Department of Mechanical Engineering
Massachusetts Institute of Technology
2.14 Analysis and Design of Feedback Control Systems
Fall 2004
Assignment #1
Distributed Wednesday September 8
Due in Class: Wednesday, September 15

Reading:
Nise Chapter 1 and Chapter 2 sections 2.1-2.3

Problem 1

For <u>each</u> 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.

- Pressure regulator on a outdoor gas grill
- Water closet (the water tank on a toilet)
- Shower mixing valve
- The iris of your eye
- The angle of your elbow
- Monetary inflation

Problem 2

Nise Problem 1.3

Problem 3

Nise Problem 1.4

Problem 4

Nise Problem 1.12

The next two problems are intended to be "diagnostic" and to assess your prior understanding of linear dynamic systems. Take your best shot at them, and feel free to comment on what deficiencies you feel you have in trying to answer the questions.

PROBLEM 5

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

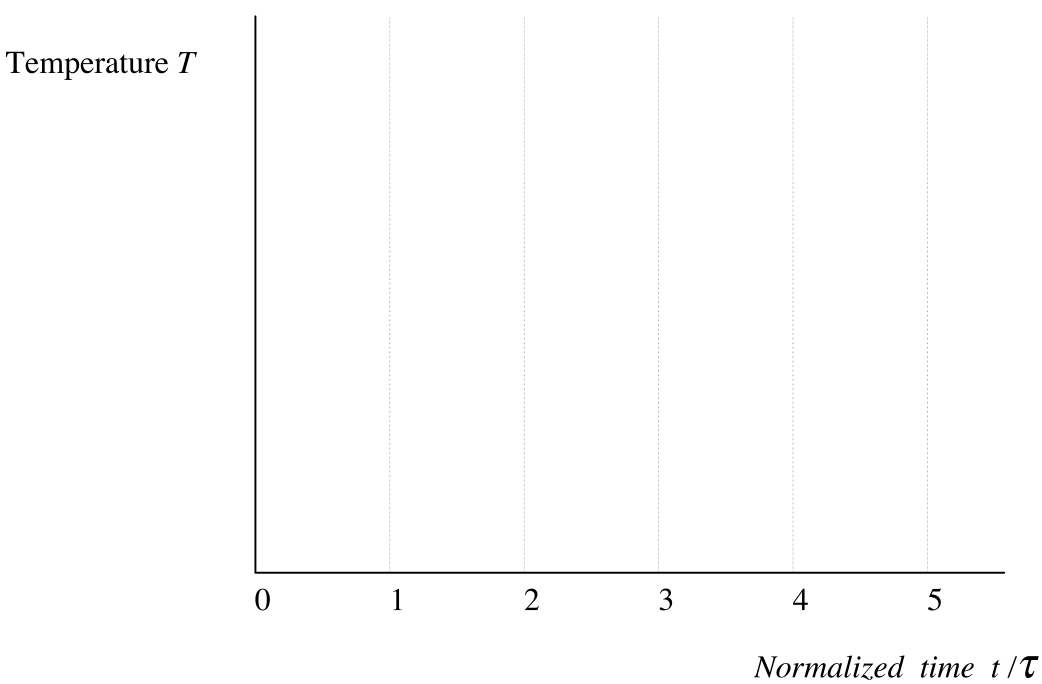
$$100\frac{dT}{dt} + 2T = 20Q_{in}$$

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?

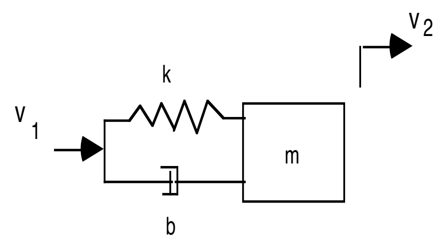
b) What is the steady - state gain (K) of the system?

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 τ, 2τ, 3τ, and 4τ.



Problem 6

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. Please express the result in the standard matrix form:

$$\frac{d}{dt}\underline{x} = \mathbf{A}\,\underline{x} + \mathbf{B}\underline{u}$$

$$y = \mathbf{C}\underline{x} + \mathbf{D}\,\underline{u}$$

(Use any method you choose to derive these equations)

