THE UNIVERSITY OF ADELAIDE
DEPARTMENT OF MECHANICAL ENGINEERING

EXAMINATION FOR THE DEGREE OF B.E.

AUTOMATIC CONTROL 1 2452

NOVEMBER 2000

TIME: 3 HOURS

[In addition, candidates are allowed 10 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.]

Total 3 pages in this exam paper.

Part 1: Fundamental Concepts (total 30 points)

Provide a **short** answer (a few sentences and a sketch at most) to each of the following questions. **15 questions, 2 points each.**

1. What are the commonalities in dynamic systems?

2. Why do we use Laplace transforms in control?

3. Your manager asks you to design a controller to control a robot. This robot will be used to clean windows. Is underdamping response allowed? Why?

4. What is the difference between an open loop control and a closed-loop control?

5. The transfer function of a first order system is $F(s) = 1/(s + a)$, with a>0. What is the time constant for this system?

6. In Question 5, when a is increased, will the system response faster or slower? Why?

7. After a proportional controller is designed and attached to a machine, it is found that there is always a steady-state error. Propose two possible approaches to reduce the error.

8. When subject to a ramp input, the steady-state error of the system's response is zero. What is the type of this system?

9. In Question 8, is the system's response constant?

10. Overshoot and peak-time are functions of what system parameters respectively?

11. In Question 10, can you adjust one system parameter so that both overshoot and peak-time can be reduced? Why?

12. Can a derivative control be used alone to track a constant reference input? Why?

13. You have two descriptions of a given system, one as a differential equation, the other as a block diagram. What is the relationship between this two?

14. What is the definition of "sensitivity"?

15. You prefer to have a high or low sensitivity system? Why?

Part 2: Basic Skills (total 40 points)
8 questions, 5 points each.

16. Derive the transfer function for the following system:

$$a\ddot{y}(t)+b\dot{y}(t)+c\int y(t)dt=u(t)$$

where y(t) and u(t) are the output and the input to the system respectively.

17. The transfer function of a system is given as follows

$$G(s)=\frac{20(s-1)}{(s^2+2s+5)(s+5)}$$

(a). Where are the poles and zeroes of the system?
(b). Is the system stable?
(c). Where are the dominant poles?
(d). Obtain the reduced-order model of the system.

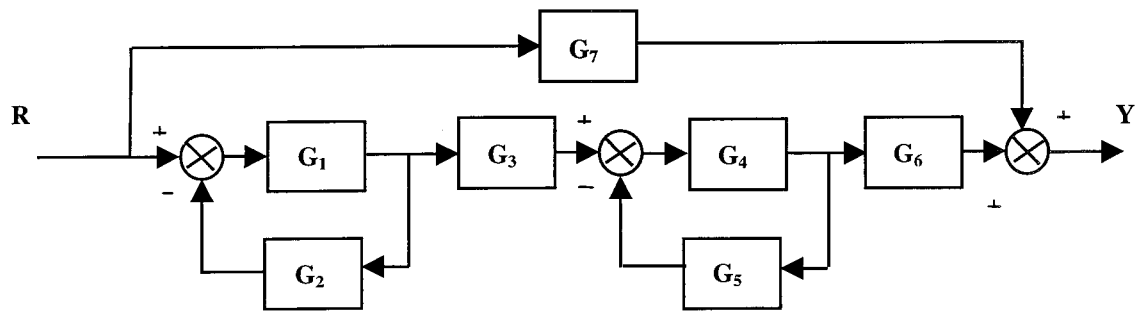
18. A chemical process can be described by the following equation:

$$G(s)=\frac{6e^{-4s}}{s+0.8}$$

Using the first Zeigler-Nichols rule, design a PID controller for the system.

19. Assume a unit feedback element, use the controller you designed above, when the system in Question 18 is to follow a unit step reference signal, obtain the steady-state error.

20. Using Mason's rule to calculate the transfer function of the following system:



Please turn to the next page

21. Given the following closed-loop system transfer function:

$$G(s) = 2/(s^4 + ks^3 + 4ks^2 + 8s + 6)$$

For the system to be stable, what is the range of the K value?

22. Consider 2 pole pairs a.) $-4 \pm j$, b.) $-1 \pm 4j$, answer the following questions:

1). Which one has a fast rise time?

2). Which one has a higher overshoot?

23. If the settling time must be less then 2 seconds, for the two pole pairs in Question 22, which one is acceptable?

Part 3: Design Questions (total 30 points)

2.4 A robotic arm is used in an assembly line in a pipeline company. The robotic arm is to pick up a pipeline and place it under a laser printer for bar code printing. The robotic arm is actuated by a servo motor and the motor is driven by a voltage input generated by a controller. The transfer functions describing the robot and motor are given as follows:

Robot $P(s)/T(s) = 2/(s^2 + 7s + 6)$

Motor $T(s)/V(s) = 2/s$

1). Assume the controller is a simple proportional control, draw the block diagram for this control system (2 points)

2). Can this system track a unit step input? Why? (4 points)

3). If there is a constant disturbance signal with magnitude 0.2 acting on the motor output, can the system reject this disturbance? Why? (4 points)

4). Follow the 7 steps to find the root locus of the system when the proportional control gain varies from 0 to infinity (10 points)

5). Design a compensator for the system such that the rise time is less than 0.73 sec and the peak time is 1.48 sec (10 points).