1. a.
Kirchoff’s Current Law at $X$:
\[
\frac{4-V_x}{4} + \frac{(-2)-V_x}{12} + \frac{V_y-V_x}{2} = 0
\]
Kirchoff’s Current Law at $Y$:
\[
\frac{V_x-V_y}{2} - \frac{V_y}{5} - 1 + \frac{(-15-V_y)}{20} + 7 = 0
\]

1. b.
Matrix Equation:
\[
\begin{pmatrix}
-5/6 & 1/2 \\
1/2 & -3/4
\end{pmatrix}
\begin{pmatrix}
V_x \\
V_y
\end{pmatrix}
= \begin{pmatrix}
-5/6 \\
-25/4
\end{pmatrix}
\]
Solve by Cramer’s Rule:
\[
\Delta = (-5/6)(-3/4) - (1/2)(1/2) = 3/8
\]
\[
V_x = \frac{1}{\Delta}\det\begin{pmatrix}
5/6 & 1/2 \\
-25/4 & -3/4
\end{pmatrix} = 10
\]
\[
V_y = \frac{1}{\Delta}\det\begin{pmatrix}
-5/6 & -5/6 \\
1/2 & -25/4
\end{pmatrix} = 15
\]
\[
V_x = +10\text{V}, \quad V_y = +15\text{V}
\]
1. c.

Transformations: (Box X):

\[
\begin{align*}
4V & \quad \rightarrow \quad +1\Omega A \\
2V & \quad \rightarrow \quad -1/6A 12\Omega
\end{align*}
\]

Thevenin Equivalent: (Box X):
Transformations: (Box $Y$):

\[ 5/6A \quad \frac{3\Omega}{2.5V} \quad 3\Omega \]

\[ 20\Omega \]

\[ -15V \quad \rightarrow \quad -3/4A \]

\[ 20\Omega \]

\[ -3/4A \quad \frac{20\Omega}{5\Omega} \quad 7A \quad \rightarrow \quad 6.25A \quad \frac{4\Omega}{6.25A} \]
Thevenin Equivalent: (Box $Y$):

\[ 6.25A \quad 4\Omega \quad 25V \]

Transformed Circuit (with solution):

\[ V_X = 2.5 + 3(2.5) = 10 \]
\[ V_Y = 25 - 4(2.5) = 15 \]

1. d.

Power is

\[ P = (4)^2/13 + 6^2/4 + 12^2/12 + 5^2/2 + 15^2/5 + 30^2/20 + 7^2/37 = 1937.731W \]

2. a.

\[ Z_T = 1/(1/(25/4) + 1/(-j25/3)) = 25/(4 + j3) = 4 - j3\Omega \]
2. b.
Optimum load is $Z_{L}^{opt} = (Z_T)^{*} = 4 + j3\Omega$

2. c.
Composite load $Z_L + Z_T = (4 - j3) + (4 + j3) = 8 + j0\Omega$ so $I = 4/(8 + j0) = 0.5$ ARMS. Power dissipated in resistive part of load is $(1/2)^2 \cdot 4 = 1.0 W$.

3. a.
The ideal op-amp rule $V_{in}(+) = V_{in}(-) = V_{out}/2$ by the resistive divider formula for the two $1.0 k\Omega$ resistors. Therefore the overall gain is $V_{out}/V_{in} = +2$. A gain of two is $6$ dB and the circuit is NON-INVERTING.

3. b.
The output voltage is independent of a load resistor from $V_{out}$ to ground, as seen by the solution above. Therefore the output voltage is not reduced by any finite load impedance and so the output impedance is $0\Omega$.

3. c.
No current flows into the terminal $V_{in}(-)$ for an ideal op-amp. Thus the input impedance $= V_{in}/I_{in} = \infty\Omega$.