STUDENT NUMBER...

CONTROL SYSTEMS - 7/4/2018

[time 2 hours; no textbooks; no programmable pocket calculator]

1) Given

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

design a controller $G(s)$ such that the feedback system $W(s) = \frac{PG(s)}{1+PG(s)}$

(i) is asymptotically stable (use the Nyquist criterion)

(ii) has zero steady state errors to inputs $v(t) = t$ (i.e. $e_1 = 0$) and steady state output response to output disturbances $d(t) = \frac{t^2}{2}$ in absolute value less than 0.1 (i.e. $|y_2| \leq 0.1$)

and the open loop system $PG(s)$ has

(iii) crossover frequency $\omega_t^* = 0.1$ rad/sec and phase margin $m_\phi^* \geq 60°$.

2) Given

$$P(s) = \frac{s+1}{(s+5)^2(s+4)}$$

a) Draw the root locus using the Routh criterion to determine the exact picture on the imaginary axis
b) Determine, if any, a controller $G(s) = K$ such that the feedback system $W(s) = \frac{PG(s)}{1+PG(s)}$ is asymptotically stable with poles p such that $Re(p) \leq -3$.
c) Determine a controller $G(s)$ such that the feedback system $W(s) = \frac{PG(s)}{1+PG(s)}$ is asymptotically stable with poles p such that $Re(p) \leq -3$ and its steady state output response to inputs $v(t) = 1$ is zero.

3) Given a plant with input u and output y, if the output step response (N.B. the step response is the response to a constant input $u(t) = 1$) is

$$y(t) = 1 - e^{-t}(t+1)$$

- calculate the impulsive response $P(t)$ $(P(t) = Ce^{At}B + D\delta_0(t))$
- give a state representation of the plant $(\dot{x} = Ax + Bu, , y = Cx + Du)$
- calculate the forced output response to an input $u(t) = t - j$ per $t \in [j, j+1)$, $j = 0, 1, \ldots$.