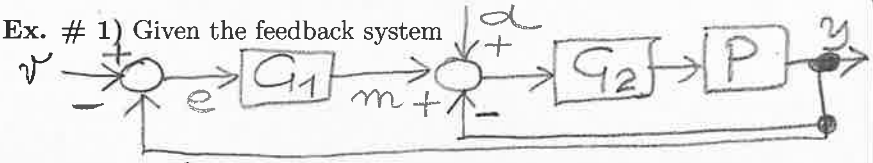
CONTROL SYSTEMS (b) - 2/2/2024

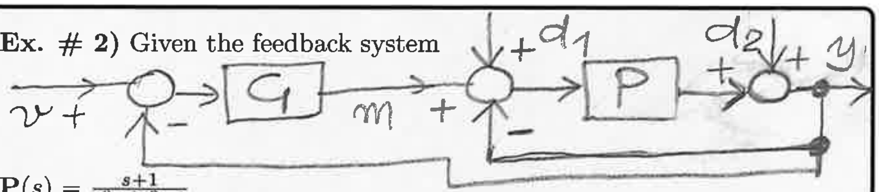
[time 3 hours; no textbooks or notes; no programmable calculators; all the mathematical passages must be motivated and clearly explained]

Ex. # 1) Given the feedback system



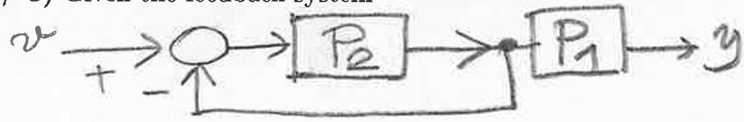
with $\mathbf{P}(s) = \frac{1}{s(s+1)}$, design controllers $\mathbf{G}_1(s)$ and $\mathbf{G}_2(s)$ such that
(i) $\mathbf{G}_2(s)$ is minimal dimensional and the internal control loop $\frac{\mathbf{G}_2(s)\mathbf{P}(s)}{1+\mathbf{G}_2(s)\mathbf{P}(s)}$ is asymptotically stable with all real negative poles
(ii) the feedback system (from $\mathbf{v}$ to $\mathbf{y}$) is asymptotically stable (use Nyquist criterion for assessing stability) with steady-state error response $|\mathbf{e}_{ss}(t)| \leqslant 0.01$ to inputs $\mathbf{v}(t) = t$ and steady-state output response $\mathbf{y}_{ss}(t) \equiv 0$ to disturbances $\mathbf{d}(t) = 1$ and $\mathbf{d}(t) = t$
(iii) the open-loop system (from $\mathbf{e}$ to $\mathbf{y}$) has crossover frequency $\omega_t^* = 5$ rad/sec.

Ex. # 2) Given the feedback system



$\mathbf{P}(s) = \frac{s+1}{s^3+2s^2-1}$,
(i) determine a minimal dimensional controller $\mathbf{G}(s)$ such that the feedback system is asymptotically stable with real poles equal to -0.5, $\mathbf{y}_{ss}(t) = 0$ to constant disturbances $\mathbf{d}_1(t)$ and constant and non-zero $\mathbf{y}_{ss}(t)$ to disturbances $\mathbf{d}_2(t) = t$
(ii) determine the constant and non-zero value of $\mathbf{y}_{ss}(t)$ to disturbances $\mathbf{d}_2(t) = t$.
(iii) draw accurately the root locus of the resulting open loop system, using the Routh table for determining the crossing points of the imaginary axis.

Ex. # 3) Given the feedback system



with $\mathbf{P}_1(s) = \gamma$ and $\mathbf{P}_2(s) = \frac{K}{s+p}$, determine for which values of $\gamma, K, p \in \mathbb{R}$ the steady state response to an input $\mathbf{v}(t) = \frac{1}{K} + t$ is $\mathbf{y}_{ss}(t) = t$ and the 5% settling time of the output response $\mathbf{y}(t)$ (with input $\mathbf{v}(t) = 1$) is at most $0.01 sec$.