Department of Mechanical Engineering
Massachusetts Institute of Technology
2.010 Modeling, Dynamics and Control III
Spring 2002

Problem Set #1
DUE Thursday, February 14, 2002

Problem 1.
For each of the following systems , identify:
   a) The engineering or customer goal of the control system
   b) A measure of *good* performance
   c) The Output variable
   d) The Reference input
   e) The Plant and Actuator
   f) The Measurement
   g) The Disturbance(s)

If you don't know how the systems work, take an educated guess, keeping in mind the
function of each part of the system.
- Water closet (the water tank on a toilet)
- A refrigerator in your kitchen
- Shower mixing valve
- An industrial robot carrying a spot weld gun working along a car assembly line
- The iris of your eye

Problem 2.   Nise Problem 1.3

Problem 3.   Nise Problem 1.5

DIAGNOSTIC
Problem 4.
The next two problems are intended to be "diagnostic" and to assess your prior
understanding of linear dynamic systems. They will not be graded, but they must be
attempted. Please feel free to comment on what deficiencies you feel you have in trying
to answer the questions.

Assume that the temperature of your room is related to the heat output from the radiator
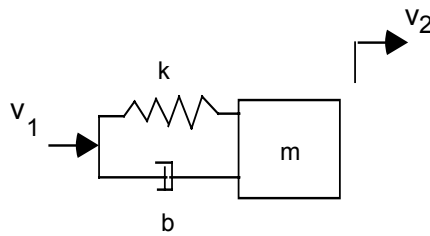by the equation:

$$180\frac{dT}{dt} + 3T = 10Q_{in}$$

Where T is the temperature in deg. C. and Q_{in} is the heat input in Watts

a) What is the time constant τ of the system?

b) What is the steady - state gain (K) of the system?

c) What is the Transfer Function T(s)/Q_{in}(s) for this system?
d) Sketch a plot of how the temperature will change with time if the initial
temperature $T(0) = 0$ and Q_{in} is changed from 0 to 1 at $t=0$ (a step input) showing the
exact output values at $= 1\tau, 2\tau, 3\tau,$ and 4τ.
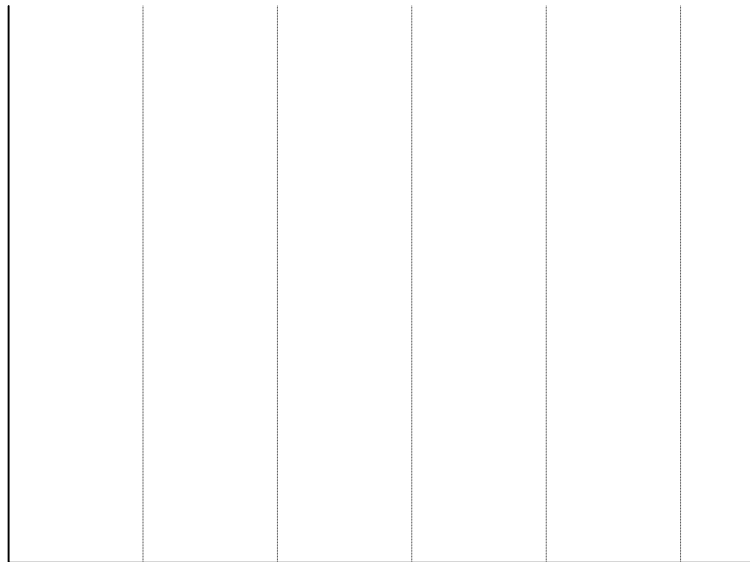
Problem 5.
The system shown below represents a simple model of a car suspension.

