GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Spring Quarter 1999

System Dynamics & Controls
EXAM AREA

Assigned Number (DO NOT SIGN YOUR NAME)

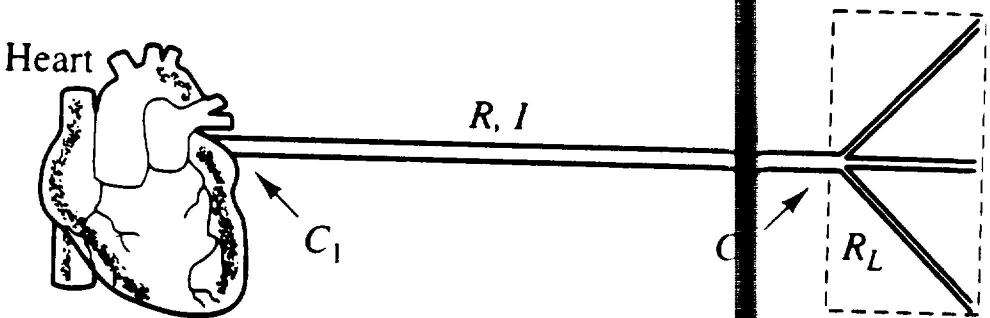
- **Please sign your <u>name</u> on the back of this page—**

Please **<u>p r i n t</u>** your name here.

The Exam Committee will get a copy of this exam and will not be no [illegible] whose paper it is until it is graded.

PROBLEM ONE

In a simple model of blood flow in the human body, the heart is considered as a pump and the artery as a flexible tube, which can be represented by an inertance and resistance bounded at each end by a capacitance. A schematic model is illustrated below:

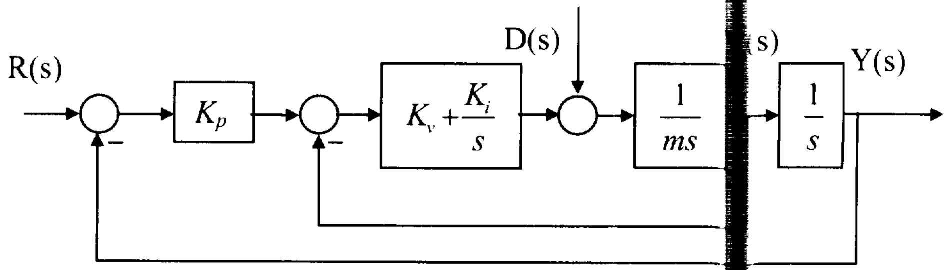


(a) Derive the transfer function, P(s)/Q(s) where P(s) and Q(s) are the Laplace transforms of the pressure at C_1 and the flow through R, as viewed by the heart.

(b) If the arteries harden, becoming less flexible, the capacitance C_1 and the inertance approach zero. Considering the heart as a pressure driver with a check valve (resistance = R in one direction and = infinite in the opposite direction) and output a periodic square wave. Determine the pressure at C_2 as a function of time.

PROBLEM TWO

The block diagram shown below depicts a servocontrol system with a PI [illegible]ocity (v) and a propo[illegible] position (y) feedback control. The parameter m represents the mass of the [illegible]stem.



a) Determine the steady-state error (i.e., r-y) for a constant reference inpu[illegible] and disturbance d. E[illegible] the benefit of the PI controller in this control system.

b) Find the PI gains such that the velocity feedback loop (without the pos[illegible]on loop) is criticall[illegible] and has a settling time of 0.1 second. Assume m=1.

c) With the PI controller you found in (b) and the position loop in place, [illegible]t the locus of the clo[illegible] loop poles of the system as K_p varies from 0 to infinity. Find K_p such t[illegible] the dominant poles [illegible] system have the same settling time as in (b). Assume m=1.

