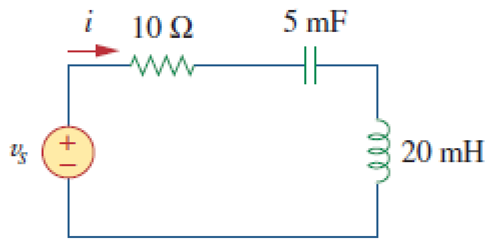
Electric Circuits II – Tutorial 08

#	Student ID	Student Name	Grade (10)
-			

<table>
<tr><td>Q1</td><td>Find current i in the circuit of Fig.   , when
$v_s(t) = 50 \cos 200t$ V.


</td></tr>
<tr><td>Sol 1</td><td>$v_s(t) = 50\cos 200t \longrightarrow V_s = 50 < 0^o, \omega = 200$

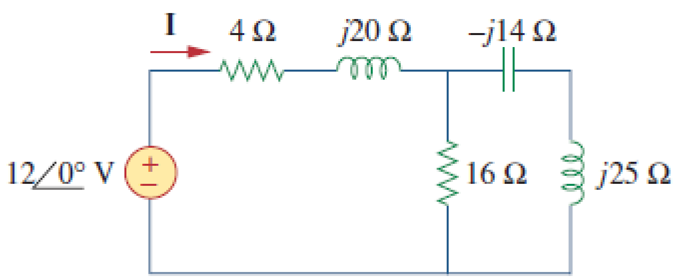
$5mF \longrightarrow \frac{1}{j\omega C} = \frac{1}{j200x5x10^{-3}} = -j$
$20mH \longrightarrow j\omega L = j20x10^{-3}x200 = j4$

$Z_{in} = 10 - j + j4 = 10 + j3$
$I = \frac{V_s}{Z_{in}} = \frac{50 < 0^o}{10 + j3} = 4.789 < -16.7^o$

i(t) = **4.789cos(200t–16.7°) A**</td></tr>
</table>

Q2

For the circuit shown in Fig. , find Z_{eq} and use that to find current **I**. Let $\omega = 10$ rad/s.



Sol 2

$$Z_{eq} = 4 + j20 + 10//(-j14 + j25) = \underline{9.135 + j27.47 \;\; \Omega}$$

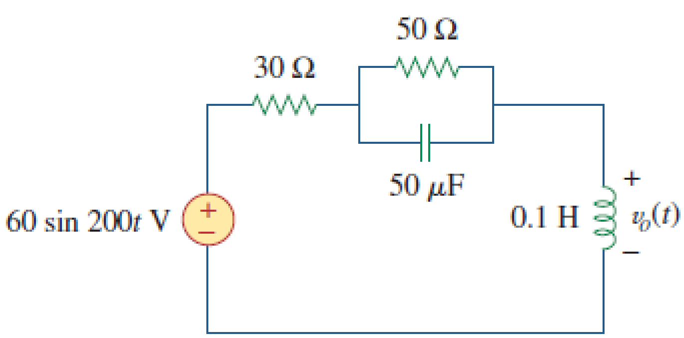
$$= \mathbf{(9.135+j27.47)\ \Omega}$$

$$I = \frac{V}{Z_{eq}} = \frac{12}{9.135 + j27.47} = 0.4145 < -71.605^{o}$$

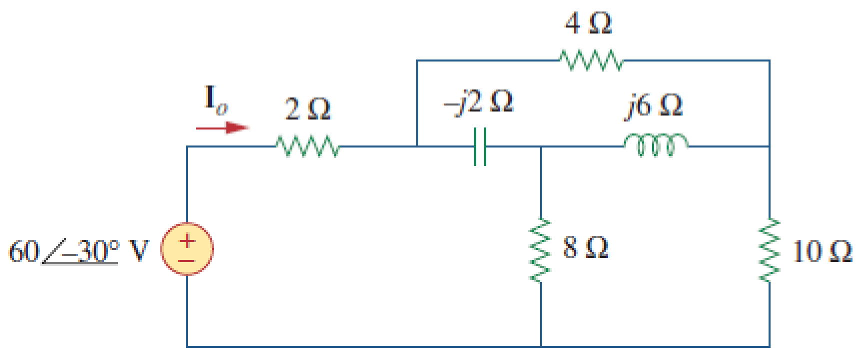
$$i(t) = \mathbf{414.5cos(10t-71.6^{\circ})\ mA}$$

