THE HONG KONG POLYTECHNIC UNIVERSITY

HONG KONG COMMUNITY COLLEGE

Subject Title : Flight Control Systems **Subject Code** : CCN2297

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Numerical Answers

Question A2

The 3 signals are 5u(t), 2tu(t) and t2/2*u(t) respectively.

Let steady state errors are ess1, ess2 and ess3 respectively. Then, we have:

$$e_{ss} = e_{ss1} + e_{ss2} + e_{ss3}$$

$$\Rightarrow e_{ss} = 0 + 0 + 1 = 1$$

Question A3

$$\begin{cases} t_p = \dfrac{\pi}{\sqrt{1-\xi^2}\,\omega_n} = 0.1 \\ \sigma\% = e^{-\xi\pi/\sqrt{1-\xi^2}} = 33.3\% \end{cases} \qquad \begin{cases} \xi = 0.33 \\ \omega_n = 33.28 \end{cases} \qquad \begin{cases} K_1 = \omega_n^2 = 1108 \\ a = 2\xi\omega_n = 22 \end{cases}$$

$$h(\infty) = \lim_{s\to 0} s\Phi(s)\cdot\frac{1}{s} = \lim_{s\to 0}\frac{K_1K_2}{s^2 + as + K_1} = K_2 = 3$$

Question A4

(b) $D(s) = s^5 + s^4 + 4s^3 + 4Ks^2 + 2Ks + K = 0$

The value to make system stable is: $0.536 < K < 0.933$

Question B1

(a) Type 1 system with order 2

(c) $\sigma_p = e^{-\pi\zeta/\sqrt{1-\zeta^2}} \times 100\%$

$$t_s = \frac{3}{\zeta\omega_n} = \frac{3}{\sigma}$$

Hence, we have:

$$\beta\uparrow \begin{cases} \xi\uparrow \quad \rightarrow \quad \sigma\%\downarrow \\ t_s = \dfrac{3.5}{\xi\omega_n} = \dfrac{7}{\beta K_2}\downarrow \end{cases} \qquad (0 < \xi < 1)$$

(d) The steady state error is directly proportional to the increase of β.

$$\beta\uparrow \quad \rightarrow \quad e_{ss} = \frac{a}{K} = \frac{a\beta}{K_1}\uparrow$$