國立嘉義大學九十三學年度
生物機電工程學系碩士班招生考試（乙組）試題

科目：自動控制

1. Given the block diagram of a control system as figure 1.

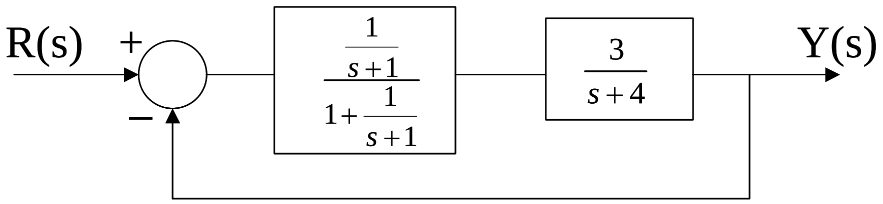

Figure 1.

(a) Find the transfer function of the system by block diagram manipulation. (6%)
(b) Convert the block diagram to signal flow diagram. (7%)
(c) Use Mason's rule to find the transfer function of the system. (7%)

2. The open-loop description of a servo system is given by the transfer function

$$G(s) = \frac{1}{s(1+1.2s+s^2)}$$

(a) Use the Nyquist plot to determine the gain and phase margins of the closed loop system. (7%)
(b) Check these stability margins by direct calculation of the gain and phase angles at the crossover frequencies. (7%)
(c) Confirm these findings by use of a Bode plot. (6%)

3. Given a control system with the following transfer function

$$T(s) = \frac{-5s^2+4s-12}{s^3+6s^2+s+3},$$

(a) Plot the complete simulation diagram in phase-variable form. (10%)
(b) Derive the state-variable equations in matrix form. (10%)

4. A fundamental electromechanical system is the servomechanism used, for example, to position a link, a robot arm, a radar tracking dish, a control surface in aircraft, process control valves, and machine tools. A representation of a simple servomechanism is as shown in Figure 2. Establish the overall transfer function between a demanded change in the output shaft position θ_d and the actual movement made by that shaft θ_o. Assume that the electrical side of the motor including the amplifier has an overall time constant of T_a and gain K_a in producing the motor torque; the load at the motor output has moment of inertia J and damping coefficient λ. The voltage to the amplifier is proportional to the difference between the demanded and output shaft positions such that $V = K(\theta_d - \theta_o)$. (20%)

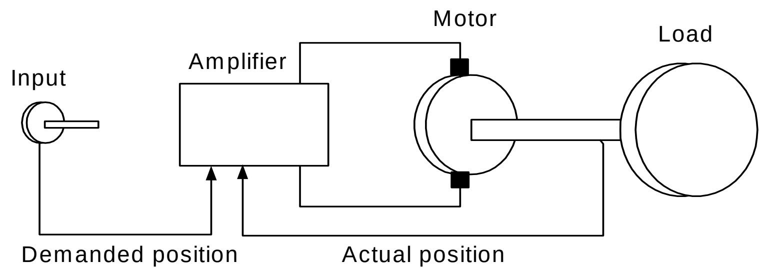

Figure 2.

5. A cylinder of mass *m* and polar moment of inertia *J* about its axis rolls without slip (Figure 3). A damping force is applied at a radius r from that axis, and a spring forces is applied at a radius 2r.

(a) Calculate the differential equation that relates *x* (horizontal displacement) to *F* (a horizontal force on the axis). (8%)
(b) Find the transfer function $G(s) = \frac{x(s)}{F(s)}$ (4%)
(c) For a unit step input find $x|_{t=\infty}$ using the final value theorem. (4%)
(d) If the damping in this system is negligible (i.e. c=0), what would be the final value of x with a unit step input. (4%)

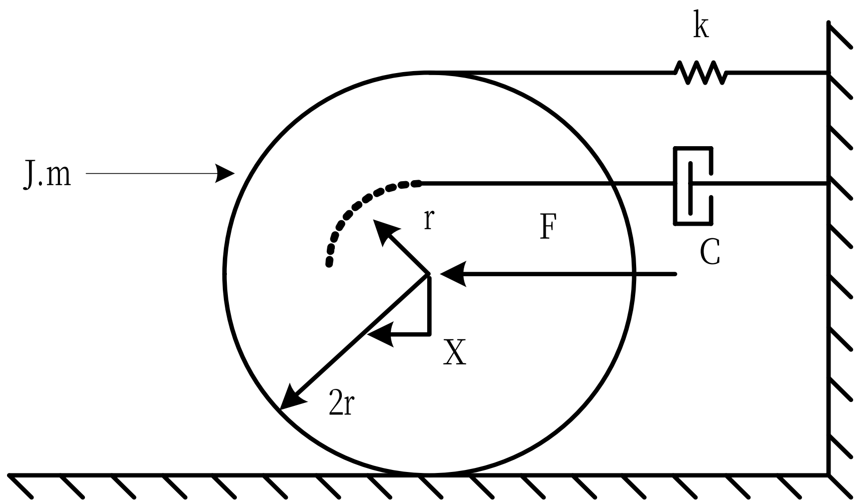

Figure 3