國立臺灣科技大學 107 學年度碩士班招生試題

系所組別：自動化及控制研究所碩士班

科　　目：自動控制系統

(總分為 100 分)

1. A negative feedback system is represented by the following equation

$$F(s) = s^3 + 10s^2 + 29s + k.$$

Shift the vertical axis of the s-plane to the right by two units using the condition $s = s_1 - 2$ and determine the value of the gain k so that the complex roots are at $s = -2 \pm j$. (10%)

2. A controller for a satellite attitude control with transfer function $G = \frac{1}{s^2}$ has been designed with a unity feedback structure and has the transfer function $D_c(s) = \frac{10(s+2)}{s+5}$.
   (a) Find the system type for reference tracking and the corresponding error constant for this system. (10%)
   (b) If a disturbance torque adds to the control so that the input to the process is $u + w$, what is the system type and corresponding error constant with respect to disturbance rejection? (10%)

3. For the system in Figure 3, determine the Nyquist plot and apply the Nyquist criterion
   (a) To determine the range of values of K (positive and negative) for which the system will be stable, and (5%)
   (b) To determine the number of roots in the RHP for those values of K for which the system is unstable. Check your answer by using a rough root-locus sketch. (5%)

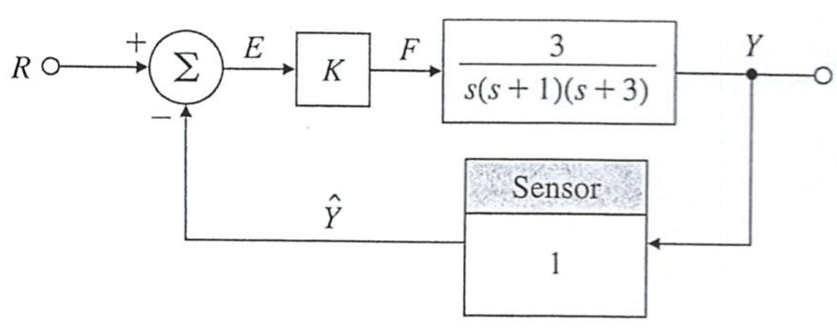

Figure 3

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4. Consider the second order unity DC gain system with an extra zero,

$$H(s) = \frac{\omega_n^2(s+z)}{z(s^2+2\zeta\omega_n s+\omega_n^2)}$$

(a) Show that the unit-step response is given by

$$y(t) = 1 - \frac{\sqrt{1+\frac{\omega_n^2}{z^2}-\frac{2\zeta\omega_n}{z}}}{\sqrt{1-\zeta^2}} e^{-\sigma t}\cos(w_d t+\beta_1),$$

where $\beta_1 = \tan^{-1}\frac{-\zeta+\frac{\omega_n}{z}}{\sqrt{1-\zeta^2}}$. (10%)

(b) Derive an expression for the overshoot, M_p, for this system. (10%)

(c) For a given value of overshoot, M_p, how do we solve for and ζ_n and ω_n? (10%)

5. An airline has opened a free bar in the tail of their airplanes in an attempt to lure customers. In order to automatically adjust for the sudden weight shift due to passengers rushing to the bar when it first opens, the airline is mechanizing a pitch-attitude autopilot. Figure 5 shows the block diagram of the proposed arrangement. We will model the passenger moment as a step disturbance $M_p(s) = M_0/s$, with a maximum expected value for M_0 of 0.6.

(a) What value of K is required to keep the steady-state error in θ to less than 0.02 rad ($\cong 1^\circ$)? (Assume the system is stable.) (5%)

(b) Draw a root locus with respect to K. (10%)

(c) Based on your root locus, what is the value of K when the system becomes unstable? (5%)

(d) You are given a black box with rate gyro written on the side and told that when installed, it provides a perfect measure of $\dot{\theta}$, with output $K_T\dot{\theta}$. Assume $K = 600$ and sketch a root locus with respect to K_T. (Hint: two of poles are around -13.5014 and -2.9352.) (10%)

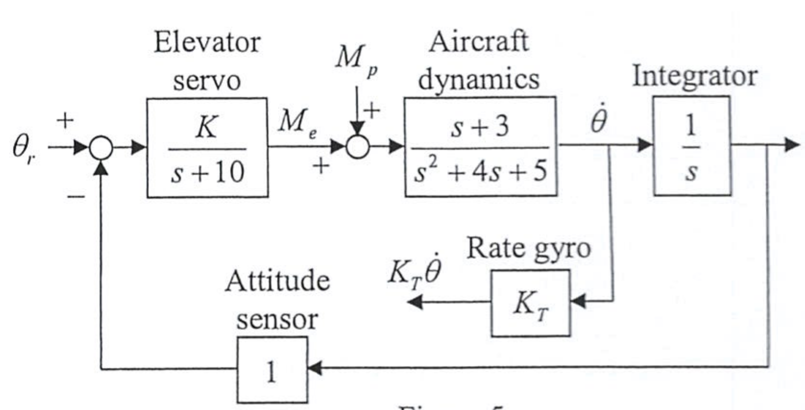

Figure 5