Chapter 9, Solution 38.

(a) $\frac{1}{6}\text{ F} \longrightarrow \frac{1}{j\omega C} = \frac{1}{j(3)(1/6)} = -j2$

$$\mathbf{I} = \frac{-j2}{4 - j2}(10\angle 45°) = 4.472\angle -18.43°$$

Hence, i(t) = **<u>4.472 cos(3t – 18.43°) A</u>**

$$\mathbf{V} = 4\mathbf{I} = (4)(4.472\angle -18.43°) = 17.89\angle -18.43°$$

Hence, v(t) = **<u>17.89 cos(3t – 18.43°) V</u>**

(b) $\frac{1}{12}\text{ F} \longrightarrow \frac{1}{j\omega C} = \frac{1}{j(4)(1/12)} = -j3$

$3\text{ H} \longrightarrow j\omega L = j(4)(3) = j12$

$$\mathbf{I} = \frac{\mathbf{V}}{\mathbf{Z}} = \frac{50\angle 0°}{4 - j3} = 10\angle 36.87°$$

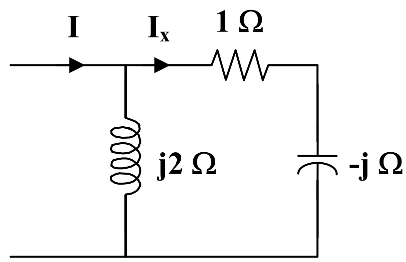
Hence, i(t) = **<u>10 cos(4t + 36.87°) A</u>**

$$\mathbf{V} = \frac{j12}{8 + j12}(50\angle 0°) = 41.6\angle 33.69°$$

Hence, v(t) = **<u>41.6 cos(4t + 33.69°) V</u>**

Chapter 9, Solution 49.

$$\mathbf{Z}_T = 2 + j2 \parallel (1-j) = 2 + \frac{(j2)(1-j)}{1+j} = 4$$



$$\mathbf{I}_x = \frac{j2}{j2+1-j}\mathbf{I} = \frac{j2}{1+j}\mathbf{I}, \qquad \text{where } \mathbf{I}_x = 0.5\angle 0° = \frac{1}{2}$$

$$\mathbf{I} = \frac{1+j}{j2}\mathbf{I}_x = \frac{1+j}{j4}$$

$$\mathbf{V}_s = \mathbf{I}\,\mathbf{Z}_T = \frac{1+j}{j4}(4) = \frac{1+j}{j} = 1-j = 1.414\angle -45°$$

$v_s(t) =$ **1.414 sin(200t – 45°) V**

Chapter 9, Solution 57.

2H $\longrightarrow$ $j\omega L = j2$

1F $\longrightarrow$ $\dfrac{1}{j\omega C} = -j$

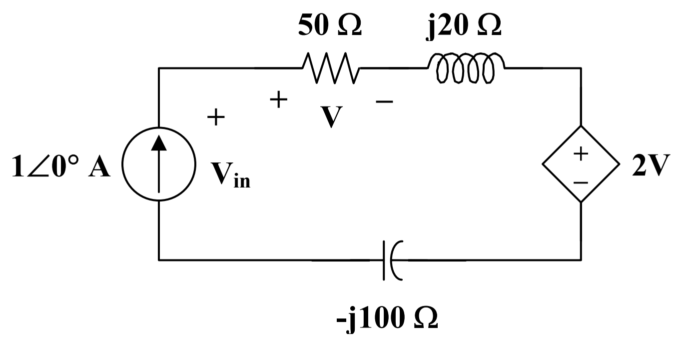
$$Z = 1 + j2 // (2 - j) = 1 + \frac{j2(2 - j)}{j2 + 2 - j} = 2.6 + j1.2$$

$$Y = \frac{1}{Z} = \underline{0.3171 - j0.1463\ \text{S}}$$

Chapter 9, Solution 62.

$$2 \text{ mH} \longrightarrow j\omega L = j(10\times10^{3})(2\times10^{-3}) = j20$$

$$1\ \mu\text{F} \longrightarrow \frac{1}{j\omega C} = \frac{1}{j(10\times10^{3})(1\times10^{-6})} = -j100$$



$$\mathbf{V} = (1\angle0°)(50) = 50$$

$$\mathbf{V}_{in} = (1\angle0°)(50 + j20 - j100) + (2)(50)$$
$$\mathbf{V}_{in} = 50 - j80 + 100 = 150 - j80$$

$$\mathbf{Z}_{in} = \frac{\mathbf{V}_{in}}{1\angle0°} = \underline{\mathbf{150 - j80\ \Omega}}$$

Chapter 9, Solution 64.

$$Z_T = 4 + \frac{-j10(6+j8)}{6-j2} = \underline{19 - j5\Omega}$$

$$I = \frac{30\angle 90°}{Z_T} = -0.3866 + j1.4767 = \underline{1.527\angle 104.7°\,A}$$

Chapter 9, Solution 67.