Q3

Calculate $v_o(t)$ in the circuit of Fig.

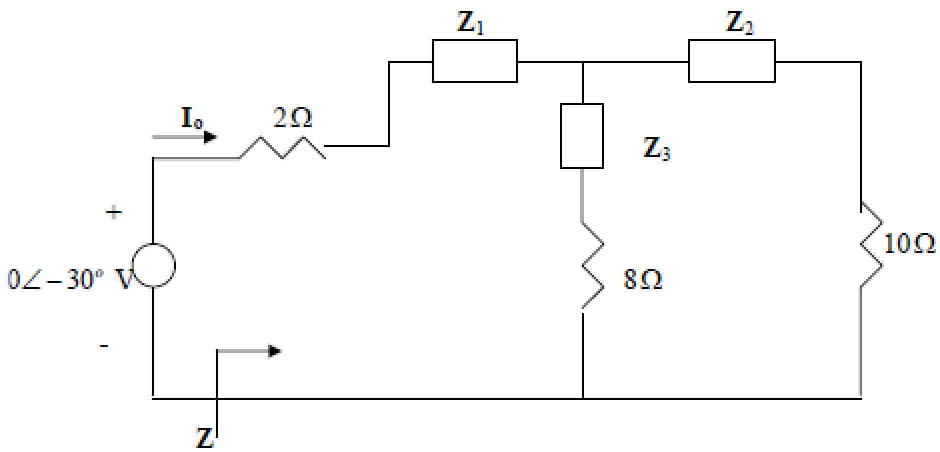


Sol 3	$\omega = 200$ $50\ \mu F \longrightarrow \frac{1}{j\omega C} = \frac{1}{j(200)(50\times 10^{-6})} = -j100$ $0.1\ H \longrightarrow j\omega L = j(200)(0.1) = j20$ $50 \parallel -j100 = \frac{(50)(-j100)}{50 - j100} = \frac{-j100}{1 - j2} = 40 - j20$ $V_o = \frac{j20}{j20 + 30 + 40 - j20}(60\angle 0°) = \frac{j20}{70}(60\angle 0°) = 17.14\angle 90°$ Thus, $v_o(t) = \mathbf{17.14\ sin(200t + 90°)\ V}$ or $v_o(t) = \mathbf{17.14\ cos(200t)\ V}$

Q4	Find I_o in the circuit of Fig. 

Sol 4

Convert the delta to wye subnetwork as shown below.



$$Z_1 = \frac{-j2x4}{4+j4} = \frac{8\angle -90^\circ}{5.6569\angle 45^\circ} = -1 - j1, \qquad Z_2 = \frac{j6x4}{4+j4} = 3 + j3,$$

$$Z_3 = \frac{12}{4+j4} = 1.5 - j1.5$$

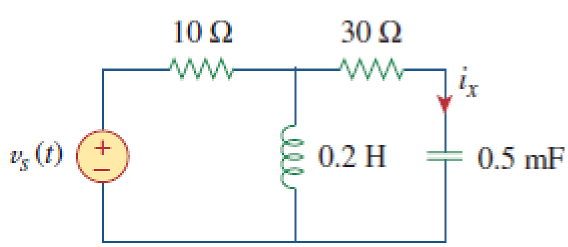
$$(Z_3 + 8)//(Z_2 + 10) = (9.5 - j1.5)//(13 + j3) = 5.691\angle 0.21^\circ = 5.691 + j0.02086$$

$$Z = 2 + Z_1 + 5.691 + j0.02086 = 6.691 - j0.9791$$

$$I_o = \frac{60\angle -30^o}{Z} = \frac{60\angle -30^o}{6.7623\angle -8.33^o} = \underline{8.873\angle -21.67^o \ \ A}$$

