國立臺灣科技大學 110 學年度碩士班招生試題
系所組別：機械工程系碩士班丁組
科　　目：系統控制

**Problem 1. (20%)**

Please answer **the questions (a) to (d)** by choosing **from system (1) to system (6)**. It can be single or multiple answers for each question. Please write down your answers on the answer sheet. No credits will be awarded if you write down the answer on this examination paper.

System (1)

The Bode plot of the system (1) is shown as in the Figure 1.

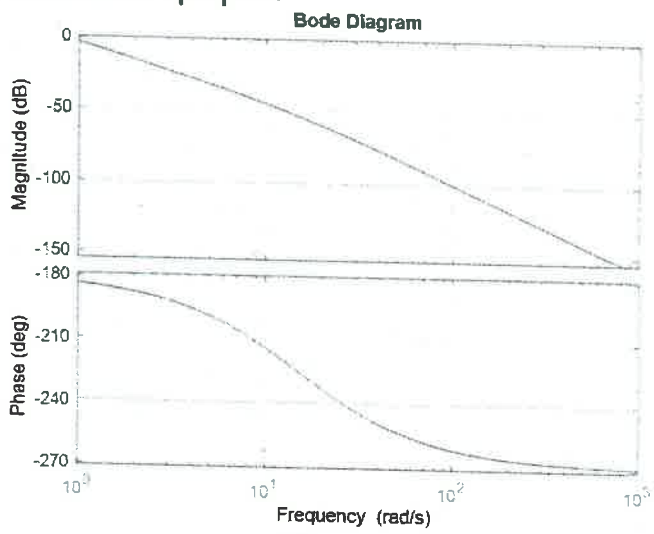



Figure 1.

System (2)

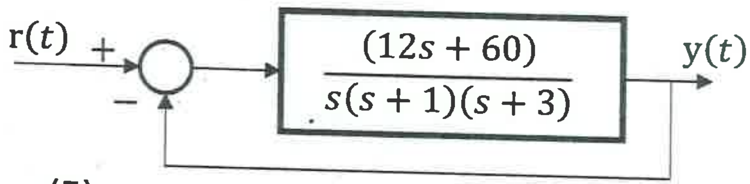
$$T(s) = \frac{(s+10)}{s(s+3)(s+5)}$$

System (3)

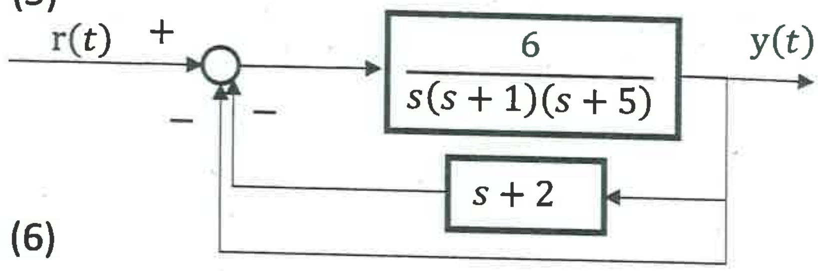
$$\dot{x}(t) = \begin{bmatrix} -50 & -600 \\ 1 & 0 \end{bmatrix} x(t) + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u(t)$$

$$y(t) = \begin{bmatrix} 3 & 3 \end{bmatrix} x(t)$$

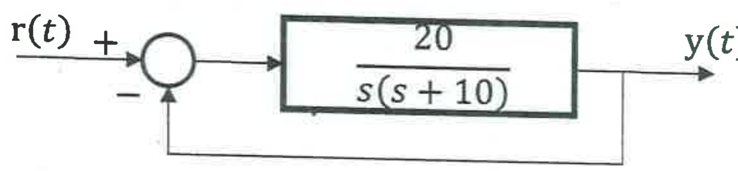
System (4)




System (5)




System (6)




**(a)** Which system is asymptotic stable? (5%)

**(b)** Which system has poles on the imaginary axis? (5%)

**(c)** Which system BIBO (bounded-input, bounded-output) stable? (5%)

**(d)** Which system has **zero** steady state error to **a step** input? (5%)

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**Problem 2. (20%)**

Please calculate the value of **α and β** in the system illustrated in Figure 2 so that the system will have **a peak time of 1 second and a settling time of 1.5 second** to a unit step input.