(a) 20 mH $\longrightarrow$ $j\omega L = j(10^3)(20\times10^{-3}) = j20$

12.5 μF $\longrightarrow$ $\dfrac{1}{j\omega C} = \dfrac{1}{j(10^3)(12.5\times10^{-6})} = -j80$

$$\mathbf{Z}_{in} = 60 + j20 \,||\, (60 - j80)$$

$$\mathbf{Z}_{in} = 60 + \frac{(j20)(60 - j80)}{60 - j60}$$

$$\mathbf{Z}_{in} = 63.33 + j23.33 = 67.494\angle 20.22°$$

$$\mathbf{Y}_{in} = \frac{1}{\mathbf{Z}_{in}} = \underline{\mathbf{14.8\angle -20.22°\ mS}}$$

(b) 10 mH $\longrightarrow$ $j\omega L = j(10^3)(10\times10^{-3}) = j10$

20 μF $\longrightarrow$ $\dfrac{1}{j\omega C} = \dfrac{1}{j(10^3)(20\times10^{-6})} = -j50$

$30 \,||\, 60 = 20$

$$\mathbf{Z}_{in} = -j50 + 20 \,||\, (40 + j10)$$

$$\mathbf{Z}_{in} = -j50 + \frac{(20)(40 + j10)}{60 + j10}$$

$$\mathbf{Z}_{in} = 13.5 - j48.92 = 50.75\angle -74.56°$$

$$\mathbf{Y}_{in} = \frac{1}{\mathbf{Z}_{in}} = \underline{\mathbf{19.7\angle 74.56°\ mS}} = 5.24 + j18.99\text{ mS}$$

Chapter 9, Solution 68.

$$\mathbf{Y}_{eq} = \frac{1}{5 - j2} + \frac{1}{3 + j} + \frac{1}{-j4}$$

$$\mathbf{Y}_{eq} = (0.1724 + j0.069) + (0.3 - j0.1) + (j0.25)$$

$$\mathbf{Y}_{eq} = \underline{\mathbf{0.4724 + j0.219\ S}}$$

Chapter 9, Solution 77.

(a) $$\mathbf{V}_o = \frac{-jX_c}{R - jX_c}\mathbf{V}_i$$

where $$X_c = \frac{1}{\omega C} = \frac{1}{(2\pi)(2\times 10^6)(20\times 10^{-9})} = 3.979$$

$$\frac{\mathbf{V}_o}{\mathbf{V}_i} = \frac{-j3.979}{5 - j3.979} = \frac{3.979}{\sqrt{5^2 + 3.979^2}}\angle(-90° + \tan^{-1}(3.979/5))$$

$$\frac{\mathbf{V}_o}{\mathbf{V}_i} = \frac{3.979}{\sqrt{25 + 15.83}}\angle(-90° - 38.51°)$$

$$\frac{\mathbf{V}_o}{\mathbf{V}_i} = 0.6227\angle -51.49°$$

Therefore, the phase shift is **51.49° lagging**

(b) $$\theta = -45° = -90° + \tan^{-1}(X_c/R)$$

$$45° = \tan^{-1}(X_c/R) \longrightarrow R = X_c = \frac{1}{\omega C}$$

$$\omega = 2\pi f = \frac{1}{RC}$$

$$f = \frac{1}{2\pi RC} = \frac{1}{(2\pi)(5)(20\times 10^{-9})} = \mathbf{1.5915\ MHz}$$

Chapter 9, Solution 90.

Let $\mathbf{V}_s = 145\angle 0°$, $X = \omega L = (2\pi)(60)L = 377L$

$$\mathbf{I} = \frac{\mathbf{V}_s}{80 + R + jX} = \frac{145\angle 0°}{80 + R + jX}$$

$$\mathbf{V}_1 = 80\,\mathbf{I} = \frac{(80)(145)}{80 + R + jX}$$

$$50 = \left| \frac{(80)(145)}{80 + R + jX} \right| \qquad (1)$$

$$\mathbf{V}_o = (R + jX)\,\mathbf{I} = \frac{(R + jX)(145\angle 0°)}{80 + R + jX}$$

$$110 = \left| \frac{(R + jX)(145)}{80 + R + jX} \right| \qquad (2)$$

From (1) and (2),

$$\frac{50}{110} = \frac{80}{|R + jX|}$$

$$|R + jX| = (80)\left(\frac{11}{5}\right)$$

$$R^2 + X^2 = 30976 \qquad (3)$$

From (1),

$$|80 + R + jX| = \frac{(80)(145)}{50} = 232$$

$$6400 + 160R + R^2 + X^2 = 53824$$

$$160R + R^2 + X^2 = 47424 \qquad (4)$$

Subtracting (3) from (4),

$$160R = 16448 \longrightarrow R = \underline{\mathbf{102.8\ \Omega}}$$

From (3),

$$X^2 = 30976 - 10568 = 20408$$

$$X = 142.86 = 377L \longrightarrow L = \underline{\mathbf{0.3789\ H}}$$

Chapter 9, Solution 91.