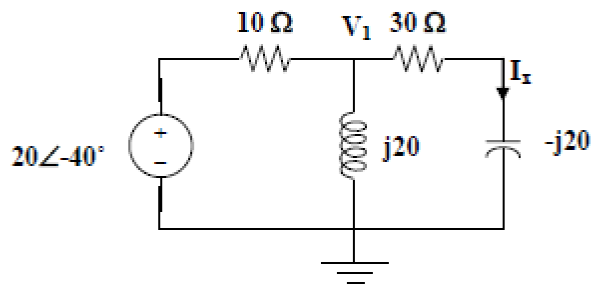
Q5

Given that $v_s(t) = 20\sin(100t - 40^\circ)$ in Fig. determine $i_x(t)$.



Sol 5

Converting the circuit to the frequency domain, we get:



We can solve this using nodal analysis.

$$\frac{V_1 - 20\angle -40^\circ}{10} + \frac{V_1 - 0}{j20} + \frac{V_1 - 0}{30 - j20} = 0$$

$$V_1(0.1 - j0.05 + 0.02307 + j0.01538) = 2\angle -40^\circ$$

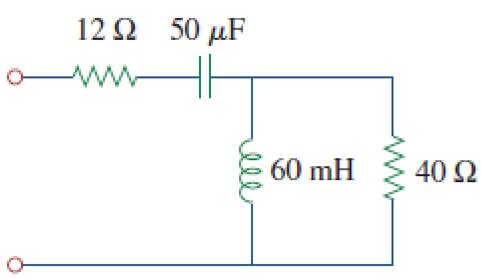
$$V_1 = \frac{2\angle 40^\circ}{0.12307 - j0.03462} = 15.643\angle -24.29^\circ$$

$$I_x = \frac{15.643\angle -24.29^\circ}{30 - j20} = 0.4338\angle 9.4^\circ$$

$$i_x = \underline{0.4338\sin(100t + 9.4^\circ)\ A}$$

Q6

At $\omega = 377$ rad/s, find the input impedance of the circuit shown in Fig.



Sol 6

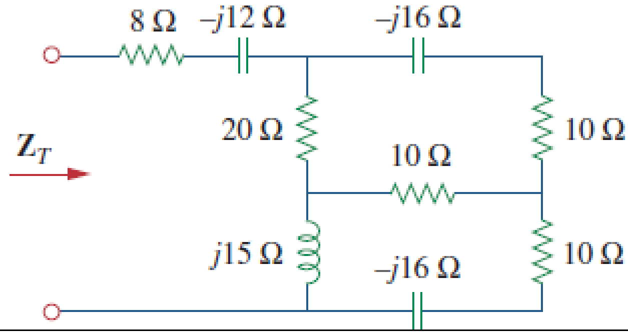
$$50\mu F \longrightarrow \frac{1}{j\omega C} = \frac{1}{j377x50x10^{-6}} = -j53.05$$

$$60mH \longrightarrow j\omega L = j377x60x10^{-3} = j22.62$$

$$Z_{in} = 12 - j53.05 + j22.62 // 40 = \underline{21.692 - j35.91\ \Omega}$$

Q7

For the circuit in Fig. , find the value of $\mathbf{Z}_T$.

