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

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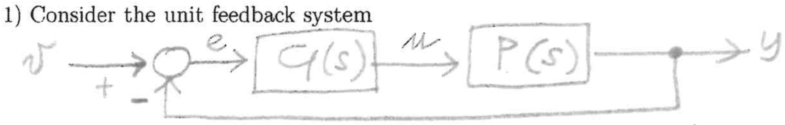
CONTROL SYSTEMS - 7/1/2020 (A)

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

1) Consider the unit feedback system



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

(i) the closed-loop system is asymptotically stable (use Nyquist criterion with approximate Bode plots),

(ii) the open loop system has largest as possible crossover frequency ω_t^*,

(iii) $|G(j\omega)|_{dB} \leq 30$ dB for all ω.

2) Consider the unit feedback system at point 1) with $P(s) = \frac{s+2}{s^2+1}$. Design a controller $G(s)$ such that

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

(ii) $G(s)$ has minimal dimension.

Draw the root locus for $PG(s)$. Determine if, with a one-dimensional controller $G(s) = K\frac{s+z}{s+p}$, $K, z, p \in \mathbb{R}$, it is possible to satisfy (i) above and to have all the closed-loop poles with the same real part $-\alpha < 0$ and determine the value of α. Finally, design a controller $G(s)$ satisfying (i) above and

(iii) $G(s)$ is strictly proper.

3) Given $P : \dot{x} = Ax + Bu$, $y = Cx$, with $A = \begin{pmatrix} -1 & 0 \\ 1 & -2 \end{pmatrix}$, $B = \begin{pmatrix} 1 \\ \beta \end{pmatrix}$, $C = (1 \quad \alpha)$, and using the separation principle, determine for which values of $\beta, \alpha \in \mathbb{R}$ it is possible to design an output feedback controller such that:

(i) the eigenvalues of the controlled process P are all equal to -2,

(ii) the observer error tends asymptotically to 0 at least as e^{-2t}.