GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Spring Quarter 1998

System Dynamics & Controls
EXAM AREA

____

Assigned Number (DO NOT SIGN YOUR NAME)

- **Please sign your name on the back of this page—**

Please **print** your name here.

The Exam Committee will get a copy of this exam and will not be notified whose paper it is until it is graded.

George W. Woodruff School of Mechanical Engineering

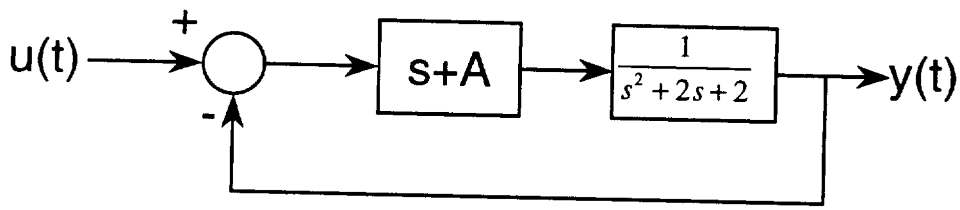
Spring 1998 Doctoral Qualifying Examination

INSTRUCTIONS

There are 3 questions attached, please solve all questions as completely as possible. State all assumptions, and make sure that you clearly indicate the thought processes that you employed to arrive at your answer.

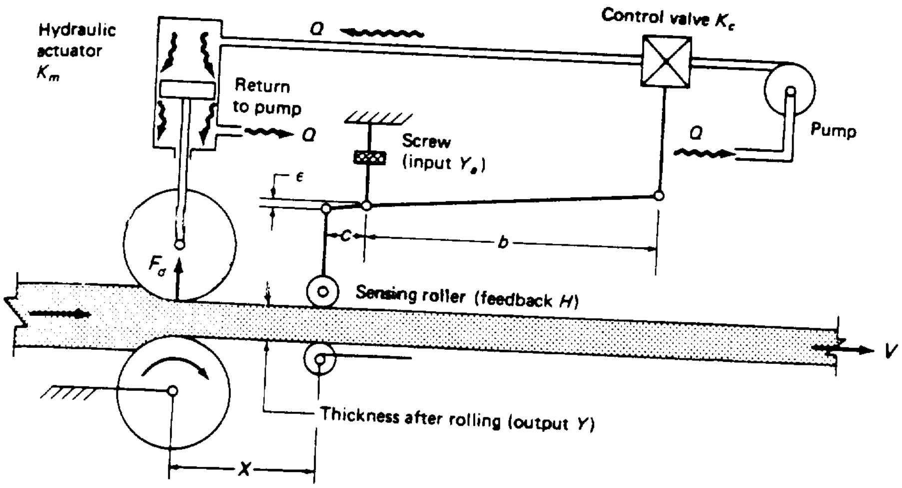
Problem 1

For the following plant, discuss the effects of changing the value of A for the closed-loop system dynamics between the input, u(t) and the output, y(t). Remember that the zero will affect the system response.



Problem 2

In a foundry, hot slabs of steel are rolled into successively thin slabs until sheets are formed. This is accomplished by squeezing the material between a pair of rollers. However, due to variations in the materials and in the hydraulic supply, the thickness of the finished product was found to vary. One method to maintain the thickness using feedback control is suggested as shown in the following figure:



In the above figure, the control valve can be modeled by the following approximation:

$$\Delta P = K_c z - K\Delta Q$$

where ΔP and ΔQ are the small change in pressure and flow about its operating point at the outlet of the control valve; and z is the valve manipulated input. In addition, the plant (squeezing roller and the slab) can be represented as a spring-mass system with damping. Assume that the time delay between the squeezing roller and the sensing roller can be neglected but the fluid inertia between the control valve and the cylinder is not negligible.

(1) Draw the complete block diagram of the thickness control system and determine the corresponding closed-loop transfer function, $Y(s)/Y_a(s)$.

(2) Determine the steady-state error of the system, if any, for a step change in F_d.

Problem 3

An experimentally determined magnitude part of Bode plot has the following characteristics:

(1) an initial slope of -1 $dB/decade$.
(2) a break, up to 0 $dB/decade$ slope, at $\omega = 1$ rad/sec, at which frequency the magnitude is $+2$ dB, and
(3) a break, down to -1 $db/decade$, at $\omega = 100$ rad/sec.

(i) Sketch the straight-line approximation to the (magnitude part) Bode plot and the phase part. Assume that the system is of minimum phase.

(ii) From the above plot, sketch the Nyquist plot. Label several points on the Bode plot and Nyquist plot to show the equivalence.

(iii) Write the transfer function represented by this data.