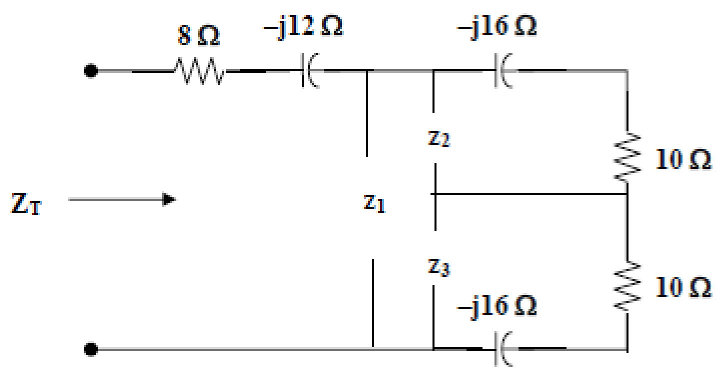


Sol 7

First, replace the wye composed of the 20-ohm, 10-ohm, and j15-ohm impedances with the corresponding delta.

$$z_1 = \frac{200 + j150 + j300}{10} = 20 + j45$$

$$z_2 = \frac{200 + j450}{j15} = 30 - j13.333, \; z_3 = \frac{200 + j450}{20} = 10 + j22.5$$



Now all we need to do is to combine impedances.

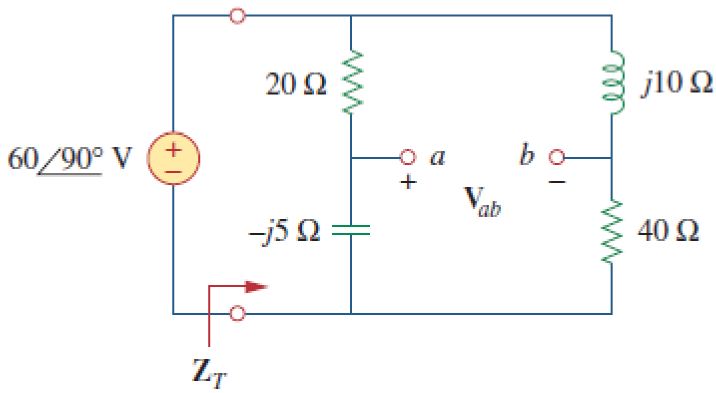
$$z_2 \| (10 - j16) = \frac{(30 - j13.333)(10 - j16)}{40 - j29.33} = 8.721 - j8.938$$

$$z_3 \| (10 - j16) = 21.70 - j3.821$$

$$Z_T = 8 - j12 + z_1 \| (8.721 - j8.938 + 21.7 - j3.821) = \underline{34.69 - j6.93\Omega}$$

Q8

For the circuit in Fig. , calculate $\mathbf{Z}_T$ and $\mathbf{V}_{ab}$.

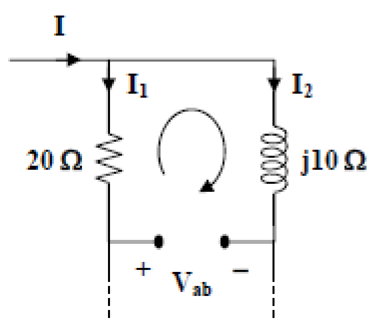


Sol 8

$$\mathbf{Z}_T = (20 - j5) \,||\, (40 + j10) = \frac{(20 - j5)(40 + j10)}{60 + j5} = \frac{170}{145}(12 - j)$$

$$\mathbf{Z}_T = \mathbf{14.069 - j1.172\ \Omega} = 14.118\angle{-4.76^\circ}$$

$$\mathbf{I} = \frac{\mathbf{V}}{\mathbf{Z}_T} = \frac{60\angle 90^\circ}{14.118\angle -4.76^\circ} = 4.25\angle 94.76^\circ$$



$$\mathbf{I}_1 = \frac{40 + j10}{60 + j5}\mathbf{I} = \frac{8 + j2}{12 + j}\mathbf{I}$$

$$\mathbf{I}_2 = \frac{20 - j5}{60 + j5}\mathbf{I} = \frac{4 - j}{12 + j}\mathbf{I}$$

