This exam corresponds to learning objective 1.

Solve the following problems. The number of points for each problem is shown in the table below.

Use only the space provided to solve each problem, and copy the answers to the space marked "Answer:..." Do not forget to specify units.

Show all the steps of your solution. Final answers alone will not be considered.

Non-integer answers can be written as $a/b$ or as $c.d$ where $d$ can be rounded to 2-3 digits.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>/ 40</td>
</tr>
<tr>
<td>2</td>
<td>/ 40</td>
</tr>
<tr>
<td>3</td>
<td>/ 20</td>
</tr>
<tr>
<td>Total</td>
<td>/ 100</td>
</tr>
</tbody>
</table>
Problem 1

In the following circuit, \( r_m = 1 \Omega \). Answer the questions below with respect to the circuit.

(a) Define variables for *nodal* analysis as learned in class. Mark the variables on the circuit.

(10 points) Answer (Variables only): \( V_1 \)

(b) Using the variables you defined in part (a), write equations for *nodal* analysis as learned in class. Do not simplify the equations for this part.

(10 points) Answer (Equations):

\[
\frac{V_1 - 2}{1} + \frac{V_1 + I_2}{1} + \frac{V_1 - 1}{1} = 0
\]

\[
I_2 = \frac{2 - 1}{2} + \frac{V_1 - 1}{1}
\]
(c) Solve the equations you wrote in part (b).

\[
\begin{align*}
V_1 - 2 + V_1 + I_2 + V_1 - 1 &= 0 \\
I_2 &= 0.5 + V_1 - 1 = V_1 - 0.5 \\
3V_1 + I_2 - 3 &= 0 \\
3V_1 + V_1 - 0.5 - 3 &= 0 \\
4V_1 &= 3.5 \\
V_1 &= 0.875V
\end{align*}
\]

(10 points) Answer (Values): \( V_1 = 0.875V \)

(d) If \( I_2 \) is not one of the variables you defined, compute its value. If you already computed it, simply copy its value to the space below.

\[
I_2 = V_1 - 0.5 = 0.375A
\]

(10 points) Answer: \( I_2 = 0.375A \)
Problem 2

Answer the questions below with respect to the following circuit.

(a) Define variables for loop analysis as learned in class. Mark the variables on the circuit.

(10 points) Answer (Variables only): \( I_1, I_2 \)

(b) Using the variables you defined in part (a), write equations for loop analysis as learned in class. Do not simplify the equations for this part.

(10 points) Answer (Equations):

\[
20I_1 + 80(I_1 - I_2) - 21 = 0 \\
80I_2 + 24 + 80(I_2 - I_1) = 0
\]
(c) Solve the equations you wrote in part (b).

\[ 100I_1 - 80I_2 = 21 \]
\[ -80I_1 + 160I_2 = -24 \]

\[ 120I_1 = 18 \]
\[ I_1 = 0.15A \]
\[ I_2 = \frac{100I_1 - 21}{80} = -0.075A \]

(10 points) Answer (Values): \( I_1 = 0.15A, I_2 = -0.075A \)

(d) If \( V_a \) is not one of the variables you defined, compute its value. If you already computed it, simply copy its value to the space below.

\[ V_a = 80(I_1 - I_2) = 18V \]

(10 points) Answer: \( V_a = 18V \)
Problem 3

For the following circuit, use the superposition property to find $v_{out}$ in terms of $v_{s1}$ and $v_{s2}$.

$$v_{s2} = 0:$$
$$\frac{1}{\frac{1}{180} + \frac{1}{90}} = 60\Omega$$
$$\frac{1}{\frac{1}{360} + \frac{1}{720}} = 240\Omega$$
$$v_{out} = \frac{v_{s1}}{60+240} \cdot 240 = 0.8v_{s1}$$

$$v_{s1} = 0:$$
$$\frac{1}{\frac{1}{180} + \frac{1}{360}} = 120\Omega$$
$$\frac{1}{\frac{1}{90} + \frac{1}{720}} = 80\Omega$$
$$v_{out} = -\frac{v_{s2}}{120+80} \cdot 80 = -0.4v_{s2}$$

(20 points) Answer: $v_{out} = 0.8v_{s1} - 0.4v_{s2}$