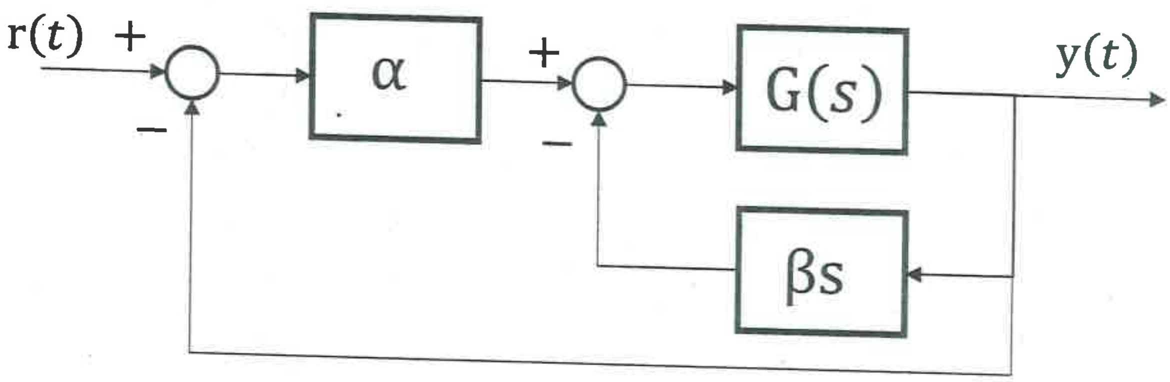


Figure 2

**where** $G(s) = \dfrac{20}{s(s+30)}$

For a general second-order transfer function $T(s)$, as following

$$T(s) = \frac{\omega_n{}^2}{s^2 + 2\xi\omega_n s + \omega_n{}^2}$$

The peak time $T_p$ is found as

$$T_p = \frac{\pi}{\omega_n\sqrt{1-\xi^2}}$$

The settling time $T_s$ is found as

$$T_s = \frac{4}{\xi\omega_n}$$

where $\xi$ is the damping ratio and $\omega_n$ is the natural frequency.

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**Problem 3. (20%)**

For the electrical circuit depicted in the Figure 3-1, please answer questions (a) to (c).

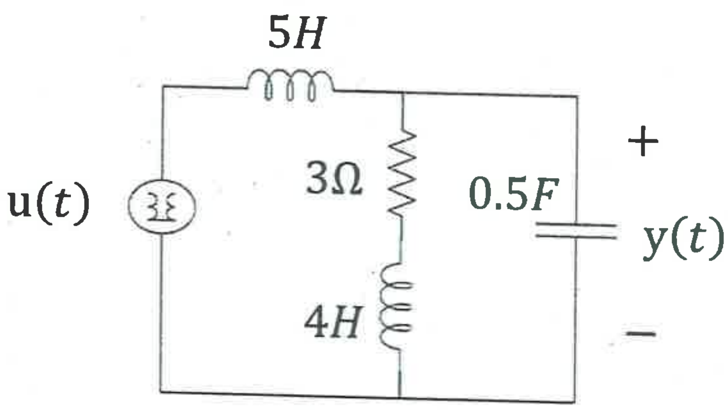


Figure 3-1

**(a) (7%)**

Find the transfer function of $G(s) = \dfrac{Y(s)}{U(s)}$

**(b) (8%)**

Represent the transfer function from (a), $G(s) = \left(\dfrac{1}{U(s)}\right)(Y(s))$,

in a block diagram with phase variables. (i.e. using integrator blocks and constant gain blocks such as in the Figure 3-2 to draw the system block diagram.)

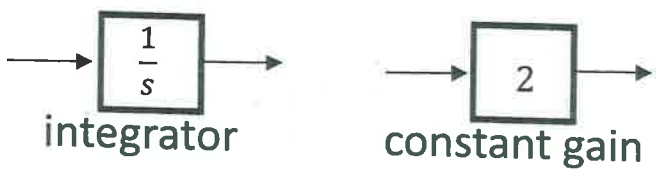


Figure 3-2 Examples of integrator and constant gain block

**(c) (5%)**

Write down a state space representation for the electrical system $G(s)$ using phase variables from (b).

