國立中正大學 114 學年度碩士班招生考試試題

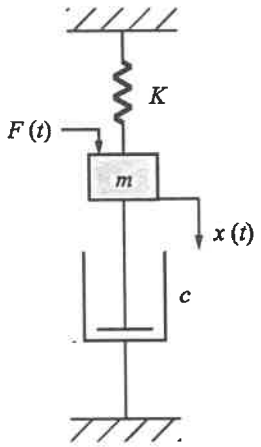
科目名稱：自動控制　　本科目共 2 頁　第 1 頁

系所組別：機械工程學系-乙組

1. (10%) For the following relaxed MCK mechanical system, please derive the transfer function:

$$G(s) = \frac{X(s)}{F(s)},$$

where $X(s)$ and $F(s)$ represent the Laplace transforms of displacement $x(t)$ and external force $F(t)$, respectively.



2. (10%) For a unity feedback control system as shown in the following figure, if its open-loop transfer function

$$G(s) = \frac{25}{s(s+5)}$$

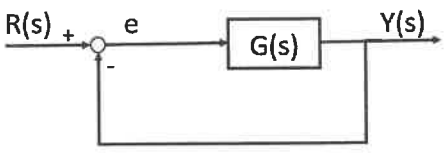
is given, determine the system's rise time (from 10% to 90%) and maximum overshoot, where the control input is a unit step input.

Hint: the rise time formula is

$$t_r = \frac{\pi - \cos^{-1}(\xi)}{\omega_n\sqrt{1-\xi^2}}$$

and maximum overshoot formula is

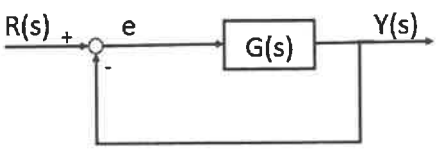
$$M_o = e^{-\frac{\pi\xi}{\sqrt{1-\xi^2}}}$$



3. (15%) For the feedback system shown in the figure below, if the transfer function

$$G(s) = \frac{12(s+3)}{s(s+1)(s+2)}$$

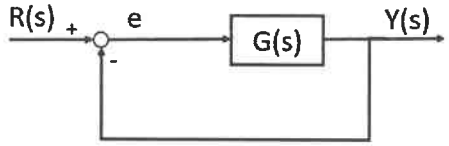
is given, try to determine the system's position error constants K_p, velocity error constant K_v and acceleration error constant K_a.



4. (15%) Given that the open-loop transfer function of the unity feedback system is

$$G(s)=\frac{K(0.5s+1)}{0.5s^2+s+1},$$

try to plot the root locus of the closed-loop system.



5. (25%) Consider the first-order dynamics G described by the following differential equation:

$$\dot{y}+y=u\,;y(0)=0\,,$$

where y is the output and u is the input.

(a) (5%) Calculate the transient and forcing responses of y as G is submitted to a sinusoidal input:

$$u(t)=\sin(\omega t)\equiv Im\left(e^{j\omega t}\right),$$

where ω is the input frequency.

(b) (5%) Based on (a), what is the frequency response of G?

(c) (3%) Based on (b), sketch the Bode plot of G.

(d) (2%) Based on (c), sketch the Nyquist plot of G.

(e) (2%) What is the DC-gain of G?

(f) (2%) What is the bandwidth of G?

(g) (2%) Is G a low-pass filter and phase-lag compensator?

(h) (2%) What is the gain margin of G?

(i) (2%) What is the phase margin of G?

6. (25%) Consider the second-order dynamics G described by the following differential equation:

$$m\ddot{y}+b\dot{y}+ky=0\,;m>0\,,k>0\,,$$

where y is the dependent variable.

(a) (20%) Prove by Nyquist Criterion that G is asymptotically stable for all $b>0$.

(b) (5%) Prove by Nyquist Criterion that G is unstable for all $b<0$.