Mechanical System Analysis
Midterm #1

April. 12. 2009

1. Briefly answer following questions.
   A. Explain what linearity is. (State an equation)

   B. Discuss what is meant by the order of a dynamic system.

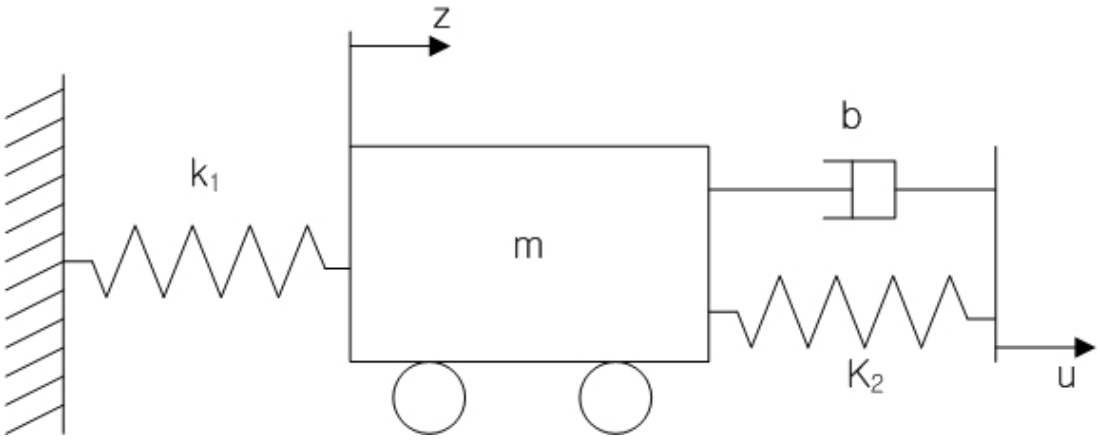
   C. Define the term damping ratio as it applies to the dynamic systems.

2. State space equations for a particular system are

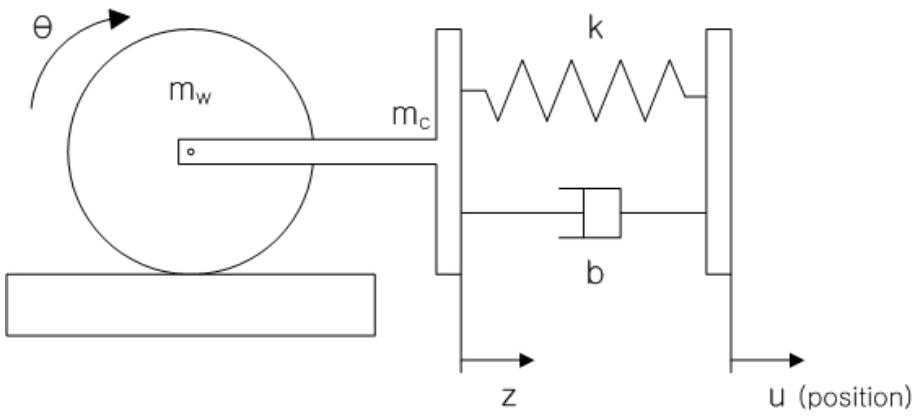
$$\dot{y}_1 = -2y_2 - y_1 + e^{-t} + \sin \omega t$$
$$\dot{y}_2 = y_1$$

   A. Find the equivalent classical second order differential equation of the above system.
   B. Find the transfer function of the system and the Laplace transform of the input.
   C. Find the system response in time using inverse Laplace transform. Assume that the initial conditions are zero.

3. Obtain a state space model of the system shown below. The displacement *u* is the input to the system and the displacement *z* is the output of the system.



4. A wheel is moved by the mechanical system shown in the figure. The mass of the wheel is m_w, and the mass of the attachment is m_c. The radius of the wheel is r, and is connected with the attachment using a frictionless bearing.
   A. Draw a Free body diagram of the system.
   B. Write the modeling and geometric equations for the translational and rotational systems.
   C. Derive the transfer function for the output motion z as a function of the input motion u(t)
   D. Under what condition would there be slip between the wheel and the ground? (State an equation.)



5. Given the combined translation and rotational system shown in the figure find the transfer function $G(s) = X(s)/T(s)$