國立臺灣科技大學103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

（總分為100分）

1.

(a) What is a "causal" system? (5%)

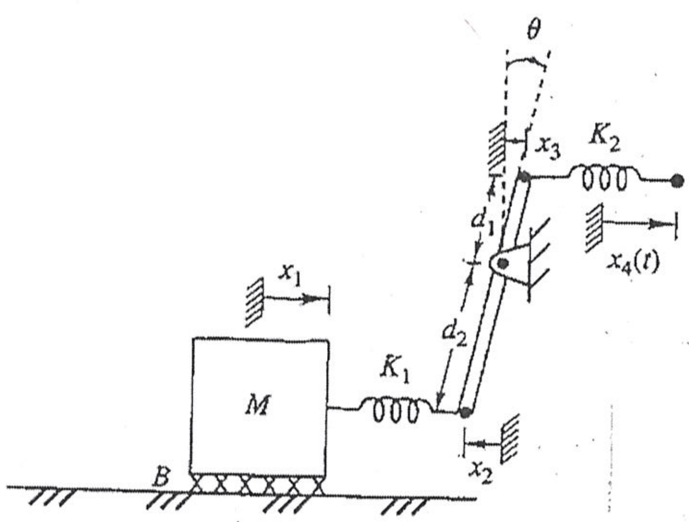
(b) Explain the goal of "sensitivity function" in the control design from the "frequency domain" perspective. (5%)

(c) What does "non-minimum phase zero" mean? (5%)

(d) If a stable system has no zeros, it can go unstable using proportional control if it at least has how many poles? (Guessing without analysis gives NO credit.) (5%)

(e) Write the transfer function for a system with 16% overshoot and a 98% settling time of 0.8 seconds. (5%)

2. Consider a practical dynamic system which is modeled as the following translational system containing a lever, where the input is the displacement $x_4(t)$ and the output is the displacement of mass M. The lever has a fixed pivot and is assumed to be massless yet rigid. Assume angle θ is small. K_1 and K_2 represent the stiffness of the lever and of associated linkages that have a certain degree of flexibility.



Note: The model parameter values are $d_1 = 1$, $d_2 = 2$, $K_1 = 1$, $K_2 = 4$, $M = 0.5$, $B = 1$, $\theta \neq 0$.

(a) Derive the governing equation using physical law. (5%)

(b) Find the transfer function $X_1(s)/X_4(s)$ with the above parameter values. (5%)

(c) Find the unit step response of the system in part (b). (5%)

(d) Suppose the moment of inertia of the lever cannot be ignored and let J denote the lever's moment of inertia about the pivot point. Now derive the governing equation using physical law again. (5%)

(e) The value of J is given as 4. Find the transfer function $X_1(s)/X_4(s)$ for the system in part (d). (5%)

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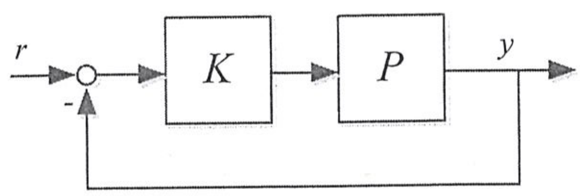
3. Consider the undamped mechanical system shown below, where the plant model is

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



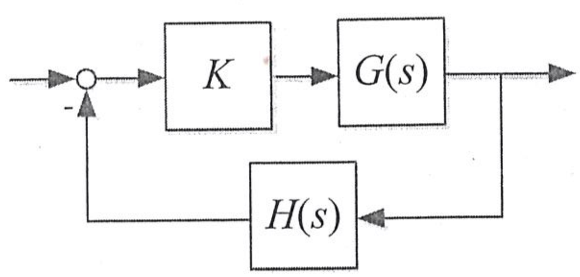
As a control engineer you need to design stabilizing controllers that satisfy the following control specifications. To get FULL credits you have to clearly write down the design process and explain how you choose the design parameter values.

(a) Design K(s) such that K(s) has as many poles as zeros. (5%)

(b) Design K(s) such that the feedback control system has zero steady state error to a step command $r(t) = 1$. (10%)

(c) Design K(s) such that the feedback control system has zero steady state error to a sinusoidal command $r(t) = \sin(t)$. (10%)

4. A remote-controlled robot manipulator is simply modeled as the following control block diagram. $G(s) = \frac{1}{(\tau s + 1)}$ is the actuator with time constant τ and $H(s) = e^{-Ts}$ is the time delay due to communication.



(a) Sketch the Bode plot of the open-loop system $KG(s)H(s)$ for the case where $T = 0$, i.e., no time delay. (5%)

(b) Sketch the Bode plot for the case where $T \neq 0$ and explain how the time delay can de-stabilize the control system. (7%)

(c) Use Taylor series expansion for e^{-Ts} to approximate the time delay term assuming $T \approx 0$. Compare the Bode plot of the approximated system with that of part (b). (8%)

(d) Continued with part (c), sketch the root locus of the system when $\tau = 1$ and $T = 0.1$ and explain how the time delay can de-stabilize the control system. (5%)