Exam 1A Solutions
October 20, 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:______ / 10
Problem 3:______ / 15
Problem 4:______ / 15

Total:______ / 50

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

Use the circuit diagram shown above to answer the following questions. Assume that the circuit elements listed in the possible answers below have **finite, non-zero values**. Some of the questions have multiple answers.

a. (1 pt) As labeled, is the circuit element producing power?
   - Yes
   - No
   - Can’t Tell

b. (1 pt) If $v = 5 \text{ V}$ and $i = -2 \text{ mA}$, is the passive sign convention satisfied?
   - Yes
   - No
   - Can’t Tell

c. (1 pt) If $v = -5 \text{ V}$ and $i = -2 \text{ mA}$, is the passive sign convention satisfied?
   - Yes
   - No
   - Can’t Tell

d. (1 pt) If $v = -2 \text{ V}$ and $i = 5 \text{ mA}$, which of the following circuit elements could the circuit element possibly be?
   - Current Source
   - Voltage Source
   - Resistor

e. (1 pt) If $v = 3 \text{ V}$ and $i = 7 \text{ mA}$, which of the following circuit elements could the circuit element possibly be?
   - Current Source
   - Voltage Source
   - Resistor

f. (1 pt) If $v = 0 \text{ V}$ and $i = -7 \text{ mA}$, which of the following circuit elements could the circuit element possibly be?
   - Current Source
   - Voltage Source
   - Resistor

g. (1 pt) If $v = -12 \text{ V}$ and $i = 0 \text{ A}$, which of the following circuit elements could the circuit element possibly be?
   - Current Source
   - Voltage Source
   - Resistor

h. (1 pt) Which of the following circuit elements can either absorb or dissipate power?
   - Current Source
   - Voltage Source
   - Resistor

i. (1 pt) Which of the following circuit elements can in general be safely connected in series with another circuit element of the same type? Do not make any assumptions about the circuit element’s value.
   - Current Source
   - Voltage Source
   - Resistor

j. (1 pt) Which of the following circuit elements can in general be safely connected in parallel with another circuit element of the same type? Do not make any assumptions about the circuit element’s value.
   - Current Source
   - Voltage Source
   - Resistor
2. Resistive Networks (10 pts)
Find the equivalent resistance of the circuits shown below.

a. (2 pts)

\[ R_{eq} = 1 \, kΩ + \left[ 6k \parallel 5k \parallel 7k \parallel (4k + 2k) \right] \]

\[ R_{eq} = 2.479 \, kΩ \]

b. (2 pts)

\[ R_{eq} = 3k + \left[ 3k \parallel \left( 3k + \left[ 3k \parallel 3k \parallel (3k + 3k) \right] \right) \right] + 3k \]

\[ R_{eq} = 8.118 \, kΩ \]

c. (2 pts)

\[ R_{eq} = (2k + 2k) \parallel \left( 4k + \left[ 5k \parallel (4k + 3k + 1k) \right] \right) \]

\[ R_{eq} = 2.556 \, kΩ \]
2. Resistive Networks Continued (10 pts)
Find the equivalent resistance of the circuits shown below.

(d) (2 pts)

\[ R_{eq} = \left( \left( \frac{1}{2k} + \frac{1}{4k} \right) \parallel \frac{1}{2k} \right) \parallel \frac{1}{3k} \]

\[ R_{eq} = 4.00 \, \text{k}\Omega \]

Wye-to-Delta Transform

\[ R_{eq} = \left[ \left( \frac{1}{4k} + \frac{1}{12k} \right) \parallel \frac{1}{4k} \right] \parallel \frac{1}{12k} \]

\[ R_{eq} = 4.00 \, \text{k}\Omega \]

e. (2 pts)

\[ R_{eq} = 0.00 \, \Omega \]
3. Mesh Current Method (15 pts)

(a) (10 pts) Use the mesh-current method to write three independent equations in terms of the currents \(i_1, i_2,\) and \(i_3.\) Do not use any other variables in your equations. If appropriate, use a supermesh. Do not simplify your equations.

Eq. 1: \[500(i_3 - i_2) + 7k \cdot i_1 + 2k(i_2 - i_3) + 5k \cdot i_2 = 0\]

Eq. 2: \[i_2 - i_1 = 2m\]

Eq. 3: \[2(i_3 - i_2) + 4k \cdot i_3 + 14 = 0\]

(b) (3 pts) Solve for the currents \(i_1, i_2,\) and \(i_3.\)

\[i_1 = -1.192 \text{ mA} \quad \quad i_2 = 0.8077 \text{ mA} \quad \quad i_3 = -2.064 \text{ mA}\]

(c) (1 pt) How much power is being absorbed by the dependent source?

\[P_{500} = 500i_\alpha \cdot i_1 = 500(i_3 - i_2) \cdot i_1 = 1.712 \text{ mW}\]

d. (1 pt) How much power is being dissipated by the 5k\(\Omega\) resistor?

\[P_{5k} = 5k(i_2)^2 = 3.262 \text{ mW}\]
4. Node Voltage Method & Supernodes (15 pts)

![Circuit Diagram]

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: \[-0.3 \left( \frac{v_3 - v_1}{2k} \right) + \frac{v_2}{2k} + \frac{v_2}{5k} = 0\]

Eq. 2: \[0.3 \left( \frac{v_3 - v_1}{2k} \right) + \frac{v_1}{7k} + \frac{v_1 - v_3}{2k} = 0\]

Eq. 3: \[\frac{v_3}{4k} + \frac{v_3 - v_1}{2k} + \frac{24 + v_3}{4k} = 0\]

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

$v_1 = -6.067 \text{ V}$  
$v_2 = -0.5778 \text{ V}$  
$v_3 = -9.303 \text{ V}$

c. (1 pt) What is $i_a$?

$i_a = \frac{v_3 - v_1}{2k} = -1.348 \text{ mA}$

d. (1 pt) How much power is absorbed by the 24 V source?

$p_{24} = \left( \frac{-v_3 - 24}{4k} \right) \cdot 24 = -88.18 \text{ mW}$

e. (1 pt) How much power is absorbed by the dependent source?

$p_{ds} = \left( -17k \cdot 0.3i_a + v_1 - v_2 \right) \cdot (0.3i_a) = -0.3428 \text{ mW}$