※ 考生請注意：本試題不可使用計算機

1. (25%)

A feedback control system and the Bode plots of loop transfer function, $L(s)=G(s)C(s)$, are shown below, where K_Δ is the modeling uncertainty. In order to investigate what value of K_Δ can be tolerated in this feedback system to keep stable, please do the following analysis.

(1) (5%) Please draw the Nyquist plot of $L(s)$.

(2) (5%) Please draw the Nichols plot of $L(s)$

(3) (5%) If K_Δ is a positive real number, please draw the root loci when K_Δ varies from 1 to 10.

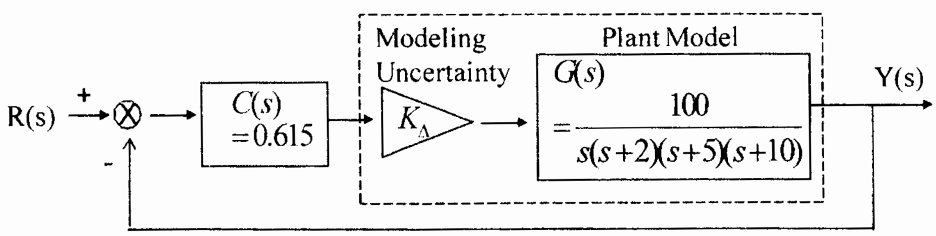
(4) (10%) Now, if K_Δ is a complex number and of the form,

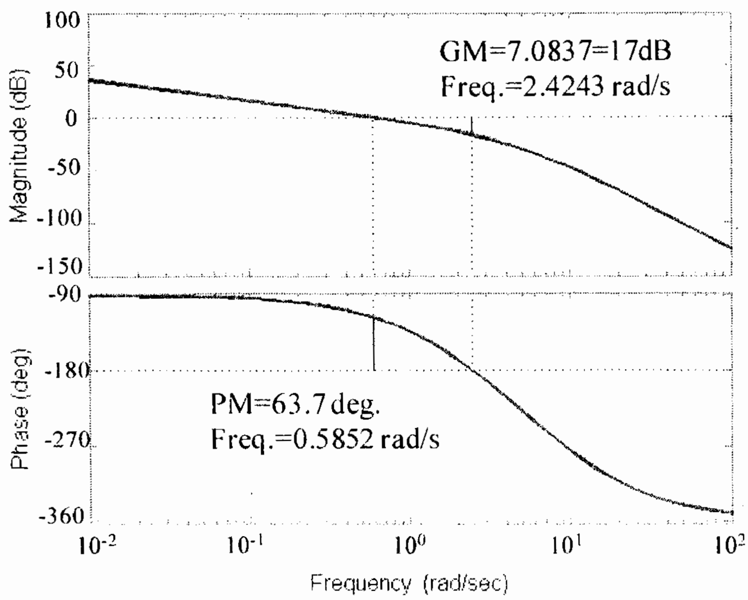
$$K_\Delta = e^{-j\theta},$$

and a control-engineer proposes a method called "phase loci" by varying θ to see how the roots change in the equation,

$$1+e^{-j\theta}G(s)C(s)=0.$$

Explain what would be the value of θ that makes the branch intersect the imaginary axis and the corresponding intercept value?





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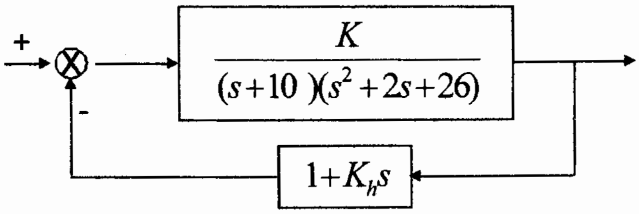
2. (25%)

A control system shown below will become unstable as K increases if $K_h=0$. However, an added zero from the feedback can change this situation.

(1) (15%) Please use root-locus method to investigate the effect of increasing the value of K_h.

(2) (10%) Based on your result in (1), please discuss how to determine proper values of K and K_h if your concerns are both the performance and the stability of the system.



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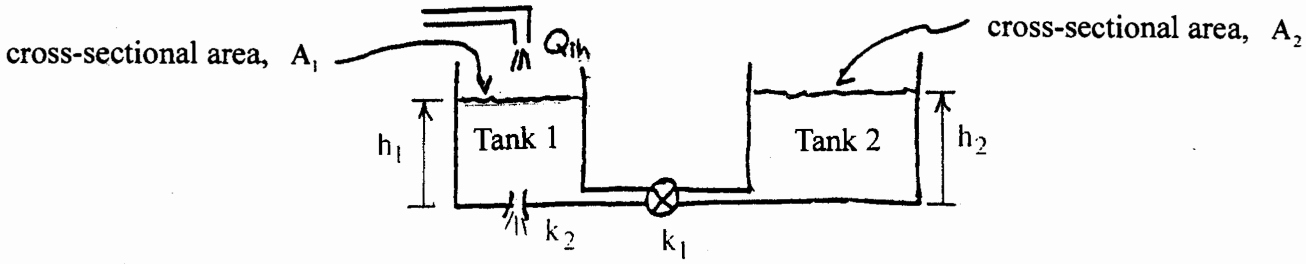
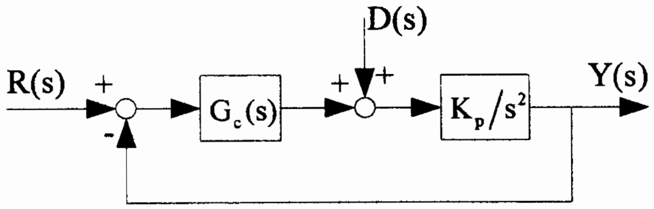
3. A two-tank system is used in a process plant, as shown in the following figure. The flow rates between tanks and draining from tank 1 are linearly proportional (gains: k_1 and k_2, respectively) to height difference and the height of tank 1, respectively.

(1) Find the transfer function between inflow to tank 1, $Q_{in}(t)$, and the output, $h_2(t)$. (8%)

(2) For a unit impulse input in inflow (i.e. a sudden addition of liquid) find the initial value of $\dot{h}_2(t)$ if $A_1=1$, $A_2=1$, $k_1=1$ and $k_2=1$. (5%)



4. A mechanical system is modeled to be a double integrator plant k_p/s^2. The input and output are force and position respectively. The block diagram for positioning feedback control is sketched below.



(1) Assume that the controller is of PD-type: $G_c(s)=K_c(1+T_d s)$. Find the unit step disturbance response.

(Assume $(K_cK_pT_d)^2-4K_cK_p>0$.) (10%)

(2) Show that if the control gain K_c of the PD controller is set large, the dominant mode becomes close to e^{-t/T_d}. Find the unit step disturbance response for large K_c retaining only the dominant mode. (12%)

(3) Let the mechanical system include a vibrating mode which has been ignored in the model k_p/s^2.

Let a more realistic plant model be $K_p\left[\frac{1}{s^2}-\frac{1}{s^2+2\varsigma w_n s+w_n^2}\right]$.

In this case a large control gain K_c is not a good idea. Show a sample root locus plot when the control gain K_c in the PD controller is changed from 0 to ∞. Find the condition in terms of w_n, ς and T_d so that the closed loop system remains stable for all positive K_c. (15%)