Midterm 1
ME EN 3210 – Spring 2004

Monday, February 23, 2002

Notes:
1. DO NOT OPEN THIS EXAM UNTIL YOU ARE NOTIFIED.
2. Permitted resources: one half page (8.5” x 5.5” = 46.76 sq. in. single sided) of notes, calculator, pencil, and eraser. This is a closed book exam.
3. A 50 minute period will be provided to take this exam.
4. Read each question CAREFULLY and COMPLETELY before starting.

Name: __________________________

Student Number: ____________________

#1. ______
#2. ______
#3. ______

TOT: ______
1) A mechanism from a nail gun is shown below. The system is driven by the velocity source, $V_s$ applied to the drive shaft. The shaft slides through a sliding bearing, $B_1$, in the lever arm and a spring, $K$, compliantly couples translation of the shaft and the end of the lever arm. The lever arm pivots on a rotational bearing with damping $B_2$. The hammer, represented by the mass, $M$, is fixed to the opposite end of the arm.

![Diagram of mechanism](image)

a) Place nodes for your linear graph in the space below. Clearly indicate all velocities on the figure above and the linear graph. (10 pts)

b) Add elements to the linear graph modeling all of the features of the system described above. Label all elements on the linear graph and list governing equations for any transformer or gyrator elements (20 points).
2) A simple shock absorber is shown in the diagram and modeled by the linear graph below. It consists of a hydraulic cylinder and piston with an orifice in the piston that permits fluid to flow between the two sides of the cylinder as the velocities, $v_2$ and $v_1$, and pressures, $P_2$ and $P_1$, vary. Assume that the piston has area, $A$, and that the orifice provides fluid resistance, $R$. The piston/cylinder is described by typical gyrator equations ($Q_B = v_A A$ and $P_B = -\frac{1}{A} F_A$) with the subtlety that the fluid flow is now attributed to flow through the orifice. Determine the translational damping coefficient of the shock absorber. (i.e.: find $B$ for a typical mechanical damper where $F = B v$). (30 pts)
3) A diagram of a geared DC motor and load is shown below with a simplified linear graph.

![Diagram of a geared DC motor and load]

a) Based on the linear graph, derive the transfer function \( \frac{\omega_3(s)}{V_s(s)} \) (30 points).

b) The above model is over simplified. If you could add one element to the model to improve its accuracy the most, what would it be and why? (one sentence justification) (10 points)