Massachusetts Institute of Technology
Department of Mechanical Engineering

2.010 Modeling, Dynamics, and Control III
Spring 2002

Problem Set #8
Due Friday, April 12, 2002

Problem 1   Nise Problem 8-25

Problem 2   Nise Problem 9-1

Problem 3   Nise Problem 9-6. **Extra Credit** for solving Problem 9-7.
Problem 9-7 is an extension of Problem 9-6, using MATLAB.

Problem 4   Shown below is the schematic of an elevator system carrying a cargo of
mass M. Since the cable is long, the cable compliance cannot be ignored. For simplicity
the cable compliance can be approximated to be constant over the length of the cable and
have a stiffness K. An actuator of rotor inertia, J ,winds the spool of radius, R, with the
cable. Answer the following questions.

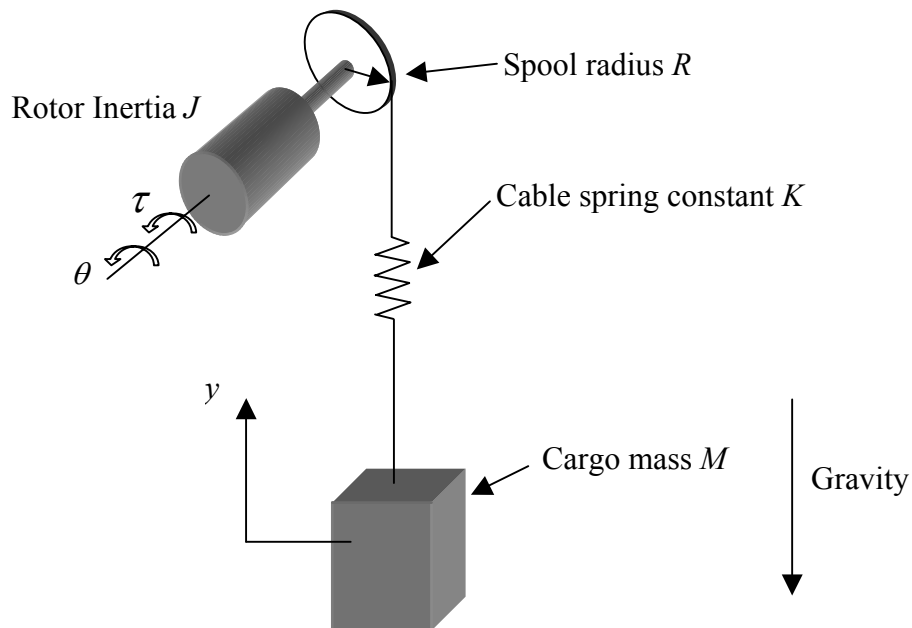
Figure 1: Elevator system

a)   Obtain the equations of motion.

b) Obtain the actuator torque needed for holding the cargo, $\bar{\tau}$. Obtain the transfer function from the *net* actuator torque $\tau_n = \tau - \bar{\tau}$ to the cargo position y;

$G_1(s) = \dfrac{y(s)}{\tau_n(s)}$. Also obtain the transfer function from the net actuator torque to

the actuator angular displacement θ; $\quad G_2(s) = \dfrac{\theta(s)}{\tau_n(s)}$.

c) Consider feedback controls of $G_1(s), G_2(s)$, as shown below. Sketch root loci of i) Proportional Control ($k_d = 0$) and ii) Proportional-and-Derivative Control ($k_d \neq 0$) of each of the plant transfer function, $G_1(s)$ and $G_2(s)$. Address stability and discuss the difference between the two plant transfer functions. Use any positive value for the gains and parameters involved in the systems. The results do not depend on specific values of the parameters.
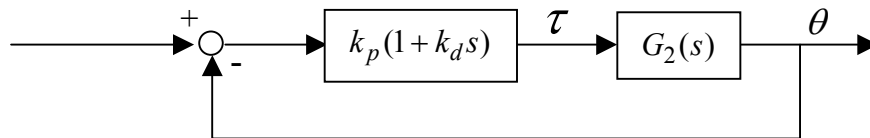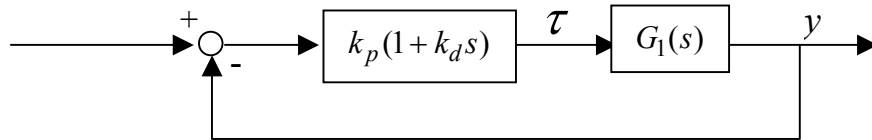

Figure 2: Two feedback control systems