THE UNIVERSITY OF ADELAIDE
DEPARTMENT OF MECHANICAL ENGINEERING

EXAMINATION FOR THE DEGREE OF BE

AUTOMATIC CONTROL 2452

NOVEMBER, 1999

TIME: 3 HOURS

[In addition, candidates are allowed ten minutes before the examination begins to read the paper.]
[The use of notes, textbooks and calculating devices other than computers is permitted in the examination room.]
[Graph paper is provided.]

Part 1: Fundamental Concepts.

Provide a *short* answer (a few sentences and a sketch at most) to each of the following questions. **2 points per question.**

1. When a system is said to be unstable, what is actually meant?

2. Why is it that control systems can be designed by considering system poles, when the inputs to the system (such as rocks hitting a satellite) are often unknown at the time of design?

3. Why would a person consider the use of an integral component in a control system (for example, in a PI controller)?

4. What does a transfer function describe?

5. Describe the relationship between a root locus plot and frequency response.

6. Name one benefit the Laplace transform brings when solving a complex differential equation.

7. The response of a system, as measured by rise time, is deemed too slow. What is one approach to fixing the problem?

8. A second order system is said to be lightly damped. How many poles would it have, and would you expect any to be on the real axis?

9. In general, what is the purpose of implementing an automatic control system?

Please turn to next page.

10. You are generally happy with the response of a system, except for a larger-the-allowable steady state error. What type of controller would you be considering?

11. Given that very few systems are actually subject to a purely sinusoidal input, what is it that the frequency response can provide us with an useful information?

12. What defines the values of 's' that can be included in a given root locus?

13. Consider the transfer function:

$$G(s) = \frac{(s+1)}{(s+2)(s+3)}.$$

What is the phase of the transfer function at $s = 2j$?

14. From the standpoint of approaching the design of an automatic control system, what does an electric motor have in common with a satellite?

15. A system has a transfer function:

$$G(s) = \frac{1}{(s+1)(s+20)}.$$

What is an approximation of this system with only one pole (ie, an approximation with the slow pole removed)?

Please turn to next page.

Part 2: Basic Skills

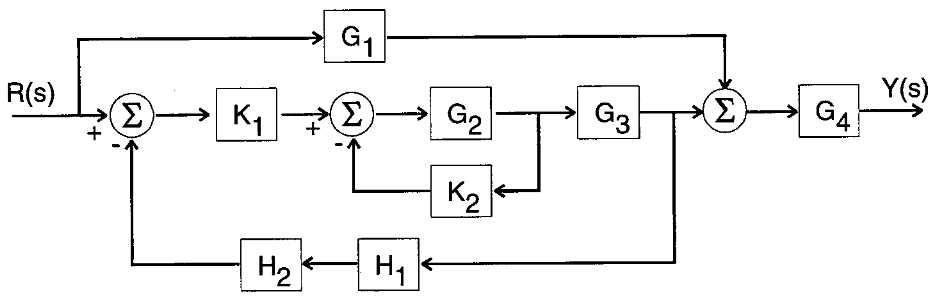
Solve each of the following questions.
5 points per question, except for 21 which is 10 points).

16. A system is described by the following differential equation:

$$2\frac{d^2y}{dt^2} + 2\frac{dy}{dt} + 8y = f(t),$$

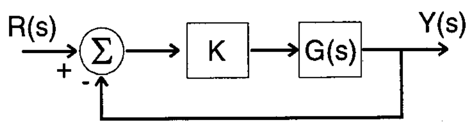
and is subject to a step input of amplitude 2 with initial conditions $y(0) = 0$, $dy(0)/dt = 0$. Solve for the time response $y(t)$ and sketch it. Be sure to give values for all variables in the solution.

17. Calculate the transfer function Y(s)/R(s) of the system shown below:



Questions 18 - 21 refer to the figure below, where K is a scalar and

$$G(s) = \frac{(s+2)(s+10)}{s(s^2+2s+4)}.$$



18. What is the system type of G(s)? Calculate the steady state error to a unit step and unit ramp input.

19. Determine the range of values of K for which the system is stab

20. Plot the (root) locus of the closed loop pole locations as a function of proportion gain K.

21. Plot the frequency response of $G(s)$. (**10 points**)

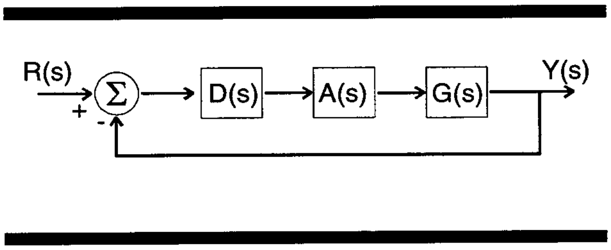
Please turn to next page.

