國立台灣科技大學九十七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

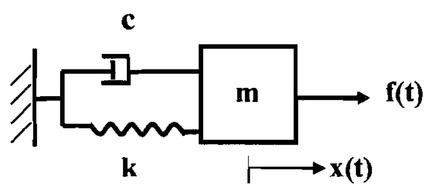
Total 100 points

1. Please give an example in differential equation description for each system below:
   (a) SISO 1st-order LTI system (5%)
   (b) SISO 2nd-order LTI control system (5%)
   (c) MISO 1st-order LTI control system (5%)
   (d) MIMO 2nd-order LTV control system (5%)
   Hint: All symbols in the system should be well defined.

2. Answer the following questions:
   (a) What would happen in realizing a control system containing illegal pole-zero cancellations? (5%)
   (b) What is a non-minimum phase system, and please give a practical example for describing its characteristics. (5%)
   (c) State the separation principle. (5%)
   (d) What are the differences among stability, asymptotical stability and marginal stability? (5%)
   (e) You are asked to design a controller for a mechanical table driven by a servo motor. Suppose the bandwidth for the table, motor, and driver are respectively ω_t, ω_m, and ω_d. Which one of these bandwidths is the largest and which one is the smallest? State the reason. (5%)
   (f) Please write code for realizing a PI controller in any available computer language. (5%)

國立台灣科技大學九十七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

3. Consider a mass m connected to a spring (spring constant k) and a damper (damping coefficient c) slides on a smooth horizontal table. An external force $f(t)$ is applied resulting in displacement $x(t)$ from the equilibrium point.



(a) Draw a free body diagram (FBD) of mass m for arbitrary displacement $x(t)$ and show that the equation of motion:

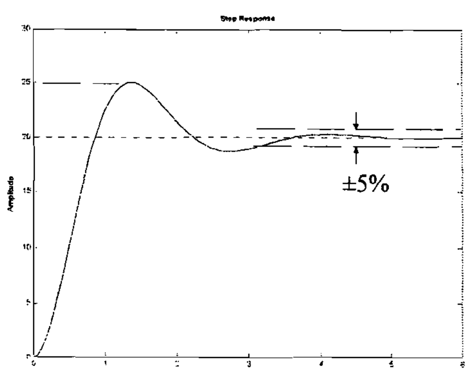
$$m\ddot{x}(t)+c\dot{x}(t)+kx(t)=f(t)$$

Clearly state which rule is used. (5%)

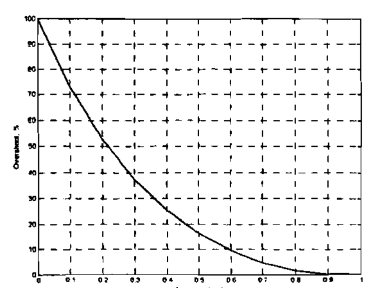
(b) Put the differential equation in (a) in state space format. Assume the input is the external force $f(t)$, output is the displacement $x(t)$, and the two states are the displacement $x(t)$ and velocity $\dot{x}(t)$. (5%)

(c) Find the transfer function $G(s)=\dfrac{X(s)}{F(s)}$. (5%)

(d) To identify the value of m, k and c, a unity step force is applied, i.e. $f(t)=1$. The step response of the displacement $x(t)$ is shown in the figure below. Use the following information to determine the value of m, k and c. (7%)



Settling time (±5%): $t_s=\dfrac{3}{\varsigma\omega_n}$



國立台灣科技大學九十七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

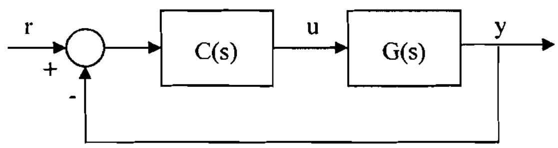
4. Consider the following system with input $u(t)$ and output $y(t)$:

$$\frac{d}{dt}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 2 & 1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} -1 \\ -1 \end{bmatrix} u(t)$$

$$y(t) = \begin{bmatrix} \tfrac{1}{2} & -\tfrac{1}{2} \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

(a) Find the transfer function $G(s) = \dfrac{Y(s)}{U(s)}$. (7%)

(b) A unity feedback configuration is used:



If the controller C(s) is of proportional type (i.e. C(s)=K, a constant), find the range of K so that the closed-loop system is stable. (7%)

(c) Use Nyquist plot to double check the results of (b). Clearly state which transfer function you are plotting. (7%)

(d) Choose another controller C(s) to stabilize the system. It is **NOT** necessary to find exact values for the gains, but use a diagram or other method to indicate how stability depends on the controller gains. (7%)