad L_1 = \frac{R_2^2 L_1}{R_2^2 + w^2 L_2^2} \]

b) \[ R_2 = 50 \text{ k}\Omega \quad L_2 = 2.5 \text{ H} \quad w = 20 \text{ kr}\text{rad/sec} \]

\[ \Rightarrow R_1 = \frac{(2 \cdot 10^4)^2 (2.5)^2 5 \cdot 10^4}{(5 \cdot 10^4)^2 + (2 \cdot 10^4)^2 (2.5)^2} = \frac{4 \cdot 6.25 \cdot 5 \cdot 10^4}{(5 \cdot 10^4)^2 + (2 \cdot 10^4)^2 (2.5)^2} \]

\[ = \frac{125 \cdot 10^4}{25 + 25} = 25 \text{ k}\Omega \]
\[ L_1 = \frac{(5 \cdot 10^4)^2 \cdot 2.5}{(5 \cdot 10^4)^2 + (2 \cdot 10^4)^2 \cdot (2.5)^2} = \frac{25 \cdot 2.5 \cdot 10^5}{25 \cdot 10^5 + 4 \cdot 0.25 \cdot 10^8} \]

\[ = \frac{62.5}{50} = 1.25 \text{ H} \]

10) Problem 9.14)

![Circuit Diagram]

\[ V_S = 750 \cos 5000t \text{ mV} \quad \text{Equivalent resistance of } R, L, C: \]

\[ Z = 400 + j(5 \cdot 10^3)(4 \cdot 10^{-3}) + \frac{1}{j(5 \cdot 10^3)(0.4 \cdot 10^{-6})} \]

\[ = 400 + j200 - j \frac{1000}{Z} = 400 - j300 = 500/\angle -36.86^\circ \text{ ohm} \]

\[ I_o = \frac{V_S}{Z} = \frac{0.75/0^\circ}{500/\angle -36.86^\circ} = 1.5/\angle 36.86^\circ \text{ mA} \]

\[ \Rightarrow i_o(t) = 1.5 \cos(5000t + 36.86^\circ) \text{ mA} \]
\( V_g = 96 \cos 10000t \text{ V} \)

a) \( Z_1 = 1600 + \frac{1}{j (10^4)(62.5 \cdot 10^{-9})} = 1600 - j1600 \Omega \)

\[
Z_2 = \frac{4000 (j10^4L)}{4000 + j10^4L} = \frac{j16 \cdot 10^4L + 4 \cdot 10^5L^2}{16 + 100L^2}
\]

\[
Z_T = Z_1 + Z_2 = 1600 + \frac{4 \cdot 10^5L^2}{16 + 100L^2} - j1600 + j\frac{16 \cdot 10^4L}{16 + 100L^2}
\]

For \( i_g \) and \( V_g \) to be in phase require \( Z_T \) to be purely resistive \( \Rightarrow \text{Im}(Z_T) = 0 \)

\[
\Rightarrow 1600 = \frac{16 \cdot 10^4L}{16 + 100L^2} \Rightarrow 16 \cdot 10^4L = 25600 + 160000L^2
\]

\[
\Rightarrow 1600L^2 - 1600L + 256 = 0 \Rightarrow 25L^2 - 25L + 4 = 0
\]

\[
A = 625 - 400 = 225 \Rightarrow L_1, L_2 = \frac{25 \pm 15}{50} = 0.8, 0.2 \text{ H}
\]
6) \( L = 0.8 \Omega \Rightarrow Z_T = 1600 + \frac{4 \times 10^5 \cdot 0.6 \mu}{16 + 6 \mu} = 4800 \Omega \)

\[
I_g = \frac{V_g}{Z} = \frac{96 \angle 0^\circ}{4800} = 20 \angle 0^\circ \text{ mA}
\]

\[\Rightarrow i_g = 20 \cos 10000t \text{ mA}\]

\( L = 0.2 \Omega \Rightarrow Z_T = 1600 + \frac{4 \times 10^5 \cdot 0.04}{16 + 4 \mu} = 2400 \Omega \)

\[
I_g = \frac{V_g}{Z} = \frac{96 \angle 0^\circ}{2400} = 40 \angle 0^\circ \text{ mA}
\]

\[\Rightarrow i_g = 40 \cos 10000t \text{ mA}\]