Final Exam B
March 17, 2003

ECE 222: Signals and Systems
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.
• You are not allowed to use a calculator during this exam.

Problem 1:______ / 12
Problem 2:______ / 17
Problem 3:______ / 11
Problem 4:______ / 10

Total:______ / 50

First Letter in Last Name:_____________

6-Digit Identification Number:_____________

Student Identification Number:_____________
1. Fundamental Concepts (12 pts)

Circle the appropriate answers to the multiple choice questions below. Note that some questions may have more than one correct answer that must be circled.

a. (1 pt) If a circuit contains 2 independent sources, what methods of analysis can we use?
   - Two-Port Network
   - Transfer Function
   - Convolution
   - Laplace Transform
   - Circuit
   - None

b. (1 pt) If a signal has finite energy \( E_\infty < \infty \), what do you know about its power?
   - \( P_\infty = 0 \)
   - \( P_\infty = \infty \)
   - Nothing

c. (1 pt) What is the magnitude of \( x(t) = \exp(-j500\omega t) \)?
   - \(|x(t)| = \) _______________

d. (1 pt) What type of symmetry does the following signal have? \( x(t) = u(t) - 0.5 \).
   - Even
   - Odd
   - None

e. (1 pt) What properties do all memoryless systems have?
   - Invertible
   - Causal
   - Stable
   - Linear
   - Time-Invariant

f. (1 pt) For circuits consisting solely of resistors, inductors, and capacitors, what must be true before the circuit is linear and time invariant?

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g. (1 pt) Which filter has the least amount of ripple in the stopband and passband?
   - Butterworth
   - Elliptic
   - Chebyshev I
   - Chebyshev II

h. (1 pt) For a set of specifications, which filter is generally the least expensive to build?
   - Butterworth
   - Elliptic
   - Chebyshev I
   - Chebyshev II

i. (1 pt) For a practical set of filter specifications, which of the lowpass filters might have a steady-state error to a constant input signal?
   - Butterworth
   - Elliptic
   - Chebyshev I
   - Chebyshev II

j. (1 pt) Which types of 4th-order filters could a series RLC circuit be used to implement?
   - Lowpass
   - Highpass
   - Bandpass
   - Bandstop
   - Notch
   - None

k. (1 pt) Which of the practical filters is Q defined for?
   - Lowpass
   - Highpass
   - Bandpass
   - Bandstop
   - Notch

l. (1 pt) What property must two filters, \( H(s) \) and \( G(s) \), have in order for the transfer function of the cascade of the filters to be \( H(s)G(s) \)?

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2. Bode Plots (17 points)

Use the following transfer function to answer the questions below.

\[ H(s) = 10^6 \frac{s(s + 1)}{(s + 10)^2 (s + 100)^2} \]

a. (2 pts) Convert the transfer function to standard form.

\[ H(s) = \]

b. (9 pts) Draw the straight-line approximation of amplitude and phase due to the gain, zeros, and poles with dashed lines in the plots below. Note double zeros/poles at the same location with “×2”.

c. (6 pts) Draw the straight-line approximation of the bode plot magnitude and phase with solid lines in the plots below.
3. Filters and Bode Plot Analysis (11 points)
The straight-line approximation and true bode plot of an LTI system are shown below. All of the poles and zeros are real.

a. (1 pt) What type of filter is this? (Circle one)
   Lowpass    Highpass    Bandpass    Bandstop    Notch    None

b. (1 pt) What is the maximum gain of this circuit? Express as raw gain, not dB.
   \[ H_{\text{max}} = \]

c. (1 pt) What is the cutoff frequency? If the circuit is a bandpass or bandstop filter, list both cutoff frequencies. Hint: use the real bode plot to answer this question.
   \[ \omega_c = \]

d. (1 pt) What is the steady-state response to a step input, \( x(t) = u(t) \)?
   \[ \lim_{t \to \infty} y(t) = \]

e. (2 pts) List all of the poles. Hint: all of the poles are in the left-half of the s plane.

f. (2 pts) List all of the zeros.

g. (1 pt) How many zeros are in the right half of the s plane?
   \[ n = \]

h. (1 pt) What is the order of this circuit? (Circle one)
   Zero    One    Two    Three    Four    Five    Six

i. (1 pt) What is the final value of the impulse response?
   \[ h(\infty) = \]
4. Transfer Functions and Circuit Analysis (10 pts)

Use the circuit shown below to answer the following questions. You may assume that the inductor is initially uncharged. Simplify your answers as much as possible.

\[ V_1(t) \]
\[ R_1 \]
\[ C \]
\[ i_1(t) \rightarrow \]
\[ i_2(t) \]
\[ R_2 \]
\[ v_1(t) \]
\[ v_2(t) \]

a. (2 pts) Find the transfer function \( H(s) = \frac{V_2(s)}{V_1(s)} \). Simplify your expression as much as possible.

\[ H(s) = \]

b. (1 pt) Given that \( v_1(t) = 5 \text{ V} \), solve for \( v_2(t) \).

\[ v_2(t) = \]

c. (1 pt) What type of filter is this? (Circle one)

Lowpass  Highpass  Bandpass  Bandstop  Notch  None

d. (1 pt) What is the order of this circuit? (Circle one)

Zero  One  Two  Three  Four  Five  Six

e. (1 pt) What is the maximum gain of this circuit?

\[ H_{\text{max}} = \]

f. (1 pt) At what frequency does the filter achieve this maximum gain?

\[ \omega_{\text{max}} = \]

g. (1 pt) What is the cutoff frequency? If the circuit is a bandpass or bandstop filter, list both cutoff frequencies.

\[ \omega_c = \]

h. (1 pt) What is the two-port inverse hybrid parameter \( g_{12} \)?

\[ g_{12} = \]

i. (1 pt) What is the two-port impedance parameter \( z_{21} \)?

\[ z_{21} = \]