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

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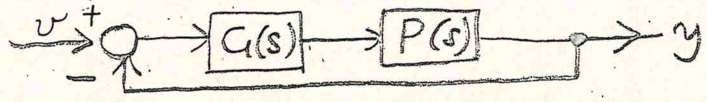
CONTROL SYSTEMS - 23/3/2019

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

1) Given



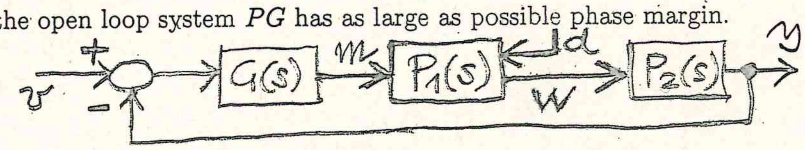
with $P(s) = \frac{1}{(s-1)(s+1)}$ design a 1-dimensional controller $G(s)$ such that

(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 error e_{ss} to inputs $v(t) = \delta_{-1}(t)$ is such that $|e_{ss}| \leq 1$,

(ii) $20log_{10}|G(j\omega)| \leq 26dB$;

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

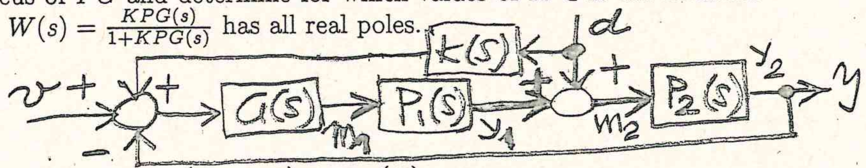
2) Given



$$P_1 : \dot{x} = \begin{pmatrix} 0 & 0 \\ 0 & -2 \end{pmatrix} x + \begin{pmatrix} 1 \\ 0 \end{pmatrix} m + \begin{pmatrix} 0 \\ 1 \end{pmatrix} d, \; w = (1 \;\; 0)\, x, \qquad (1)$$

and $P_2(s) = \frac{s-1}{s+1}$, determine, if any, a 2-dimensional controller $G(s)$ such that the given feedback system has the following properties:
i) it is asymptotically stable with poles having negative real part ≤ -2
ii) the steady state output response y_{ss} to constant disturbances $d(t)$ is 0.
Set $d(t) = 0$. Let PG the series interconnection of P_1, P_2 and G. Draw the root locus of PG and determine for which values of $K \in \mathbb{R}$ the feedback system $W(s) = \frac{KPG(s)}{1+KPG(s)}$ has all real poles.

3) Given



$$P_1 : \dot{x}_1 = \begin{pmatrix} 0 & -10 \\ 1 & -11 \end{pmatrix} x_1 + \begin{pmatrix} 2 \\ 1 \end{pmatrix} m_1, \; y_1 = (0 \;\; 1)\, x_1,$$

$$P_2 : \dot{x}_2 = -2x_2 + m_2, \; y_2 = x_2,$$

determine, if any, controllers $G(s)$ and $K(s)$ such that the given feedback system has the following properties:
i) the input-output (from v to y) transfer function $W(s)$ has two complex poles at $-1 \pm j$
ii) the disturbance-output (from d to y) transfer function $W_d(s)$ is such that $|W_d(j\omega)| \leq 0.1$ for all $\omega \in [0, 10]$ rad/sec.