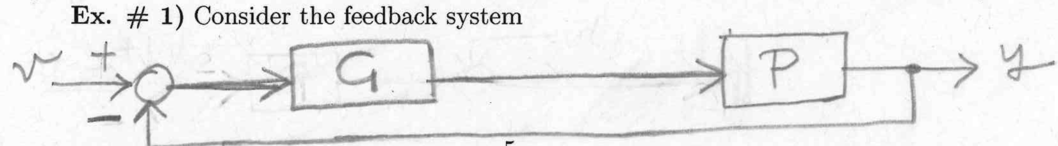
CONTROL SYSTEMS - 11/1/2021

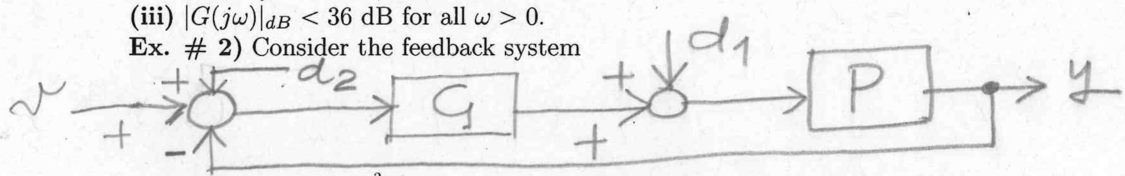
[time 2 hours and 30 minutes; no textbooks; no programmable calculators]

Ex. # 1) Consider the feedback system



with controlled process $\mathbf{P}(s) = \dfrac{-5}{s(s+1)}$. Design a controller $\mathbf{G}(s)$ such that
(i) the closed-loop system is asymptotically stable (use Nyquist criterion) with steady state error response $|\mathbf{e}_{ss}(t)| \leqslant 0.02$ to ramp inputs $\mathbf{v}(t) = t$,
(ii) the open loop system $\mathbf{PG}(s)$ has phase margin $m_f^* \geqslant 50°$ and crossover frequency $\omega_t^* = 10$ rad/sec,
(iii) $|G(j\omega)|_{dB} < 36$ dB for all $\omega > 0$.

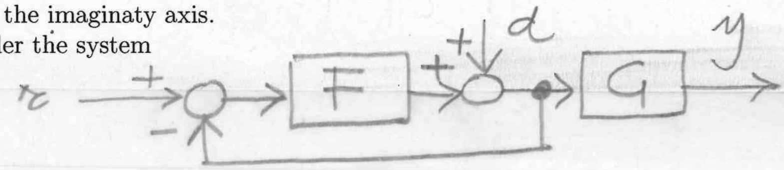
Ex. # 2) Consider the feedback system



with $\mathbf{P}(s) = \frac{s^2+b}{(s+2)^2(s+1)}$ and parameter $b \in \mathbb{R}$. Determine the value of $b > 0$ and an interval of frequencies $a > 0$ (in rad/sec) for which it is possible to design a 2-dimensional controller $\mathbf{G}(s)$ such that the closed-loop system is asymptotically stable with
(i) steady state error response $\mathbf{e}_{ss}(t) \equiv 0$ to constant inputs $\mathbf{v}(t)$,
(i) steady state output response $\mathbf{y}_{ss}(t) \equiv 0$ to disturbances $\mathbf{d}_2(t) = M\sin(at + N)$, $M, N \in \mathbb{R}$ and $a > 0$,
(ii) steady state output response $\mathbf{y}_{ss}(t) \equiv 0$ to disturbances $\mathbf{d}_1(t) = M\sin(2t + N)$, $M, N \in \mathbb{R}$.

Draw the root locus of $\mathbf{PG}(s)$ using the Routh table for a study of the crossing points of the imaginaty axis.

Ex. # 3) Consider the system



with $\mathbf{F}(s) = \frac{s+1}{s+2}$, $\mathbf{G}(s) = \frac{1}{s+1}$.
(i) Determine a state space representation (or realization) of the above interconnected system.
(ii) Compute the forced output response $\mathbf{y}$ to the input $\mathbf{r}(t) = \sin(2t-3)\delta^{(-1)}(t)$.
(ii) Compute the steady state output response $\mathbf{y}_{ss}$ to the input $\mathbf{r}(t)$.