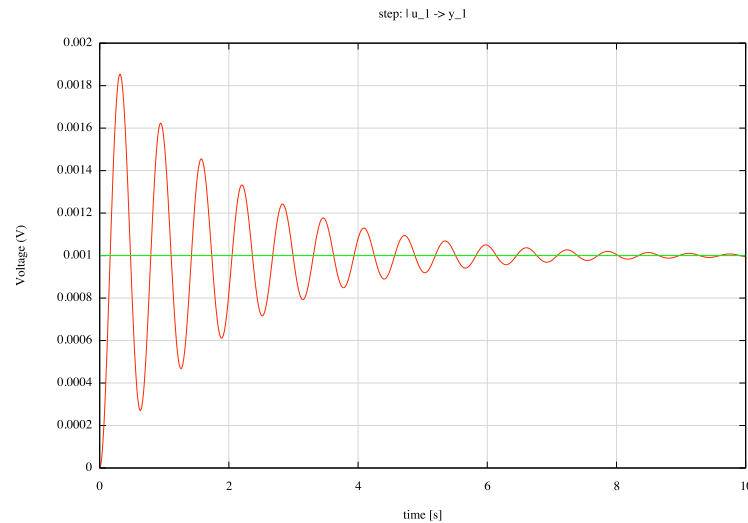
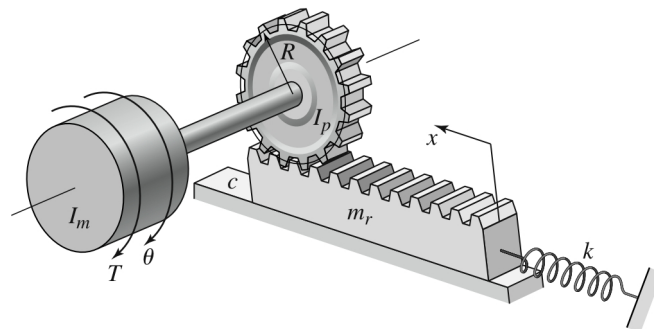


You may use 1 formula sheet (to be turned in), computer with matlab and simulink, calculator, fundamentals of engineering handbook and email (but only as directed in the exam). No other use of email or the web is allowed.

1. Estimate a model for the system for which the step response is given below. List each electrical component's value. Sketch the system.



2. A system  $1000\ddot{x} + 10\dot{x} + 0.1\dot{x} + 1400x = \dot{f}(t)$  is excited by  $f(t) = 20 \sin(10t - \frac{\pi}{4})$ .
  - (a) What is the magnitude (not in dB) and phase of the frequency response (transfer) function at the frequency of interest?
  - (b) What is the magnitude of the frequency response function at the frequency of interest in dB?
  - (c) Using this information directly, what is  $x(t)$ .
  - (d) What is the transfer function  $X(s)/F(s)$ .
  - (e) Generate the bode plot of the system. Submit the Bode diagram.
3. Derive the equation of motion of the following system in terms of  $\theta$ .



4. Develop a model of the two liquid heights in the system shown in the figure below. The inflow rate  $q_{mi}(t)$  is a mass flow rate. Using the values  $R_1 = R$ ,  $R_2 = 3R$ ,  $A_1 = A$  and  $A_2 = 4A$ , determine

(a) The transfer function  $\frac{H_2(s)}{Q_{mi}(s)}$

(b) The state space model presuming outputs  $h_1$ ,  $h_2$ , and  $q_{mo}$ .