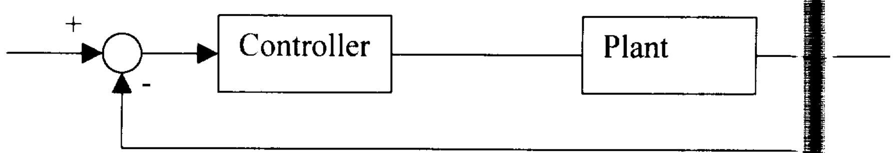
d) Assuming the control gains are set to the values you found in (b) and ([illegible], plot the locus of the [illegible] poles of the system as mass m varies from 0 to infinity. For what rang[illegible]f m is the system stab[illegible]

PROBLEM THREE

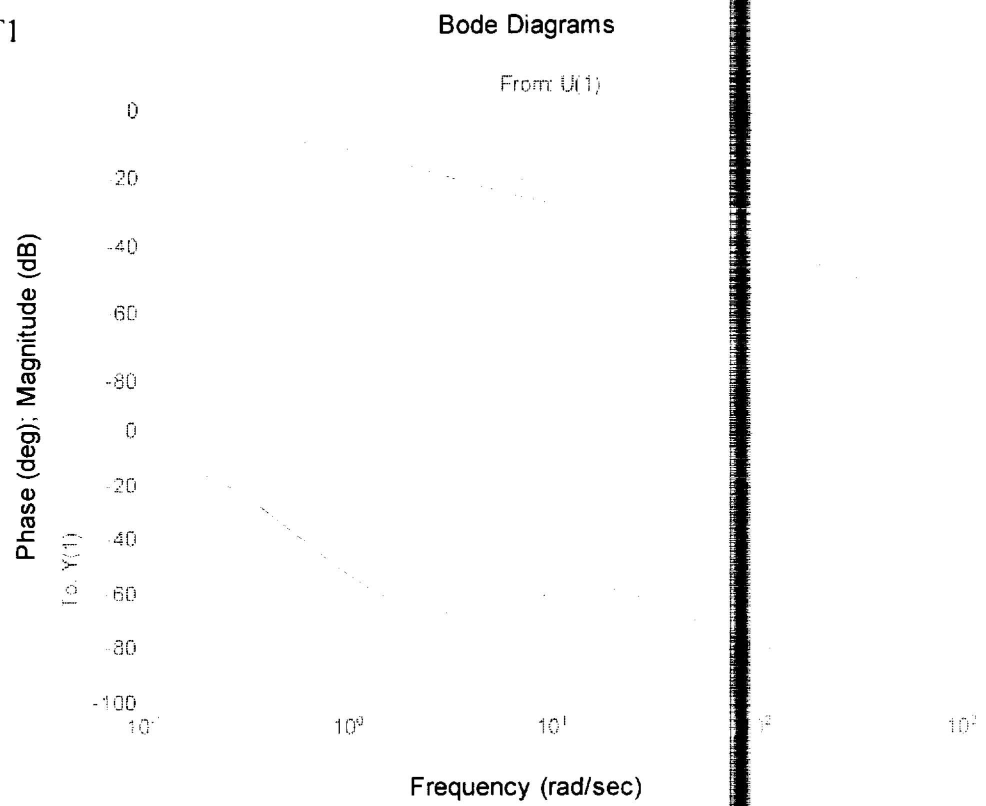
The following page shows the Bode diagrams of two plants.

a) Consider the first plant. It is to be placed in a feedback loop as shown in the figure below. The controller block consists of a simple gain K and a pure time delay of [illegible] seconds due to transmission of the information from the plant to the controller. The design specification is such that the steady state error is to be minimized and the gain margin is to be maximized. Select the control gain K that you think will achieve this specification and **thoroughly** explain your selection in quantitative terms and any assumptions that you made to come to your conclusion. If there is additional information that you would find useful for further refining your answer, please state what it is.

b) Consider the second plant whose Bode diagram is given at the bottom of the next page. Describe the difference between this plant and the first plant in standard control terminology. How would you modify your process from part a) to select K for this plant?



PLANT1



PLANT 2