Final Exam  
December 7, 2000  

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 begin the exam or look at the problems until instructed to do so.  
- You have 100 minutes to complete the exam.  
- Once you begin, write your student ID at the top of each page.  
- Do not use separate scratch paper. If you need more space, use the backs of the exam pages.  
- If you have extra time, double check your answers. If you run out of time, write the equations that can be used to help solve the problem for partial credit.  

Problem 1: ______ / 14  
Problem 2: ______ / 11  
Problem 3: ______ / 15  
Problem 4: ______ / 15  

Total: ______ / 55  

First Letter in Last Name: ____________  
6-Digit Identification Number: ____________  
Student Identification Number: ____________
1. Passive Sign Convention & Dot Conventions (14 pts)
Use the passive sign convention and the dot conventions to write expressions for the voltage ($v$), current ($i$), power absorbed ($p$), or energy stored ($w$), as specified by each of the problems below.

a. (2 pts)
\[ v_1 = \quad v_2 = \]

b. (2 pts)
\[ v_1 = \quad v_2 = \]

c. (2 pts)
\[ v_2/v_1 = \quad i_2/i_1 = \]

d. (2 pts)
\[ v_2/v_1 = \quad i_2/i_1 = \]

e. (2 pts)
\[ i = \quad w = \]

f. (2 pts)
\[ v = \quad p = \]

g. (2 pts)
\[ v = \quad p = \]
2. Nodal Analysis (11 points)

a. (4 pts) Write an expression for the node labeled $V_1$ using the node-voltage method. You do not need to simplify your expression.

Equation:

b. (2 pts) Solve for the phasor voltage $V_1$.

$$V_1 = \text{_______________ V (rms)}$$

c. (2 pts) The frequency of all the voltage sources is 60 Hz. Write the time-domain expression for $v_1(t)$ below.

$$v_1(t) = \text{___________________________________ V}$$

d. (1 pt) How much average power is absorbed by the capacitor?

$$P_C = \text{_______________ W}$$

e. (2 pts) How much average complex power is produced by the 40 V source?

$$S_{40} = \text{_______________________ VA}$$
3. Ideal Transformers & Power Factor Correction (15 pts)

![Diagram of power system with transformers and impedances](image)

a. (1 pt) What is the impedance reflected into the primary (left) side of the transformer from the secondary (right) side?

\[ Z_R = \text{_______________} \ \Omega \]

b. (1 pt) What is the phasor current \( I_1 \)?

\[ I_1 = \text{_______________} \ \text{A (rms)} \]

c. (1 pt) How much total average power is absorbed by the line & transformer?

\[ P_L = \text{_______________} \ \text{W} \]

d. (1 pt) What is the phasor current \( I_2 \)?

\[ I_2 = \text{_______________} \ \text{A (rms)} \]

e. (1 pt) How much total average power is absorbed by the load?

\[ P_L = \text{_______________} \ \text{W} \]

f. (1 pt) What is the power factor of the load?

\[ \text{pf} = \text{_______________} \]

g. (1 pt) What is the capacitive reactance that, when connected in parallel with the load, will make the load look purely resistive?

\[ X_C = \text{_______________} \ \Omega \]

h. (1 pt) What is the equivalent resistance of the load in parallel with the capacitive reactance?

\[ R_{eq} = \text{_______________} \ \Omega \]
3. Ideal Transformers & Power Factor Correction Continued (15 pts)
The figure from the previous page is repeated below for convenience.

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i. (1 pt) What is the power factor of the corrected load? Note: if you can not answer the previous question, use $R_{eq} = 30 \, \Omega$ to answer the remaining questions.

$\text{pf} = \underline{\phantom{0000}}$

j. (1 pt) What is the impedance reflected into the primary (left) side of the transformer from the secondary (right) side with the corrected load in place?

$Z_R = \underline{\phantom{0000}} \, \Omega$

k. (1 pt) What is the phasor current $I_1$ with the corrected load in place?

$I_1 = \underline{\phantom{0000}} \, \text{A (rms)}$

l. (1 pt) How much total power is absorbed by the transmission line & transformer with the corrected load?

$P_L = \underline{\phantom{0000}} \, \text{W}$

m. (1 pt) How much does the corrected load reduce the power loss in the line & transformer?

$R_p = \underline{\phantom{0000}} \, \%$

n. (1 pt) What is the phasor current $I_2$ with the corrected load in place?

$I_2 = \underline{\phantom{0000}} \, \text{A (rms)}$

o. (1 pt) How much total average power is absorbed by the load with the corrected load in place?

$P_L = \underline{\phantom{0000}} \, \text{W}$
4. Operational Amplifiers (15 pts)

Your answers to the following questions should include the voltage $V_s$ and should not include the voltages $V_a$, $V_b$, $V_c$, or $V_d$, or the currents $I_3$, $I_X$, $I_s$, or $I_4$, unless otherwise specified. However, you will receive partial credit if your answer includes these terms and is correct. Simplify your expressions as much as possible.

a. (1 pt) Write an expression for $V_a$.

$$V_a = \text{______________}$$

b. (2 pts) Write an expression for $V_b$.

$$V_b = \text{______________}$$

c. (1 pt) Write an expression for $V_c$.

$$V_c = \text{______________}$$

d. (2 pts) Write an expression for $I_3$. Hint: use your previous answers.

$$I_3 = \text{______________}$$

e. (1 pt) Write an expression for $I_X$. Hint: use your previous answer.

$$I_X = \text{______________}$$

f. (2 pts) Write an expression for $V_d$. Hint: use your previous answer.

$$V_d = \text{______________}$$
4. Operational Amplifiers Continued (15 pts)

The circuit from the previous page is repeated below for your convenience. Remember that your answers to the following questions **should include** $V_s$ and **should not include** the voltages $V_a$, $V_b$, $V_c$, or $V_d$, or the currents $I_3$, $I_X$, $I_s$, or $I_4$, unless otherwise specified.

![Circuit Diagram]

- **g.** (2 pts) Write an expression for $I_4$. Hint: use your previous answer.

  \[ I_4 = \text{______________} \]

- **h.** (1 pt) Write an expression for $I_4$. Your answer should not include $V_s$ and should include $I_s$.

  \[ I_4 = \text{______________} \]

- **i.** (2 pts) What is the equivalent impedance seen by the voltage source? Your answer should not include $V_s$ or $I_s$. Hint: use your previous answers.

  \[ Z_s = \text{______________} \]

- **j.** (1 pt) What type of circuit element does this equivalent impedance resemble? Circle one.

  - Resistor
  - Inductor
  - Capacitor
  - Linear Transformer