Part 3: Compensator Design

Questions 22 and 23 refer to the system shown below, where the transfer function of the actuator $A(s)$, and the transfer function of the system $G(s)$, are given by

$$A(s) = \frac{20}{s+20}, \quad G(s) = \frac{s+10}{s^2+2s+2}.$$

The transfer function of the controller is $D(s)$.



22. Given the following desired performance criteria:

(1) Rise time to be less than 0.2 seconds
(2) Overshoot to be less than 15%

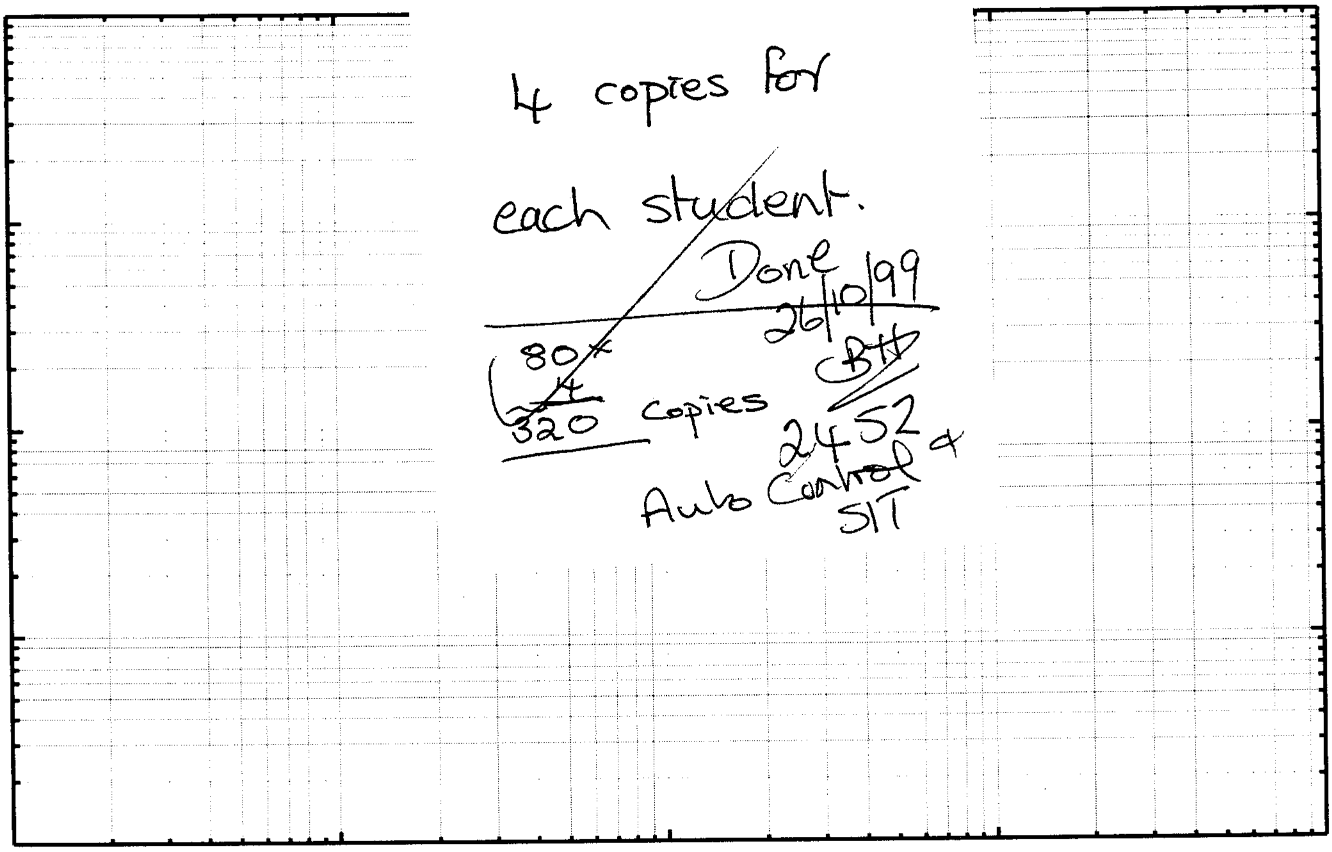
I. Determine a suitable value of scalar gain K if proportional control is to be used ($D(s)=K$).
II. What is the error to a unit ramp command input with this selected value of K?
15 points

23. Given the following desired performance criteria:

(1) Steady state error to a unit ramp input to be less than 10%
(2) Minimum phase margin to be 30°

Design a lag-lead compensator $D(s)$ to achieve the result.
20 points

END OF EXAMINATION PAPER



4 copies for each student.

Done 26/10/99 BH

80 × 4

320 copies

2452 Auto Control & SIT