Final Exam
ME 3210 – Spring 2002
Wednesday, May 8, 2001

Notes:
1. DO NOT OPEN THIS EXAM UNTIL YOU ARE NOTIFIED.
2. Permitted resources: 3 pages single sided notes, calculator, pencil, and eraser. This is a closed book exam.
3. Approximately 120 minutes will be provided to take this exam.
4. DO NOT USE ADVANCED CAPABILITIES ON YOUR CALCULATOR SUCH AS PLOTTING, ROOT FINDING, OR ALGEBRAIC EQUATION SOLVING. SHOW YOUR WORK FOR FULL CREDIT

Name: ________________________________
Student Number: ________________________

#1. ______
#2. ______
#3. ______
#4. ______
#5. ______
TOT: ______
1) Shown below is a diagram of a positioning system consisting of a DC motor, a gearbox, a lead screw, and a mass. Construct a linear graph for the system and clearly indicate all velocities and voltages on both the linear graph and system diagram. (20 points)
2) Shown below is a diagram of a system and its linear graph. Determine the transfer function \( \frac{V_{M3}(s)}{V_{M1}(s)} \) for the system. (20 points)
3) Determine the transfer function \( \frac{C(s)}{R(s)} \) of the following block diagram: (20 points)
4) Consider the following unity feedback system where

\[ G_C(s) = K(s + 3) \quad \text{and} \quad G_p(s) = \frac{1}{(s + 1)^2(s + 2)^2} = \frac{1}{s^4 + 6s^3 + 13s^2 + 12s + 4} \]

\[ C(s) = \frac{K(s + 3)(s^4 + 6s^3 + 13s^2 + (12 + K)s + 4 + 3K)}{R(s)} \]

a) Determine if the control gain \( K = 12 \) will produce a stable closed loop transfer function \( \frac{C(s)}{R(s)} \). Show your work for full credit. (15 points)

b) By inspection of the open-loop transfer function can you determine if the closed loop system will become unstable for some gain \( K \)? Explain very briefly. (5 pts)
5) Consider the following unity feedback system where

\[ G_C(s) = K(s - z) \quad \text{and} \quad G_P(s) = \frac{2}{(s + 2)(s + 4)(s + 6)} = \frac{2}{s^3 + 12s^2 + 44s + 48} \]

where \( z = -\frac{12}{11} \). Sketch the root locus of the closed loop system for \( 0 \leq K \leq \infty \).

**INDICATE ALL ASYMPTOTES AND BREAKAWAY POINTS FOR FULL CREDIT.**

Your calculations should show that the breakaway points are determined by the equation:

\[ 2s^3 + \frac{168}{11}s^2 + \frac{288}{11}s = 0 \]

but show your work deriving this equation for full credit. (20 points)