NAME, SURNAME AND STUDENT NUMBER (* required fields):

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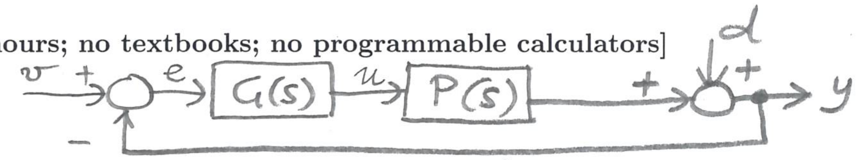
CONTROL SYSTEMS (A) - 4/6/2019

[time 3 hours; no textbooks; no programmable calculators]

1) Given



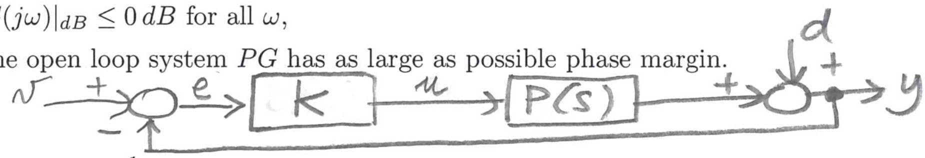
with $P(s) = \frac{1}{s^3}$ design a controller $G(s) = K\left(\frac{1+\tau_1 s}{1+\tau_2 s}\right)^2$ such that

(i) the feedback system $W(s) = \frac{PG(s)}{1+PG(s)}$ is asymptotically stable (use the Nyquist criterion with reasonable approximations for the Bode plots) and its steady state output y_{ss} to disturbances $d(t) = \sin \omega t$ is such that $|y_{ss}| \leq 0.11$ for all $\omega \in [0, 0.1]$ rad/sec,

(ii) $|G(j\omega)|_{dB} \leq 0\, dB$ for all ω,

(iii) the open loop system PG has as large as possible phase margin.

2) Given



with $P(s) = \frac{1}{(s^2+a^2)(s+9)}$, determine for which real values of K and a the feedback system $W(s) = \frac{KP(s)}{1+KP(s)}$ has the following properties:
i) it is asymptotically stable
ii) all its poles are real and negative.
Draw the root locus of $P(s)$. Choose any value of K and a for which (i) and (ii) are satisfied and calculate the steady state response $y_{ss}(t)$ to disturbances $d(t) = \sin(at)$.

3) Given the system $\dot{x} = Ax + Bu$ with

$$A = \begin{pmatrix} 0 & 1 \\ -\alpha & -(1+\alpha) \end{pmatrix}, \quad B = \begin{pmatrix} \beta \\ -\beta \end{pmatrix}$$

discuss the values of $\alpha, \beta \in \mathbb{R}$ and $\gamma > 0$ for which there exists a control law $u = Fx$ such that the eigenvalues of $A + BF$ have real part $\leq -\gamma$ and determine F.