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**Problem 4. (20%)**

For the translation mechanical system shown in Figure 4, the spring is nonlinear with $f_s = 1.5x^2$(N/m). The applied force is $f(t) = 6 + \delta f(t)$(N). The mass $\mathrm{M} = 1$ (kg) and the damping coefficient $\mathrm{B}$ =5 (N-s/m). The input is the applied force and the output is the displacement. Please answer questions (a) to (c).

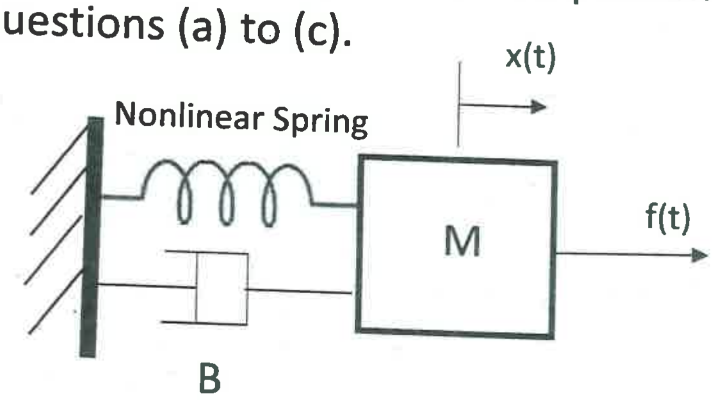


Figure 4

**(a) (7%)**

Find the linearized state space representation of this SISO system around its equilibrium $x_0$.

$$x(t) = x_0 + \delta x(t)$$

**(b) (7%)**

Find the transfer function for the linearized system.

**(c) (6%)**

Find the solution of $x(t)$ for $\delta f(t) = 0.1e^{-t}$. Assuming all initial condition is zero in the linearized system and the system starts at the equilibrium point.

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**Problem 5. (20%)**
For a feedback controlled system as depicted in Figure 5, please answer **questions (a) to (c).**

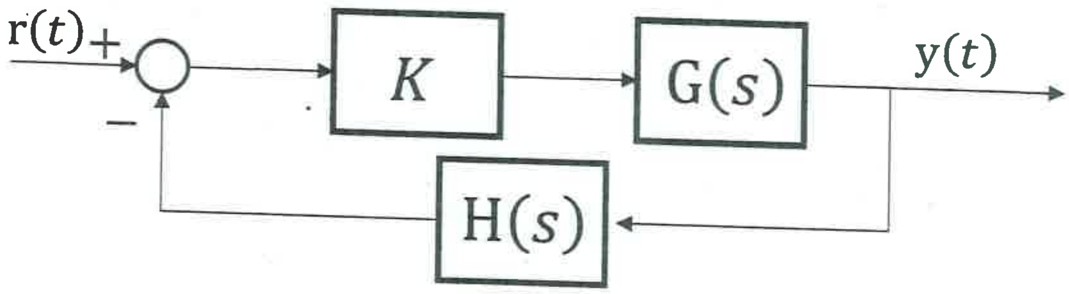

Figure 5

**where** $$G(s) = \frac{(s+10)}{s(s+3)(s+5)}$$

**(a) (8%)**
Plot the root locus and the asymptotes for the above feedback controlled system with $H(s) = 1$. Please indicate the corresponding value of K for the points which intersect the imaginary axis.

**(b) (5%)**
Find the static error constants $K_p$ (position constant), $K_v$ (velocity constant) and $K_a$ (acceleration constant) for $K = 10$ and $H(s) = 1$. Please indicate the system type based on the static error constants you found.

**(c) (7%)**
Plot the general root locus **with respect to α** for the above feedback controlled system with $K = 10$ and $H(s) = \frac{1}{(s+\alpha)}$.

**Note:**

$$s^3 + 8s^2 + 15s = s(s+3)(s+5)$$

$$s^4 + 8s^3 + 15s^2 + 10s + 100$$
$$= (s^2 + 9.326s + 23.02)(s^2 - 1.326s + 4.344)$$