Exam 2A
November 12, 2003

ECE 221: Electric Circuits
Dr. McNames

- Write the first letter in your last name, your 6-digit identification number, and your student identification number below.
- Do not open the exam until instructed to do so.
- Do not use separate scratch paper. If you need more space, use the backs of the exam pages and write a note directing my attention to these pages.
- You will have 100 minutes to complete the exam.
- If you have extra time, double check your answers.
- Remember to include units with each of your answers.

Problem 1:_____ / 10
Problem 2:_____ / 14
Problem 3:_____ / 14
Problem 3:_____ / 12

Total:_____ / 50

First Letter in Last Name:_____________
6-Digit Identification Number:_____________
Student Identification Number:_____________
1. Fundamental Concepts of Capacitors and Inductors (10 pts)

a. (2 pts) Solve for the equivalent capacitance of the circuit below.

\[ C_{eq} = \hspace{1cm} \]

b. (1 pt) What is the DC resistance of the circuit shown in part a?

\[ R_{eq} = \hspace{1cm} \]

c. (2 pts) Solve for the equivalent inductance of the circuit below.

\[ L_{eq} = \hspace{1cm} \]

d. (1 pt) What is the DC resistance of the circuit shown in part c?

\[ R_{eq} = \hspace{1cm} \]
1. Fundamental Concepts of Capacitors and Inductors Continued (10 pts)

e. (2 pts) What is the DC resistance between the terminals in the circuit shown below?

\[ R_{eq} = \text{_________} \]

f. (2 pts) Solve for the voltage shown in the circuit below.

\[ v = \text{_________} \]
2. **Node Voltage Method & Supernodes (14 pts)**

![Circuit Diagram](image)

a. (9 pts) Use the node-voltage method to write three independent equations in terms of the node voltages $v_1$, $v_2$, and $v_3$. Do not use any other variables in your equations. If appropriate, use a supernode. Do not simplify your equations.

Eq. 1:

Eq. 2:

Eq. 3:

b. (3 pts) Solve for the node voltages $v_1$, $v_2$, and $v_3$.

$v_1 = \quad v_2 = \quad v_3 =$

c. (1 pt) Which resistors have no effect on the node voltages?

2 kΩ 3 kΩ 4 kΩ 5 kΩ 7 kΩ 12 kΩ

d. (1 pt) What would the node voltages be if the voltage source was replaced with an open circuit?

$v_1 = \quad v_2 = \quad v_3 =$
3. Thevenin Equivalents, Norton Equivalents, and Superposition (14 pts)
Use the circuit below to answer the following questions. For partial credit, draw the appropriate circuit for each question.

\[ \text{a. (2 pts) Find the Thevenin/Norton equivalent resistance of the circuit.} \]

\[ R_{eq} = \boxed{} \]

\[ \text{b. (1 pt) Suppose a resistor } R_L \text{ is connected to the nodes } a \text{ and } b. \text{ What value of } R_L \text{ will maximize the power delivered to } R_L? \]

\[ R_L = \boxed{} \]

\[ \text{c. (2 pts) Use superposition to find the current that flows from terminal } a \text{ to } b \text{ when the terminals are connected (short-circuit) due to the voltage source acting alone.} \]

\[ I_{scv} = \boxed{} \]

\[ \text{d. (2 pts) User superposition to find the current that flows from terminal } a \text{ to } b \text{ when the terminals are connected (short-circuit) due to the current source acting alone.} \]

\[ I_{sci} = \boxed{} \]

\[ \text{e. (1 pt) Find the Norton equivalent current.} \]

\[ I_N = \boxed{} \]
3. Thevenin Equivalents, Norton Equivalents, and Superposition Continued (14 pts)
The circuit on the previous page is repeated below for your convenience.

![Circuit Diagram]

f. (1 pt) If the direction of the current source was reversed, what would the Norton equivalent current be? Hint: linearity.

\[ I_N = \quad \text{________} \]

g. (1 pt) Find the Thevenin equivalent voltage.

\[ V_{Th} = \quad \text{________} \]

h. (1 pt) Suppose the resistor \( R_L \) from part b. is connected to the nodes \( a \) and \( b \). What is the power that will be dissipated by \( R_L \)?

\[ P_L = \quad \text{________} \]

i. (3 pts) Draw \textbf{both} the Thevenin \textbf{and} Norton equivalents of the circuit as seen from the nodes \( a \) and \( b \). Clearly label these nodes.
4. **Operational Amplifiers (12 points)**

Use the circuit below to answer the following questions. The op amp is ideal.

![Circuit Diagram]

a. (1 pt) Solve for $v_a$.

$v_a = \underline{\hspace{2cm}}$

b. (1 pt) Solve for $v_b$.

$v_b = \underline{\hspace{2cm}}$

c. (1 pt) Solve for $v_o$.

$v_o = \underline{\hspace{2cm}}$

d. (1 pt) Solve for $i_o$.

$i_o = \underline{\hspace{2cm}}$
4. Operational Amplifiers Continued (12 points)
Use the circuit below to answer the following questions. The op amps in the circuit are ideal. For partial credit, include algebraic expressions for each answer next to the corresponding question. Each expression may include variables listed in earlier questions.

![Circuit Diagram]

e. (2 pts) Circle the resistors that have no effect on voltages in the circuit diagram above.

f. (1 pt) Find $v_1$.

$$v_1 =$$

\[v_1 = \text{expression}\]

g. (1 pt) Find $v_2$.

$$v_2 =$$

\[v_2 = \text{expression}\]

h. (1 pt) Find $v_3$.

$$v_3 =$$

\[v_3 = \text{expression}\]

i. (1 pt) Find $v_4$.

$$v_4 =$$

\[v_4 = \text{expression}\]

j. (1 pt) Find $v_5$.

$$v_5 =$$

\[v_5 = \text{expression}\]

k. (1 pt) Find $v_o$.

$$v_o =$$

\[v_o = \text{expression}\]