Problem 1:

a) For the circuit in the above figure, is it a balanced or unbalanced three-phase system? Explain why.

b) Find $I_0$

[a] The circuit is unbalanced, because the impedance in each phase of the load is not the same.

[b] $I_{aA} = \frac{240/0^\circ}{10 + j30} = 2.4 - j7.2$ A

$I_{bB} = \frac{240/120^\circ}{20 + j20} = 2.2 + j8.2$ A

$I_{cC} = \frac{240/-120^\circ}{20 - j40} = 2.96 - j4.48$ A

$I_o = I_{aA} + I_{bB} + I_{cC} = 7.55 - j3.48 = 8.32/\theta_24.75^\circ$ A
Problem 2:

The above figure shows a balanced three-phase $\Delta$-connected source.

a) Find the Y-connected equivalent circuit.

b) Show that the Y-connected equivalent circuit delivers the same open-circuit voltage as the original $\Delta$-connected source.

c) Apply an external short circuit to the terminals A, B, and C. Use the $\Delta$-connected source to find the three line currents $I_a, I_b,$ and $I_c$.

d) Repeat (c) but use the Y-equivalent source to find the three line currents.
Answer P2:

[a] Since the phase sequence is acb (negative) we have:

\[ V_{an} = 7200/30^\circ \text{ V} \]
\[ V_{bn} = 7200/150^\circ \text{ V} \]
\[ V_{cn} = 7200/-90^\circ \text{ V} \]

\[ Z_Y = \frac{1}{3}Z_\Delta = 1.8 + j9.0 \Omega/\phi \]

\[ 7200/30^\circ \text{ V} \]
\[ 7200/150^\circ \text{ V} \]
\[ 7200/-90^\circ \text{ V} \]

[b] \[ V_{ab} = 7200/30^\circ - 7200/150^\circ = 7200\sqrt{3}/0^\circ \text{ V} \]
Since the phase sequence is negative, it follows that
\[ V_{bc} = 7200\sqrt{3}/120^\circ \text{ V} \]

[c]

\[ I_{ba} = \frac{7200\sqrt{3}}{5.4 + j27} = 452.91/-78.69^\circ \text{ A} \]
\[ I_{ac} = \frac{7200\sqrt{3}/-120^\circ}{5.4 + j27} = 452.91/-198.69^\circ \text{ A} \]

\[ I_{aA} = I_{ba} - I_{ac} = 784.46/-48.69^\circ \text{ A} \]

Since we have a balanced three-phase circuit and a negative phase sequence we have:

\[ I_{bB} = 784.46/71.31^\circ \text{ A} \]

\[ I_{cC} = 784.46/-168.69^\circ \text{ A} \]

\[ I_{aA} = \frac{7200/30^\circ}{1.8 + j9} = 784.46/48.69^\circ \text{ A} \]
Problem 3:

The Δ-connected source of Problem 2 is connected to a Y-connected load by means of a balanced three-phase distribution line. The load impedance is 957+j259 Ω per phase. And the line impedance is 1.2+j12 Ω per phase.

a) Construct a single-phase equivalent circuit of the system.

b) Determine the magnitude of the line voltage at the terminals of the load.

c) Determine the magnitude of the phase current in the Δ-source.

d) Determine the magnitude of the line voltage at the terminals of the source.

\[ \text{[a]} \]

\[ \begin{align*}
\text{[b]} & \quad I_{aA} = \frac{7200/30^\circ}{960 + j280} = \frac{7.2}{13.74^\circ} \text{ A} \\
& \quad V_{AN} = (957 + j259)(7.2/13.74^\circ) = 7138.28/28.88^\circ \text{ V} \\
& \quad |V_{AB}| = \sqrt{3}(7138.28) = 12363.87 \text{ V} \\
\text{[c]} & \quad |I_{ba}| = \frac{7.2}{\sqrt{3}} = 4.16 \text{ A} \\
\text{[d]} & \quad V_{an} = (958.2 + j271)(7.20/13.74^\circ) = 7169.65/29.54^\circ \text{ V} \\
& \quad |V_{ab}| = \sqrt{3}(7169.65) = 12418.20 \text{ V}
\end{align*} \]
Problem 4:

A three-phase positive sequence Y-connected source supplies 14kVA with a power factor of 0.75 lagging to a parallel combination of a Y-connected load and a Δ-connected load. The Y-connected load used 9 kVA at a power factor of 0.6 lagging and has an a-phase current of $10\angle-30^\circ$ A.

a) Find the complex power per phase of the Δ-connected load.
b) Find the magnitude of the line voltage.

\[ a] \quad S_{T\Delta} = 14,000/41.41^\circ - 9000/53.13^\circ = 5.5/22^\circ \text{ kVA} \]
\[ S_{\Delta} = S_{T\Delta}/3 = 1833.46/22^\circ \text{ VA} \]

\[ b] \quad |V_{an}| = \frac{3000/53.13^\circ}{10/-30^\circ} = 300 \text{ V(rms)} \]
\[ |V_{line}| = |V_{ab}| = \sqrt{3}|V_{an}| = 300\sqrt{3} = 519.62 \text{ V(rms)} \]