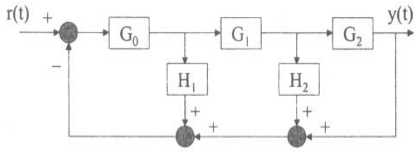
國立中正大學九十四學年度碩士班招生考試試題

系所別：光機電整合工程研究所　　　科目：自動控制

第3節

1. (15%) **Find the transfer function** from r(t) to y(t) in the following systems.

(1a) (5%) **DO NOT** use Mason's rule. No point will be given to solutions using Mason's rule.



(1b) (5%) Consider the following dynamics of an electro-mechanical system consisting of a DC motor and a mechanical load. Note that L, R, K, J, and B are constant parameters.

$$r(t) = L\frac{di(t)}{dt} + Ri(t) + K\omega(t)$$

$$J\frac{d\omega(t)}{dt} = Ki(t) - B\omega(t)$$

$$y(t) = \omega(t)$$

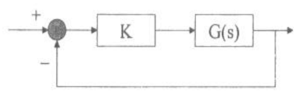
(1c) (5%) Consider the following approximate dynamics of an inverted pendulum on a moving cart. Note that M, m, L, and g are constant parameters.

$$r(t) = (M+m)\frac{d^2y(t)}{dt^2} + mL\frac{d^2\theta(t)}{d^2t}$$

$$mg\theta(t) = m\frac{d^2y(t)}{dt^2} + mL\frac{d^2\theta(t)}{d^2t}$$

$$y(t) = \theta(t)$$

2. (15%) Consider the following feedback system.



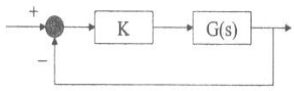
Use the root locus method to answer the following questions. **No point will be given to answers that are not based on the root locus method.**

(2a) (5%) For **negative K**, i.e., $-\infty < K < 0$, explain why the root locuses start at poles of G(s) and end at zeros of G(s) or goes to infinity as K varying from 0 to $-\infty$.

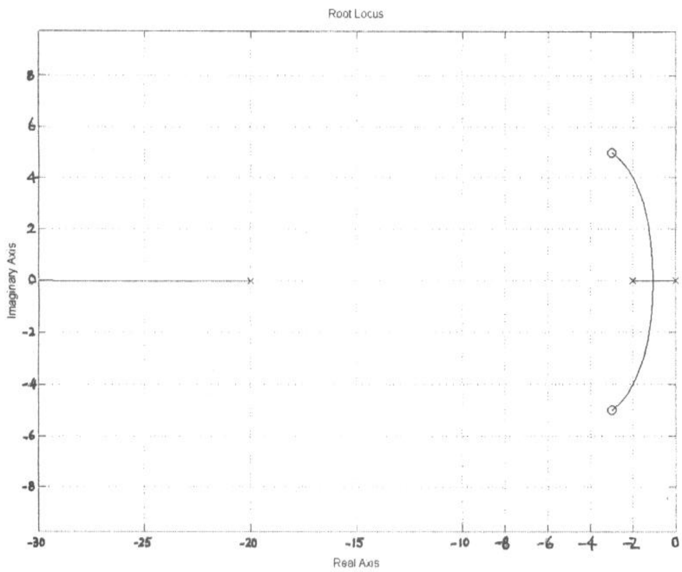
(2b) (5%) Consider **negative K**, i.e., $-\infty < K < 0$. Assume $G(s) = \frac{(s-2)}{s(s+1)(s+10)}$. Explain how you will find the root locus segments on the real axis.

(2c) (5%) Consider another case where $G(s) = \frac{(s+1)}{s(s+1)(s+10)}$. Notice there is a common factor in the numerator and denominator polynomials. When plotting the root locus, do we need to be concerned with the effect of the common factor? Why?

3. (20%) Consider the following feedback control system



where $G(s) = \dfrac{s^2 + 6s + 10}{s(s+2)(s+20)}$ and K > 0. Its root locus plot is shown below.



(3a) (10%) Use the root locus plot to determine a feedback gain such that the step response of the closed-loop system has an overshoot less than 5%. Explain your solution approach and note that $e^{-\pi} = 0.043$.

(3b) (10%) From the root locus plot, take the fractional expansion of the Laplace transform of the step response to explain why the closed-loop behavior is similar to a second order system.

4. (4a) (10%) Please find the damping ratio and natural frequency of the system

$$G_1(s) = \frac{4}{s^2 + s + 4}$$

Also, find the steady-state response of the system due to a ramp input.

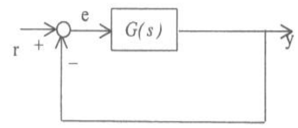
(4b) (10%) Consider two other systems given by

$$G_2(s) = \frac{s+1}{s^2 + s + 4} \text{ and } G_3(s) = \frac{-0.2s + 4}{s^2 + s + 4}$$

Please discuss the differences in the unit step responses of G_2, and G_3 and the G_1 specified in part (4a). (You do not need to solve for the unit step responses. Note the effects of zeros.)

(4c) (5%) Explain what the non-minimum plant is and its behavior?

5. (25%) Given a unit feedback system as shown in the figure below, where r is the reference, y is the output and e is the error.



The transfer function is given as:

$$G(s) = \frac{100}{(s+2)(s+20)}$$

(5a) (15%) Plot the asymptotic approximate Bode diagram.

(5b) (10%) Find the approximate gain margin and phase margin using the results in (5a).