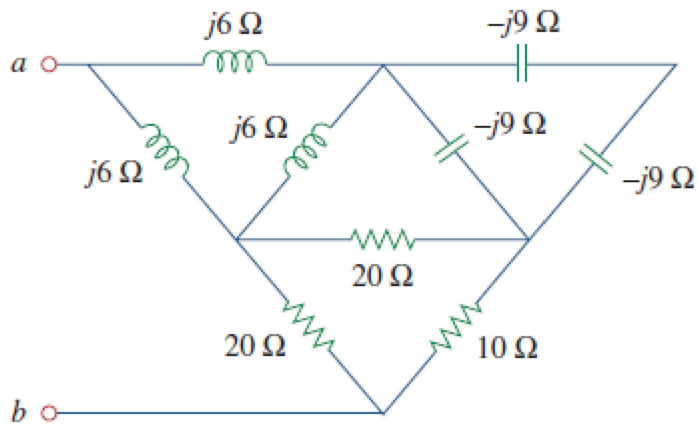
$$\mathbf{V}_{ab} = -20\mathbf{I}_1 + j10\mathbf{I}_2$$

$$\mathbf{V}_{ab} = \frac{-(160 + j40)}{12 + j}\mathbf{I} + \frac{10 + j40}{12 + j}\mathbf{I}$$

$$\mathbf{V}_{ab} = \frac{-150}{12 + j}\mathbf{I} = \frac{(-12 + j)(150)}{145}\mathbf{I}$$

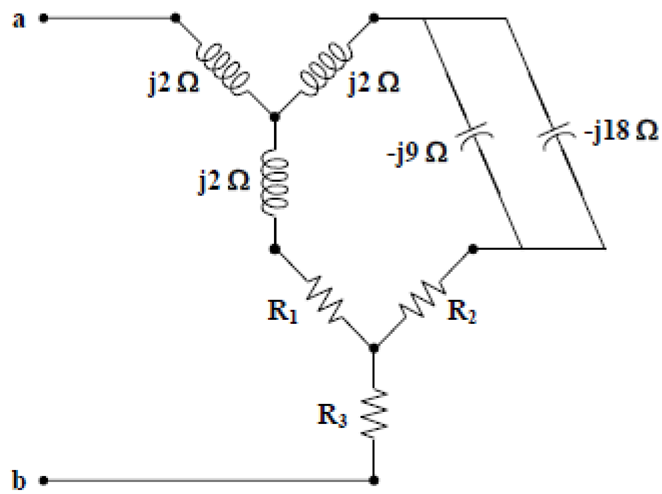
$$\mathbf{V}_{ab} = (12.457\angle 175.24^\circ)(4.25\angle 97.76^\circ)$$

$$\mathbf{V}_{ab} = \mathbf{52.94\angle 273^\circ\ V}$$

Q9	Calculate the value of $\mathbf{Z}_{ab}$ in the network of Fig. 

Sol 9

Transform the delta connections to wye connections as shown below.



$- j9 \| -j18 = -j6,$

$$R_1 = \frac{(20)(20)}{20+20+10} = 8\,\Omega, \qquad R_2 = \frac{(20)(10)}{50} = 4\,\Omega,$$

$$R_3 = \frac{(20)(10)}{50} = 4\,\Omega$$

$$\mathbf{Z}_{ab} = j2 + (j2+8) \,\|\, (j2 - j6 + 4) + 4$$

$$\mathbf{Z}_{ab} = 4 + j2 + (8 + j2) \,\|\, (4 - j4)$$

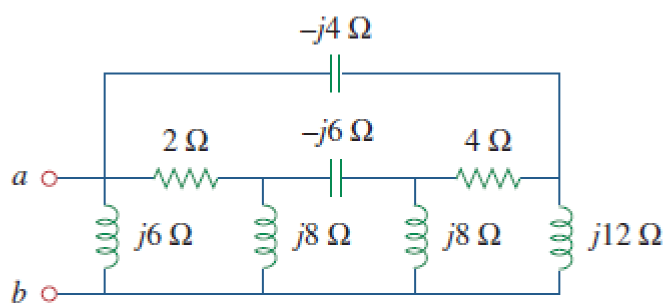
$$\mathbf{Z}_{ab} = 4 + j2 + \frac{(8+j2)(4-j4)}{12 - j2}$$