For this system:

a) Derive the equations of motion assuming the velocity v_1 is the input, and velocity v_2 is the output

b) Find the transfer function relating the input to the output:

$$G(s) = \frac{Y(s)}{U(s)}$$

c) For the following system parameter:

spring constant	$k = 400$ N/m
mass	$m = 1$ Kg
damping	$b = 300$ N/m/sec

What is the natural frequency ω_n of this system?
What is the damping ratio ζ?
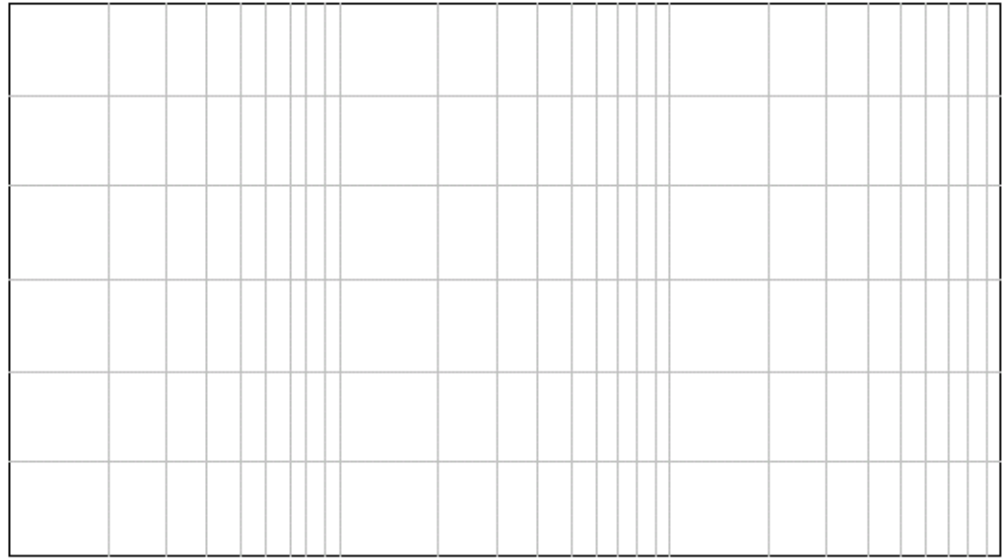What is the *approximate* 2% settling time to a step input?

d) Sketch the step response of the system.
e) On an s-plane, plot the poles and zeros of G(s).
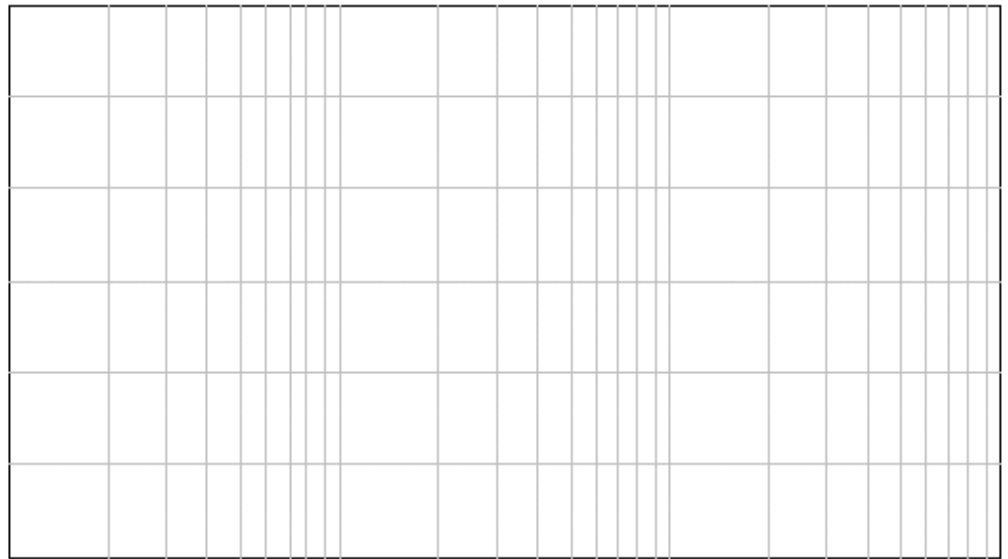f) Sketch a Bode Diagram for $G(j\omega)$ on the attached paper
h) What is the resonant frequency?

Magnitude

Frequency

Phase

Frequency