Mid-Term EXAM

Name: _______________________

Perm #: _______________________

Section Time/Day: _______________________

You have 75 MINUTES to complete this exam. A one-page note sheet is allowed, otherwise there should be no books or other materials in your purview. You may use a calculator. Be sure that your name appears prominently and legibly on the front page. The exam is worth 100 points total.

IMPORTANT POINTS FOR GRADING:

SHOW ALL WORK. ANSWERS GIVEN WITHOUT CLEAR SUPPORTING EVIDENCE OF INDEPENDENT WORK WILL BE IGNORED.

WRITE ANSWERS IN THE DESIGNATED SPACES, OR CIRCLE ANSWERS IF NECESSARY. ANY RESULTS NOT CLEARLY MARKED AS YOUR FINAL ANSWER WILL BE IGNORED. MULTIPLE ANSWERS WILL ALSO BE IGNORED.

BE NEAT. ILLEGIBLE OR SLOPPY WORK WILL NOT BE CONSIDERED FOR MERIT.
Problem 1

(15 points total: 5 pts each part)

For the resistive circuit above, find:

a) The equivalent resistance as seen by the current source: \( R_{eq} = \frac{2667}{\Omega} \)

b) The voltage across the current source, \( V_S \): \( V_S = \frac{5}{\Omega} \) V

\[ V_S = (3 \text{mA})(2667 \Omega) = 8 \text{V} \]

c) The power delivered by the source: \( P = 0.024 \) Watt

\[ P = (3 \text{mA})(8 \text{V}) = 24 \text{mW} = 0.024 \text{W} \]
Problem 2

(15 points total: 5 pts each part)

(a) Use voltage division to compute the voltage at the non-inverting input of the op-amp.

\[
\frac{V_p}{A \sin(\omega t)} = \frac{2k}{2k + 1k} \rightarrow V_p = \frac{2}{3} A \sin(\omega t)
\]

(b) Calculate the output voltage \( V_{out} \).

\[
\frac{V_o}{V_{out}} = \frac{1k}{1k + 2k} \rightarrow V_{out} = 3V_n = 3V_p
\]

\[
V_{out} = 2A \sin(\omega t)
\]

(c) What is the maximum value of \( A \) such that the output signal \( V_{out} \) is not distorted?

\[
2A_{max} = 3V \rightarrow A_{max} = \frac{3}{2} \sqrt{2} V
\]
Problem 3

(20 points total: 15 for correct node equations, 5 for solution of equations)

Find $V_o$ in the circuit below using nodal analysis:

\[
\begin{align*}
\text{At } V_1: & \quad \frac{V_1 - 4}{2} + \frac{V_1 - V_o}{6} + \frac{V_1 - \left(\frac{4 - V_1}{2}\right)}{3} = 0 \\
\text{At } V_o: & \quad \frac{V_o - V_1}{6} - 1 + \frac{V_o}{2} = 0 \\
& \quad V_o - V_1 - 6 + 3V_o = 0 \\
& \quad 4V_o - V_1 = 6 \Rightarrow 3V_o - 4V_1 = 24 \Rightarrow \frac{15V_o}{28} = 24 \Rightarrow V_o = \frac{56}{15} \text{V} \\
& \quad \boxed{V_o = \frac{56}{15} \text{V}}
\end{align*}
\]
Problem 4

(15 points total: 10 for part a, 5 for part b)

For the circuit above, do the following:

(a) Use basic source transformations to replace everything to the left of the 1kΩ resistor by a Thevenin equivalent. Draw the schematic of the resulting circuit with appropriate value labels on each component:

(b) Use your result of (a) to find \( v \): \( v = \frac{0.75}{1.5} \) V

\[ V = \frac{1k\Omega}{1k\Omega + 1k\Omega} \rightarrow V = 0.75 \text{V} \]
Problem 5

(20 points total: 15 for correct mesh equations, 5 for solution of equations)

Find the current $i$ in the circuit below using mesh analysis:

$$i = i_2 \quad \text{and} \quad i_1 = 2A$$

**Loop 2:**

$$-6V + (2A - i_2)(1\Omega) + (i_3 - i_2)(3\Omega) = 0$$

$$-4i_2 + 3i_3 = 4A \quad (1)$$

**Loop 3:**

$$(i_2 - i_3)(3) + (2 - i_3)(1) - i_3(2) = 0$$

$$3i_2 - 6i_3 = -2 \quad (2)$$

$$-8i_2 + 6i_3 = 5$$

$$-5i_2 = 6 \quad \Rightarrow \quad i = \frac{-6}{5}A \quad (i = i_2)$$
Short Answer Questions
(5 points each)

6) For the 6V voltage supply in Problem 5, circle whichever of the following is TRUE, and explain your reasoning.
   
   a) The voltage supply absorbs power from the circuit
   b) The voltage supply supplies power to the circuit

7) Find the supply current I by current-divider rules: $I = \frac{9 \text{ mA}}{2}$

   $i_2 = \frac{1}{2}i_1 = 3 \text{ mA}$
   $I = 6 \text{ mA} + 3 \text{ mA} = 9 \text{ mA}$

8) Find the current $i_{\text{out}}$ below: $i_{\text{out}} = \frac{4 \text{ A}}{2}$

   $i = 2 \text{ A}$
   $i_{\text{out}} = \frac{(2 \times 2 \times 2)}{1 \Omega} = 4 \text{ A}$