$$\mathbf{Z}_{in} = \frac{1}{j\omega C} + R \parallel j\omega L$$

$$\mathbf{Z}_{in} = \frac{-j}{\omega C} + \frac{j\omega LR}{R + j\omega L}$$

$$= \frac{-j}{\omega C} + \frac{\omega^2 L^2 R + j\omega LR^2}{R^2 + \omega^2 L^2}$$

To have a resistive impedance, $\mathrm{Im}(\mathbf{Z}_{in}) = 0$.
Hence,

$$\frac{-1}{\omega C} + \frac{\omega LR^2}{R^2 + \omega^2 L^2} = 0$$

$$\frac{1}{\omega C} = \frac{\omega LR^2}{R^2 + \omega^2 L^2}$$

$$C = \frac{R^2 + \omega^2 L^2}{\omega^2 LR^2}$$

where $\omega = 2\pi f = 2\pi \times 10^7$

$$C = \frac{9 \times 10^4 + (4\pi^2 \times 10^{14})(400 \times 10^{-12})}{(4\pi^2 \times 10^{14})(20 \times 10^{-6})(9 \times 10^4)}$$

$$C = \frac{9 + 16\pi^2}{72\pi^2}\ \text{nF}$$

C = **235 pF**

Chapter 9, Solution 92.

(a) $Z_o = \sqrt{\frac{Z}{Y}} = \sqrt{\frac{100\angle 75^o}{450\angle 48^o x 10^{-6}}} = \underline{471.4\angle 13.5^o\,\Omega}$

(b) $\gamma = \sqrt{ZY} = \sqrt{100\angle 75^o x 450\angle 48^o x 10^{-6}} = \underline{0.2121\angle 61.5^o}$

Chapter 9, Solution 93.

$$\mathbf{Z} = \mathbf{Z}_s + 2\mathbf{Z}_\ell + \mathbf{Z}_L$$
$$\mathbf{Z} = (1 + 0.8 + 23.2) + j(0.5 + 0.6 + 18.9)$$
$$\mathbf{Z} = 25 + j20$$

$$\mathbf{I}_L = \frac{\mathbf{V}_S}{\mathbf{Z}} = \frac{115\angle 0°}{32.02\angle 38.66°}$$
$$\mathbf{I}_L = \underline{\mathbf{3.592\angle\text{-}38.66°\ A}}$$

Chapter 14, Solution 46.

(a) This is an RLC series circuit.

$$\omega_o = \frac{1}{\sqrt{LC}} \longrightarrow C = \frac{1}{\omega^2{}_o L} = \frac{1}{(2\pi x 15 x 10^3)^2 x 10 x 10^{-3}} = \underline{11.26 nF}$$

(b) $Z = R$, $I = V/Z = 120/20 =$ **6 A**

(c) $$Q = \frac{\omega_o L}{R} = \frac{2\pi x 15 x 10^3 x 10 x 10^{-3}}{20} = 15\pi = \underline{47.12}$$

Chapter 14, Solution 48.

$$\mathbf{H}(\omega) = \frac{R \parallel \dfrac{1}{j\omega C}}{j\omega L + R \parallel \dfrac{1}{j\omega C}}$$

$$\mathbf{H}(\omega) = \frac{\dfrac{R/j\omega C}{R + 1/j\omega C}}{j\omega L + \dfrac{R/j\omega C}{R + 1/j\omega C}}$$

$$\mathbf{H}(\omega) = \underline{\frac{\mathbf{R}}{\mathbf{R + j\omega L - \omega^2 RLC}}}$$

$H(0) = 1$ and $H(\infty) = 0$ showing that **<u>this circuit is a lowpass filter</u>**.

Chapter 14, Solution 50.

$$\mathbf{H}(\omega) = \frac{\mathbf{V}_o}{\mathbf{V}_i} = \frac{j\omega L}{R + j\omega L}$$