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

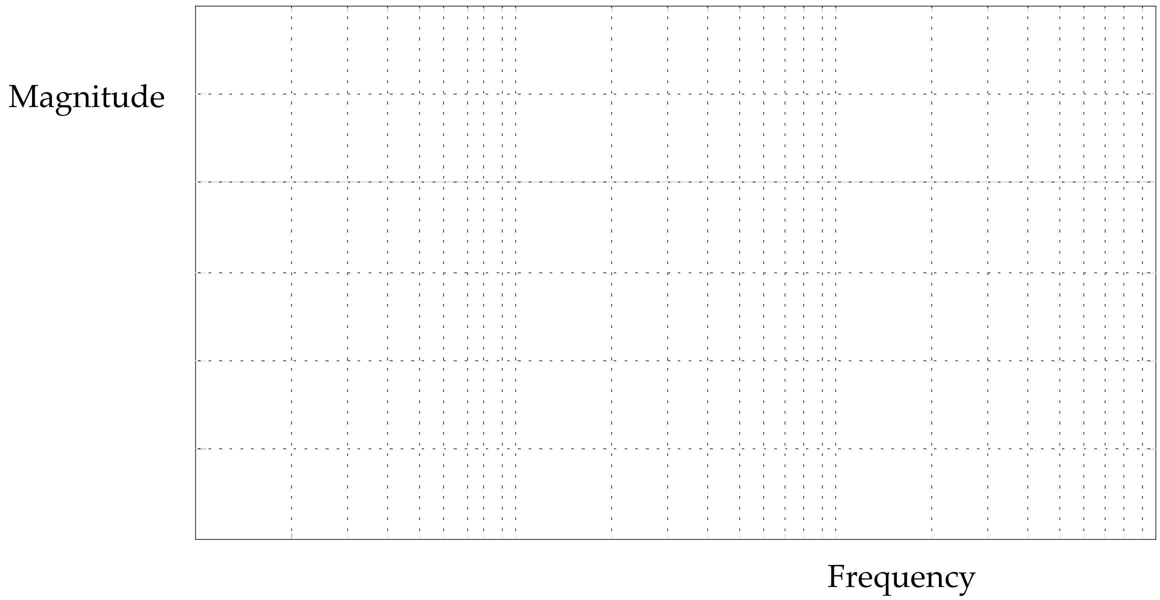
$$G(s) = \frac{Y(s)}{U(s)}$$

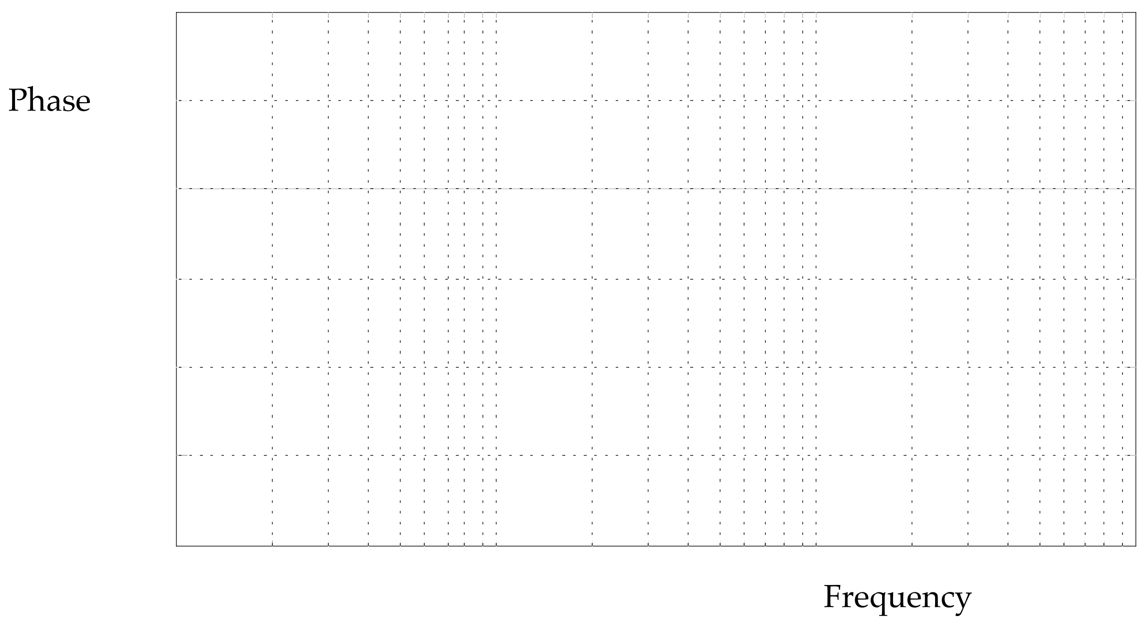
c) For the following system parameter:

spring constant	k = 100 N/m	
mass	m = 1 Kg	
damping	b = 100 N/m/sec	

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

d) Sketch the step response of the system.
e) On an s-plane, plot the poles and zeroes of G(s).
f) Sketch a Bode Diagram for G(jω) on the attached paper
g) If $u(t) = v_1(t) = 10$ m/sec sin(5 t), what is the *steady-state* result for $v_2(t)$?


Magnitude
Frequency


Phase
Frequency