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

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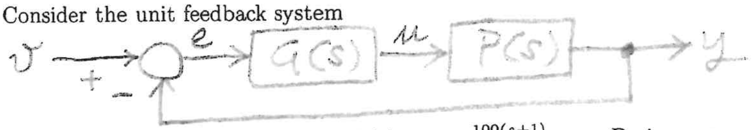
CONTROL SYSTEMS - 7/1/2020 (B)

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

1) Consider the unit feedback system

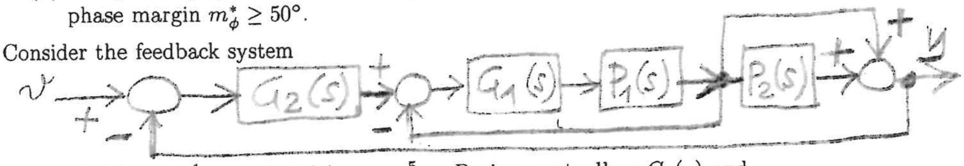


with input v, error e, output y, $P(s) = \frac{100(s+1)}{(s+5)(s^2+12s+20)}$. Design a controller $G(s)$ such that

(i) the closed-loop system is asymptotically stable (use Nyquist criterion with approximate Bode plots) and its steady state error $e_{ss}(t)$ to ramp inputs $v(t) = t$ is in absolute value less or equal to 0.04,

(ii) the open loop system has crossover frequency $\omega_t^* \in [3, 6]$ rad/sec and phase margin $m_\phi^* \geq 50°$.

2) Consider the feedback system



with $P_1(s) = \frac{1}{s(s-2)}$ and $P_2(s) = -\frac{5}{s+3}$. Design controllers $G_1(s)$ and $G_2(s)$ such that

(i) the closed-loop system is asymptotically stable and its steady state error $e_{ss}(t)$ to ramp inputs $v(t) = t$ is 0,

(ii) $G(s) = G_1(s)G_2(s)$ has dimension less or equal to 2.

Draw the root locus for $PG(s)$. Finally, design controllers $G_1(s)$ and $G_2(s)$ satisfying (i) above and

(iii) the steady state error $e_{ss}(t)$ to inputs $v(t) = \sin t$ is 0,

(iv) $G(s) = G_1(s)G_2(s)$ has minimal dimension.

3) Given $P : \dot{x} = Ax + Bu,\ y = Cx$, with $A = \begin{pmatrix} 2 & -3 & 0 & 3 \\ 0 & -2 & 1 & 0 \\ 4 & -4 & -2 & 4 \\ -1 & 0 & 2 & -2 \end{pmatrix}$, $B = (1\ \ 1\ \ 1\ \ 1)^\top$, $C = (0\ \ 0\ \ 1\ \ 0)$, and using the separation principle, determine if possible an output feedback controller C which asymptotically stabilizes P.