PROBLEM 1 (5 points each)

(a) State the voltage divider rule:
\[ V_L = \frac{R_L}{R_1 + R_2} \cdot V \]

(b) State the Maximum Power Transfer Theorem:
\[ V_{in} \quad \text{Max Power to } R_L \quad \text{when } R_L = R_{\text{th}} \]

(c) A circuit analyzed via mesh analysis yielded the following system of equations. Find mesh current \( i_2 \).
\[
\begin{bmatrix}
10 \\
-20 \\
20
\end{bmatrix} =
\begin{bmatrix}
7 & 9 & 2 \\
0 & -10 & 0 \\
2 & 0 & 30
\end{bmatrix}
\begin{bmatrix}
i_1 \\
i_2 \\
i_3
\end{bmatrix}
\]

\[ i_2 = \frac{2}{a} \quad \text{units are required} \]

(d) A circuit analyzed using nodal yields the nodal matrix shown. Is it possible to determine by examining the matrix whether or not the circuit contain controlled sources? Why or why not?
\[
\begin{bmatrix}
10 \\
0 \\
-10
\end{bmatrix} =
\begin{bmatrix}
5 & -3 & -7 \\
-3 & 10 & -12 \\
-7 & -10 & 15
\end{bmatrix}
\begin{bmatrix}
V_1 \\
V_2 \\
V_3
\end{bmatrix}
\]

Answer: Matrix is not symmetric. Controlled sources are present.
Two electric circuits are connected as shown with voltage and current as indicated.

For each of the following sets of numerical values, state whether power is flowing from A to B or from B to A. (5 points each)

| Voltage $v$  | Current $i$  | Power Flow: A → B or B → A?
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a) $v = 120$ Volts</td>
<td>$i = 5$ Amps</td>
<td>A → B</td>
</tr>
<tr>
<td>b) $v = 250$ Volts</td>
<td>$i = -8$ Amps</td>
<td>B → A</td>
</tr>
<tr>
<td>c) $v = -150$ Volts</td>
<td>$i = 16$ Amps</td>
<td>B → A</td>
</tr>
<tr>
<td>d) $v = -480$ Volts</td>
<td>$i = -10$ Amps</td>
<td>A → B</td>
</tr>
</tbody>
</table>
PROBLEM 3 (20 points)

For the circuit shown with the nodes numbered as given write the **nodal equations**. Express your answer by completing the matrix provided.

\[
\begin{bmatrix}
5 \\
3 \\
0 \\
-20
\end{bmatrix}
= 
\begin{bmatrix}
\frac{1}{2} + \frac{1}{3} & -\frac{1}{2} & 0 & -\frac{1}{3} \\
-\frac{1}{2} & \frac{1}{2} + \frac{1}{4} & 0 & 0 \\
0 & 0 & -1 + \frac{2}{3} & 1 \\
0 & 0 & 0 & 1
\end{bmatrix}
\begin{bmatrix}
V_1 \\
V_2 \\
V_3 \\
V_4
\end{bmatrix}
\]

\*
\* \quad V_4 - V_3 = 4 I_y \quad I_y = -\frac{V_3}{6}
\*
\* \quad 0 = -(-1 + \frac{2}{3})V_3 + V_4
\*
PROBLEM 4 (20 points)

For the circuit shown with the mesh currents indicated write the **mesh equations**. Express your answer by completing the matrix below.

\[
\begin{bmatrix}
10 & 10 & 0 & 0 \\
10 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 \\
\end{bmatrix}
\begin{bmatrix}
i_1 \\
i_2 \\
i_3 \\
i_4 \\
\end{bmatrix}
= 
\begin{bmatrix}
15 & 25 & -15 & -5 \\
-1 & 1 & 0 & 0 \\
0 & -15 & 60 & -20 \\
5 & -5 & -20 & 45 \\
\end{bmatrix}
\begin{bmatrix}
i_1 \\
i_2 \\
i_3 \\
i_4 \\
\end{bmatrix}
\]

\[I_x = -i_1\]
\[i_2 - i_1 = 10\]

Super mesh
\[10 = 10i_1 + (-5i_1) + 5(i_2 - i_4) + 15(i_2 - i_3) + 5i_2\]
PROBLEM 5 (20 points)

For the circuit below, $R_0$ is adjusted so that it absorbs maximum power. What is the value of $R_0$?

Max. power when
\[ R_0 = R_{Th} \]

Only $R_{Th}$ need be found.

\[ V_1 = V \]
\[ V_1 - V_3 = \frac{3}{10} V \]
\[ V_3 = \frac{3}{10} V \]

\[ I = \frac{V_2 - V_3 + V_2 - V_1 + V_2}{20} \]
\[ = \frac{1}{2} (1 - \frac{3}{10}) V + (1 - 1) V + \frac{V}{20} \]
\[ = \frac{8}{20} V \]

\[ R_{Th} = \frac{20}{8} \Omega = \frac{5}{2} \]

I have abided by the University Honor Code:

Signature

END OF EXAM

EXAM GRADE:

Test 1 - Version A