題號：340
科目：自動控制

國立臺灣大學99學年度碩士班招生考試試題

1~2 為簡答題，無須詳列計算後將答案清楚寫在答案紙上題號之後，如
1. (1) XXX; (2) XXX; (3) XXX
2. (1) (a) XXX; (b) XXX
   (2) (a) XXX; (b) XXX 以此類推

1. List three of the advantages of closed-loop control over open-loop control (9%)

2. The Nyquist diagrams for two stable, open-loop systems are sketched as Figure A:

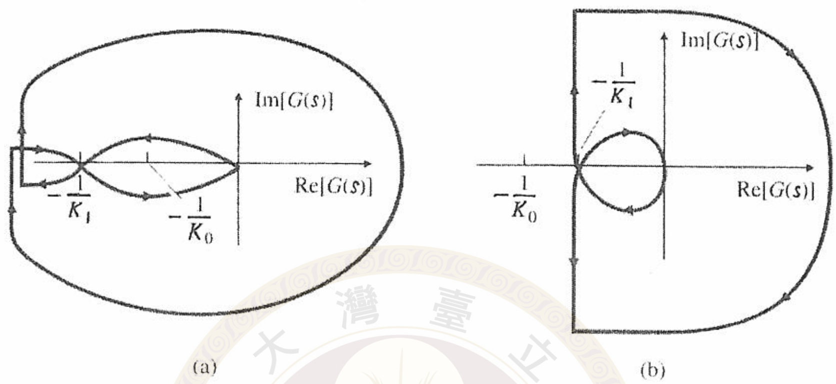

Figure A Nyquist plots for problem 2

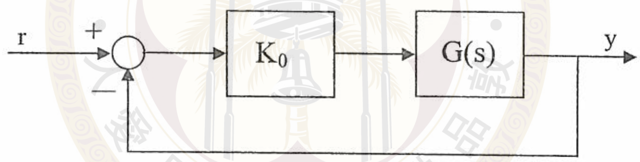

Figure B Control system for problem 2

The proposed operating gain is indicated as K_o, and arrows indicate increasing frequency. In each case give your best estimates of the following quantities for the closed loop system (as shown in Figure B):

(1) phase margin (4%)

(2) damping ratio (4%)

(3) range of gain for stability (if any) (4%)

(4) system type (0, I or II) (4%)

3. If a DC motor is modeled as:

$$Y(s) = \frac{A}{(\tau_1 s + 1)(\tau_2 s + 1)} V_a(s)$$

Please derive a PID controller ($k_p + k_i/s + k_d s$) so that the poles of the closed-loop system are as shown in Figure C. Express k_p, k_i, k_d in terms of three parameters related to the pole placement, σ(real part), ζ(damping ratio) and ω_n(undamped natural frequency). (15%)

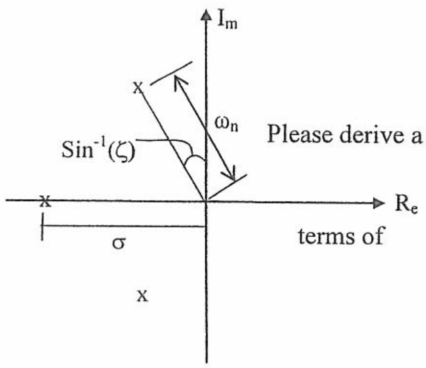

Figure C Pole placement for problem 3

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4. Consider the nonlinear autonomous system

$$\frac{d}{dt}\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} x_2(x_3 - x_1) \\ x_1^2 - 1 \\ -x_1 x_3 \end{bmatrix}$$

(a) Find the equilibrium points (4%)

(b) Find the linearized system about each equilibrium point (16%)

(c) For each case in part (b), what is the stability of the nonlinear system near the equilibrium point? (10%)

5. The frequency response data (Table A) and plot (Figure D) were taken from a DC motor that is to be used in a position control system. Assume that the motor is linear and minimum-phase.

Table A Frequency response data for problem 5

ω (rad/s)	|G(s)| (dB)	ω (rad/s)	|G(s)| (dB)	ω (rad/s)	|G(s)| (dB)
0.1	60.0	3.0	30.5	60.0	-20.0
0.2	54.0	4.0	27.0	65.0	-21.0
0.3	50.0	5.0	23.0	80.0	-24.0
0.5	46.0	7.0	19.5	100.0	-30.0
0.8	42.0	10.0	14.0	200.0	-48.0
1.0	40.0	20.0	2.0	300.0	-59.0
2.0	34.0	40.0	-10.0	500.0	-72.0

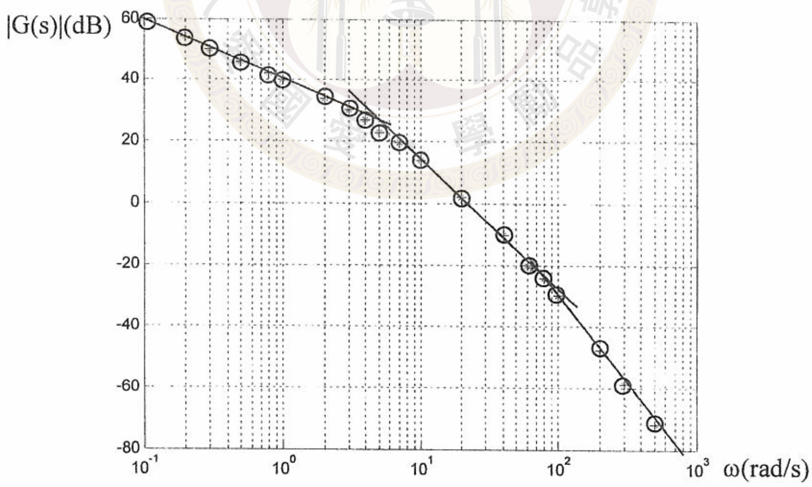

Figure D Frequency response plot for problem 5

(a) Estimate the transfer function G(s) (15%)

(b) Design a series compensator so that the closed-loop system meets the following specifications (15%)

- the steady state error to a unit ramp is less than 0.01
- phase margin PM > 40°