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

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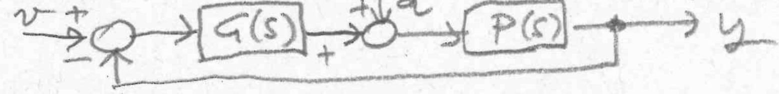
CONTROL SYSTEMS - 5/2/2019 (A)

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

1) Given



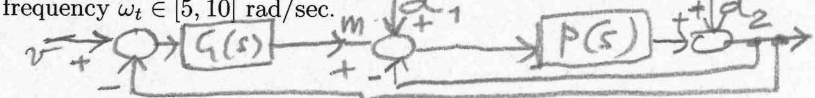
with $P(s) = \frac{s+1}{s^2}$ design a controller $G(s)$, if any, such that

(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 response y_{ss} to constant disturbances d is 0,

(ii) $|j\omega G(j\omega)|_{dB} \leq 36$ dB for all ω,

(iii) the open loop system PG has phase margin $m_\phi \geq 30°$ and crossover frequency $\omega_t \in [5, 10]$ rad/sec.

2) Given



with $P(s) = \frac{s+2}{s^3-2s^2-2}$, 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 ≤ -1
ii) the steady state output response to constant disturbances d_2 is 0
ii) the absolute value of the steady state output response to unit ramp disturbances d_1 (i.e. $d_1 = t$) is ≤ 0.1.

3) Given $P(s) = \frac{(s+1)^2}{(s^2+1)(s-1)}$ draw the root locus of P and design, if any, a controller $G_1(s) = K$ such that the closed-loop system $W(s) = \frac{PG_1(s)}{1+PG_1(s)}$ is asymptotically stable. With $G_1(s) = \frac{1}{s}$ draw the root locus of PG_1 (help: the positive root locus has the singular points $s \approx 0.2 \pm 0.6j$ for $k \approx 0.2$ and $s \approx 0.4$ for $k \approx 0.1$; the negative root locus has the singular point $s \approx -2.4$ for $k \approx -28$). Design, if any, a controller $G_2(s) = K$ such that the closed-loop system $W(s) = \frac{PG_1G_2(s)}{1+PG_1G_2(s)}$ is asymptotically stable.

4) Given the system

$$\dot{x} = \begin{pmatrix} 0 & 1 \\ 0 & 0 \end{pmatrix} x + \begin{pmatrix} 1 \\ 0 \end{pmatrix} d + \begin{pmatrix} 0 \\ 1 \end{pmatrix} u, \quad y = (1 \quad 0)\, x, \tag{1}$$

with state $x \in \mathbb{R}^2$, control u, controlled output y, disturbance $d = D \sin t$, with unknown $D \in \mathbb{R}$, and reference input $v = \delta_{-1}(t)$, find, if possible, a controller such that the closed loop system is asymptotically stable and its steady state output response y_{ss} is v.