ECEN/MAE 3723 Systems I
Fall 2004
Midterm Exam #2
November 23, 2004

Choose any four out of five problems.

Please specify which four listed below to be graded:
1) _____; 2) _____; 3) _____; 4) _____;

Name: ________________________________

Student ID: ________________________________

E-Mail Address: ________________________________
**Problem 1:** *(Electrical Circuits Modeling)*

Derive the transfer function $\frac{E_o(s)}{E_i(s)}$ of the electrical circuit shown below. The input voltage is a pulse signal given by

$$e_i(t) = \begin{cases} 
10 \text{ Volt,} & 0 \leq t \leq 5 \\
0, & \text{elsewhere}
\end{cases}$$

Obtain the output $e_o(t)$. Assume that the initial charges in the capacitors $C_1$ and $C_2$ are zeros. Assume also that $C_2 = 1.5C_1$ and $R_1C_1 = 1$ second.
Problem 2: (Mechanical System Modeling)
Derive the equations of motion for the mechanical systems (a) and (b) shown below.
Problem 3: (Analogous System)
Using the force-voltage analogy, obtain an electrical circuit of the mechanical system shown below. Assume that the displacements $x_1$ and $x_2$ are measured from their respective equilibrium positions.
Problem 4: (Time Response)
The mechanical system shown below is at rest initially. At \( t = 0 \), a unit-step displacement input is applied to point \( A \) (i.e., \( y(t) = u(t) \)). Assuming that the system remains linear throughout the response period and is critically damped, determine the response \( x(t) \) as well as the values of \( x(0+) \) and \( \dot{x}(0+) \).
**Problem 5: (Frequency Response)**
Consider the mechanical system shown below. If the numerical values of system parameters are given as \( m = 10 \, \text{kg} \), \( b = 30 \, \text{N} \cdot \text{s/m} \), \( k = 500 \, \text{N/m} \), \( p = 10 \, \text{N} \) and \( \omega = 2 \, \text{rad/s} \), what is the steady-state output \( x(t) \). The displacement \( x \) is measured from the equilibrium position before the input \( p(t) \) is given.