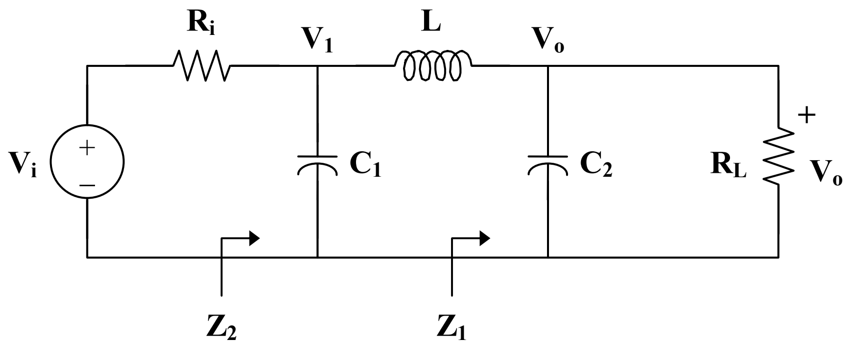
$H(0) = 0$ and $H(\infty) = 1$ showing that **<u>this circuit is a highpass filter</u>**.

$$\mathbf{H}(\omega_c) = \frac{1}{\sqrt{2}} = \frac{1}{\sqrt{1 + \left(\frac{R}{\omega_c L}\right)^2}} \longrightarrow 1 = \frac{R}{\omega_c L}$$

or $\quad \omega_c = \dfrac{R}{L} = 2\pi f_c$

$$f_c = \frac{1}{2\pi} \cdot \frac{R}{L} = \frac{1}{2\pi} \cdot \frac{200}{0.1} = \underline{\mathbf{318.3\ Hz}}$$

Chapter 14, Solution 97.



$$\mathbf{Z} = sL \parallel \left(R_L + \frac{1}{sC_2} \right) = \frac{sL\,(R_L + 1/sC_2)}{R_L + sL + 1/sC_2}, \qquad s = j\omega$$

$$\mathbf{V}_1 = \frac{\mathbf{Z}}{\mathbf{Z} + R_i + 1/sC_1}\mathbf{V}_i$$

$$\mathbf{V}_o = \frac{R_L}{R_L + 1/sC_2}\mathbf{V}_1 = \frac{R_L}{R_L + 1/sC_2} \cdot \frac{\mathbf{Z}}{\mathbf{Z} + R_i + 1/sC_1}\mathbf{V}_i$$

$$\mathbf{H}(\omega) = \frac{\mathbf{V}_o}{\mathbf{V}_i} = \frac{R_L}{R_L + 1/sC_2} \cdot \frac{sL\,(R_L + 1/sC_2)}{sL\,(R_L + 1/sC_2) + (R_i + 1/sC_1)(R_L + sL + 1/sC_2)}$$

$$\mathbf{H}(\omega) = \frac{\mathbf{s^3 L R_L C_1 C_2}}{\mathbf{(sR_i C_1 + 1)(s^2 L C_2 + sR_L C_2 + 1) + s^2 L C_1 (sR_L C_2 + 1)}}$$

where $s = j\omega$.

Chapter 14, Solution 98.

$$B = \omega_2 - \omega_1 = 2\pi(f_2 - f_1) = 2\pi(454 - 432) = 44\pi$$

$$\omega_0 = 2\pi f_0 = QB = (20)(44\pi)$$

$$f_0 = \frac{(20)(44\pi)}{2\pi} = (20)(22) = \underline{\mathbf{440\ Hz}}$$

Chapter 14, Solution 100.

$$\omega_c = 2\pi f_c = \frac{1}{RC}$$

$$R = \frac{1}{2\pi f_c C} = \frac{1}{(2\pi)(20\times 10^3)(0.5\times 10^{-6})} = \underline{\mathbf{15.91\,\Omega}}$$

Chapter 14, Solution 102.

(a) When $R_s = 0$ and $R_L = \infty$, we have a low-pass filter.

$$\omega_c = 2\pi f_c = \frac{1}{RC}$$

$$f_c = \frac{1}{2\pi RC} = \frac{1}{(2\pi)(4\times 10^3)(40\times 10^{-9})} = \underline{\mathbf{994.7\ Hz}}$$

(b) We obtain R_{Th} across the capacitor.

$$R_{Th} = R_L \,||\, (R + R_s)$$

$$R_{Th} = 5 \,||\, (4+1) = 2.5\ k\Omega$$

$$f_c = \frac{1}{2\pi R_{Th} C} = \frac{1}{(2\pi)(2.5\times 10^3)(40\times 10^{-9})}$$

$$f_c = \underline{\mathbf{1.59\ kHz}}$$

Chapter 14, Solution 103.

$$\mathbf{H}(\omega) = \frac{\mathbf{V}_o}{\mathbf{V}_i} = \frac{R_2}{R_2 + R_1 \parallel 1/j\omega C}, \qquad s = j\omega$$

$$\mathbf{H}(s) = \frac{R_2}{R_2 + \dfrac{R_1(1/sC)}{R_1 + 1/sC}} = \frac{R_2\,(R_1 + 1/sC)}{R_1 R_2 + (R_1 + R_2)(1/sC)}$$

$$\mathbf{H}(s) = \underline{\frac{R_2(1 + sCR_1)}{R_1 + R_2 + sCR_1R_2}}$$