Name _____ Section _____

ES205
Examination I
March 27, 2007

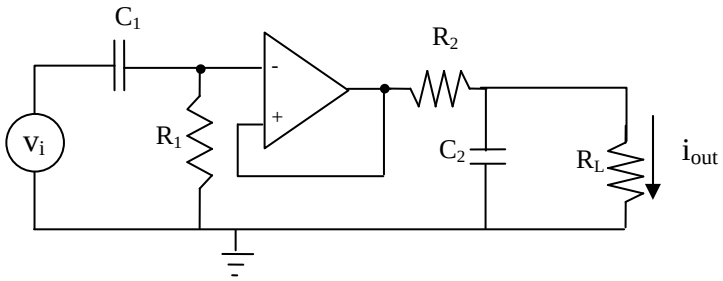
Problem	Score
1	/25
2	/45
3 (six short problems)	/30
Total	/100

Show all work for credit
AND
Turn in your signed help sheet
AND
Stay in your seat until the class ends
(Translation: I am not going to let you leave early,
so you might as well check your answers!)

Name _____ 25 pts

ES205 Examination I **Problem 1** March 27, 2007

For the circuit shown determine the equations necessary to find the differential equation relating the input v_i and the output i_{out}. Be sure to clearly label all your variables on the circuit diagram.

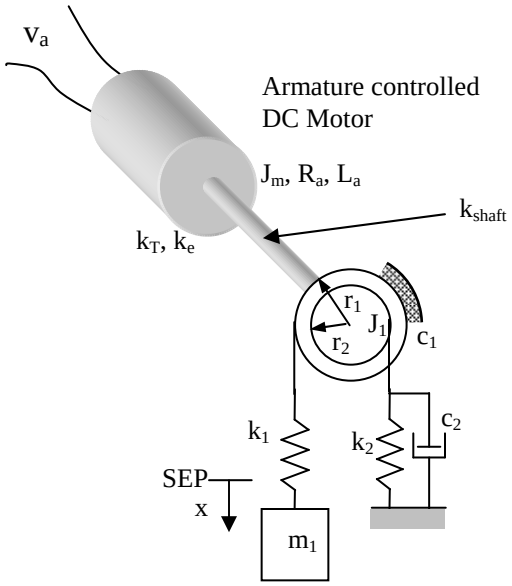


Unknowns

Name _____ 45 pts

ES205 Examination I **Problem 2** March 27, 2007

For system shown below determine the necessary equations to find the differential equation of motion (EOM) that relates the known input voltage, v_a, to the unknown output displacement, x. Assume the output shaft of the motor is flexible with a spring constant, k_{shaft}, and the motor armature has a mass moment of inertia J_m about its axis of rotation. Assume all the parameters, k_T, k_e, J_m, k_1, k_2, c_1, c_2 and m are known. **Do not find the EOM but number the equations that you would use and generate a list of the unknown variables**.



_____ Unknow

Name _____ 30 pts

ES205 Examination I **Problem 3** March 27, 2007

You must show all work for full credit on these problems.

1.1 (5 pts) A system is found to be governed by the differential equation:

$$\frac{d^3z}{dt^2} + 3\frac{dz}{dt} + 2z = f + 2\frac{df}{dt}$$

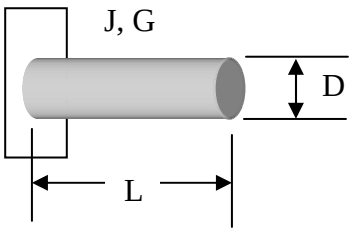
Find the transfer function relating the input f and the output z.

1.2 (6 pts) Write $\ddot{y} = 5f(t) - 2\dot{y} - z$ and $2\dot{z} + y = 2g(t)$ in state space form. Use the state variables: $x_1 = y, x_2 = \dot{y}, x_3 = z$ and assume the desired outputs are: y and T = 2(z- y). Fill in the matrices given below.

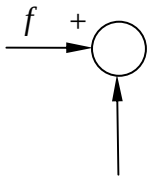
$$\begin{Bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{Bmatrix} = \begin{bmatrix} & & \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \\ x_3 \end{Bmatrix} + \begin{bmatrix} & \\ & \\ & \end{bmatrix} \begin{Bmatrix} f(t) \\ g(t) \end{Bmatrix}$$

$$\begin{Bmatrix} y \\ T \end{Bmatrix} = \begin{bmatrix} & & \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \\ x_3 \end{Bmatrix} + \begin{bmatrix} & \\ & \end{bmatrix} \begin{Bmatrix} f(t) \\ g(t) \end{Bmatrix}$$

1.3 (6 pts) Shaft shown below had a diameter, D, a length, L, a shear modulus, G, and a mass moment of inertia about its longitudinal axis of J_G. Determine the natural frequency of this system in torsion.



1.4 (5 pts) A system is governed by the following differential equation: $a\dot{y} + y^2 = \dot{f}$. Complete the simulation diagram for this system where the input is *f* and the output is *y*. Do not use any differentiation blocks.



1.5 (3 pts) What is it important to avoid differentiation blocks in simulation diagrams if at all possible?

1.6 (5 pts) A thermocouple (a temperature measuring device) is originally at room temperature (20 C) when it is put into ice water. After 2 seconds it is then put in boiling water. The resulting time history is shown below. Assuming this system is governed by a 1st order differential equation, determine the time constant.