

Name _____ Section _____

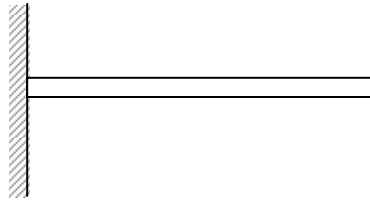
ES205
Examination I
March 26, 2004

Problem	Score
1	/22
2	/18
3	/30
4	/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!)

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

- 1.1) The cantilever beam shown below has length, L , elastic modulus, E , a mass, m , and a mass moment of inertia, I . Assuming the mass of the beam is m_{beam} and it has a natural frequency of ω_n . Assuming you were given the geometry of the beam (L =length, I = area moment of inertia), determine Young's modulus for the beam in terms of L , I , m_{beam} and ω_n ? (5 pts)



- 1.2) Write $\ddot{y} + 4\dot{y} + 2y = 3f(t) + \dot{f}(t)$ in state space form assuming the state variables are $x_1 = y$, $x_2 = \dot{y}$, $x_3 = \ddot{y}$ and the output variables of interest are: $y_1 = y$, $y_2 = \ddot{y} - 10f(t)$. (5 pts)

$$\left\{ \begin{array}{c} \\ \\ \end{array} \right\} = \left[\begin{array}{ccc} & & \\ & & \\ & & \end{array} \right] \left\{ \begin{array}{c} \\ \\ \end{array} \right\} + \left[\begin{array}{c} \\ \\ \end{array} \right] \left\{ \begin{array}{c} \\ \\ \end{array} \right\}$$

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1.3) Given the transfer function for a system: $\frac{V_o(s)}{V_{in}(s)} = \frac{3}{2 + 4s + 8s^2}$

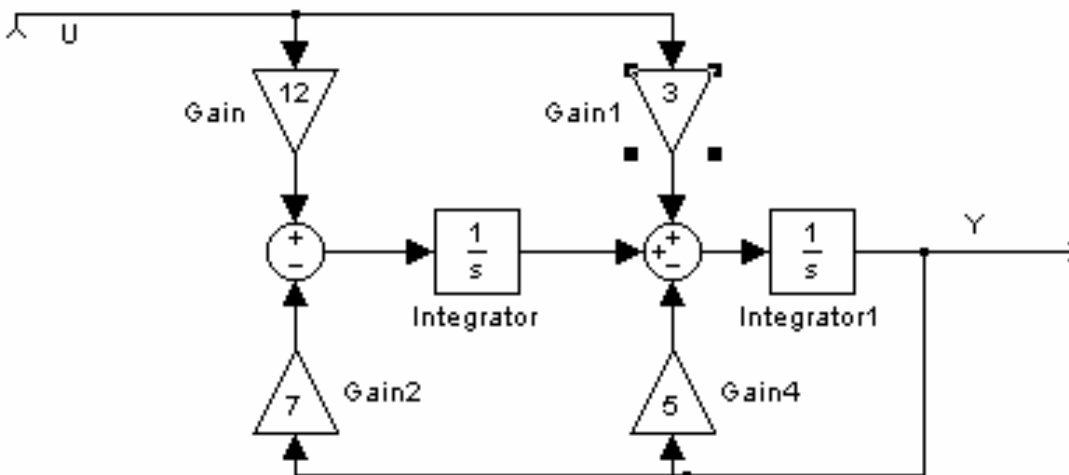
a) Determine the corresponding differential equation of motion for this system. (2 pts)

If a step input with a magnitude of two is applied determine

b) the steady state amplitude (2 pts)

c) the frequency of oscillation (2 pts)

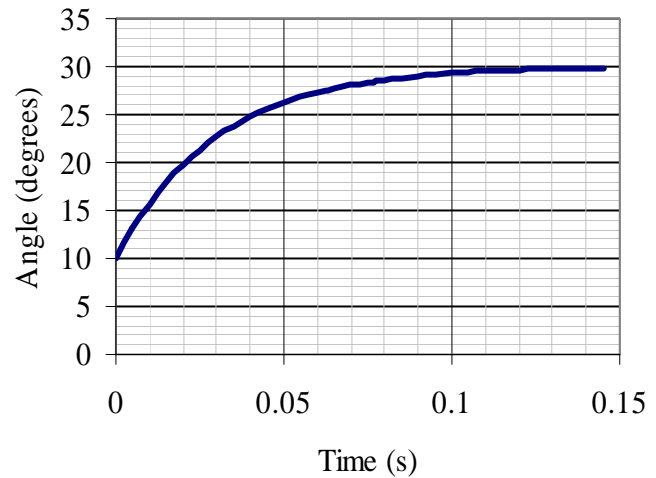
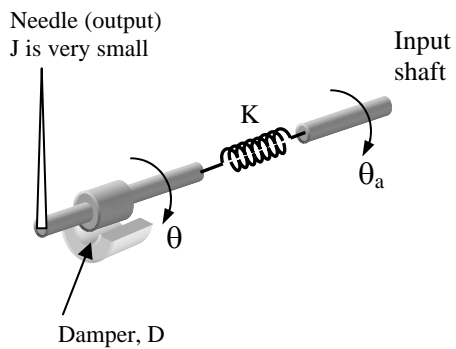
1.4) What differential equation is modeled by the block diagram shown below? The input is u and the output is y . (6 pts)



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18 pts

To minimize jerky movements of a dial display, the inputs (which may have sudden jumps and discontinuities) is not applied directly to the input. Instead the input must pass through a weak spring, which tends to filter such disturbances and thus smooth out the otherwise unreadable information. A typical device is shown below. Assume that the needle of the dial has a very small mass ($J=0$). A step input was applied to the system and the resulting experimental data is shown below.



Find:

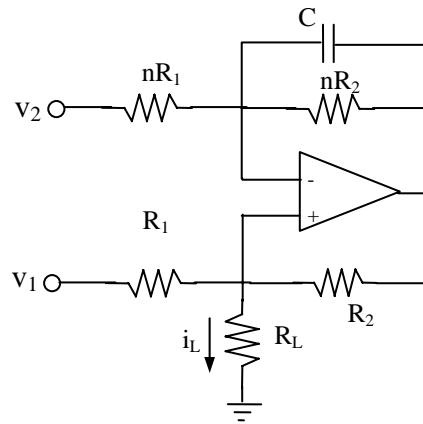
- The equation of motion of the needle relating the output θ to the input θ_a assuming $J \approx 0$
- The time constant for this system (I want a numerical value)
- The damping, D for this system given $K = 1000$ dyn-cm

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Problem 2

30 pts
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For the circuit is shown below v_1 and v_2 are both inputs and the output is i_L . Determine the equations necessary to find the transfer function between the input v_1 and the output i_L . **Do not find the transfer function.** Your solution should consist of a list of unknowns and clearly numbered equations. Be sure to clearly label all your variables on the circuit diagram.



Unknowns

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Problem 3

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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 rigid. **Do not find the EOM but number the equations that you would use and generate a list of the unknown variables.**

