Exam 2
February 21, 2000

ECE 222: Signals and Systems
Dr. McNames

- Write your 6-digit identification number and student identification numbers 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 and make sure you have all the pages.
- 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 relevant equations that can be used to help solve the problem and a note describing your approach.

Problem 1: _____ / 15
Problem 2: _____ / 20
Problem 3: _____ / 20

Total: _____ / 55

6-Digit Identification Number: _____________

Student Identification Number: _____________
1. Convolution (15 Points)
Consider a linear time-invariant system with the impulse response $h(t) = e^{-t}u(t)$ for the questions below.

![Diagram of x(t) → H \( (s) \) → y(t)]

a. (1 pt) Find the output of the system when the input is a unit impulse, $x(t) = \delta(t)$.

\[ y(t) = \]

b. (1 pt) Find the output of the system by convolution for $t \leq 0$.

\[ y(t) = \]

c. (1 pt) Find the output of the system by convolution for $0 \leq t \leq 1$.

\[ y(t) = \]

d. (3 pts) Find the output of the system by convolution for $1 \leq t \leq 2$.

\[ y(t) = \]
e. (4 pts) Find the output of the system by convolution for \( 2 \leq t \leq 3 \).

\[ y(t) = \]

f. (4 pts) Find the output of the system by convolution for \( 3 \leq t \leq 4 \).

\[ y(t) = \]

g. (1 pt) Find the output of the system by convolution for \( 4 \leq t \).

\[ y(t) = \]
2. **Bode Plots (20 points)**

Use the following transfer function to answer the questions below.

\[ H(s) = \frac{(s + 10)(s + 100)^2}{10s^2(s + 1,000)} \]

a. (4 pts) Convert the transfer function to standard form.

\[ H(s) = \]

b. (10 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 multiple poles and zeros at the same location with the note “x2” near the corresponding lines.

c. (6 pts) Draw the straight-line approximation of the bode plot magnitude and phase with **solid lines** in the plots below.
3. Integrators, Differentiators & Impedance Scaling (20 pts)

a. (2 pts) What is the transfer function for the circuit shown below?

\[
\begin{align*}
\frac{H(s)}{V_i(s)} &= \frac{V_o(s)}{V_i(s)} = \\
&= Z_2(s) V_2(s) / Z_1(s)
\end{align*}
\]

b. (3 pts) Draw the circuit diagram for a voltage integrator,

\[ v_o(t) = -1000 \int_0^t v_s(\tau) d\tau + v_o(0) \]

using a 1H inductor, an operational amplifier, and a resistor.

c. (3 pts) Suppose you replace the 1F capacitor with a 250mH inductor. Use impedance scaling to find the new value for the resistor in part b.

\[ R = \]

d. (2 pts) What is the transfer function for the circuit in part b?

\[
\frac{H(s)}{V_i(s)} = \frac{V_o(s)}{V_i(s)} = 
\]

e. (1 pt) What type of filter is this the most similar to?
f. (3 pts) Draw a circuit diagram of a voltage differentiator, \( v_o(t) = -25 \frac{dv_i(t)}{dt} \), using a 1F capacitor, an operational amplifier, and a resistor.

\[
\begin{align*}
\text{\textbf{R}} &= \\
\text{h. (2 pts) What is the transfer function for the circuit in part f?} \\
H(s) &= \frac{V_o(s)}{V_i(s)} = \\
\text{i. (1 pt) What type of filter is this the most similar to?}
\end{align*}
\]