$$\mathbf{Z}_{ab} = 4 + j2 + 3.567 - j1.4054$$

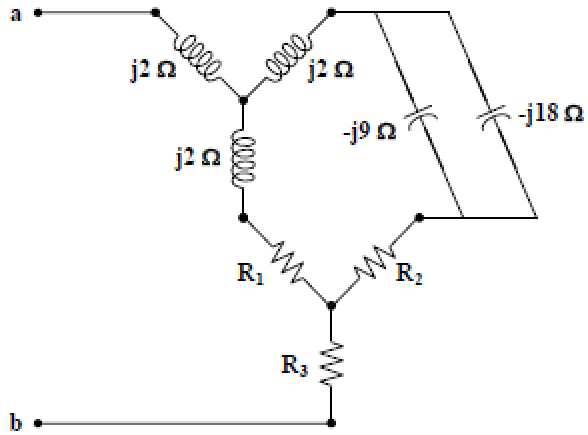
$$\mathbf{Z}_{ab} = \mathbf{(7.567 + j0.5946)\,\Omega}$$

Q10

Determine the equivalent impedance of the circuit in Fig.



Sol 10	Transform the delta connection to a wye connection as in Fig. (a) and then transform the wye connection to a delta connection as in Fig. (b).



$$\mathbf{Z}_1 = \frac{(j8)(-j6)}{j8 + j8 - j6} = \frac{48}{j10} = -j4.8$$

$$\mathbf{Z}_2 = \mathbf{Z}_1 = -j4.8$$

$$\mathbf{Z}_3 = \frac{(j8)(j8)}{j10} = \frac{-64}{j10} = j6.4$$

$$(2 + \mathbf{Z}_1)(4 + \mathbf{Z}_2) + (4 + \mathbf{Z}_2)(\mathbf{Z}_3) + (2 + \mathbf{Z}_1)(\mathbf{Z}_3) = (2 - j4.8)(4 - j4.8) + (4 - j4.8)(j6.4) + (2 - j4.8)(j6.4) = 46.4 + j9.6$$

$$\mathbf{Z}_a = \frac{46.4 + j9.6}{j6.4} = 1.5 - j7.25$$

$$\mathbf{Z}_b = \frac{46.4 + j9.6}{4 - j4.8} = 3.574 + j6.688$$

$$\mathbf{Z}_c = \frac{46.4 + j9.6}{2 - j4.8} = 1.727 + j8.945$$

$$j6 \parallel \mathbf{Z}_b = \frac{(6\angle 90°)(7.583\angle 61.88°)}{3.574 + j12.688} = 07407 + j3.3716$$

$$-j4 \parallel \mathbf{Z}_a = \frac{(-j4)(1.5 - j7.25)}{1.5 - j11.25} = 0.186 - j2.602$$

$$j12 \parallel \mathbf{Z}_c = \frac{(12\angle 90°)(9.11\angle 79.07°)}{1.727 + j20.945} = 0.5634 + j5.1693$$

$$\mathbf{Z}_{eq} = (j6 \parallel \mathbf{Z}_b) \parallel (-j4 \parallel \mathbf{Z}_a + j12 \parallel \mathbf{Z}_c)$$

$$\mathbf{Z}_{eq} = (0.7407 + j3.3716) \parallel (0.7494 + j2.5673)$$

$$\mathbf{Z}_{eq} = 1.508\angle 75.42°\ \Omega = \mathbf{(0.3796 + j1.46)\ \Omega}$$