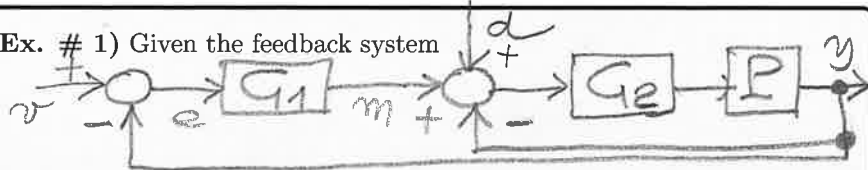


CONTROL SYSTEMS (a) - 2/2/2024

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

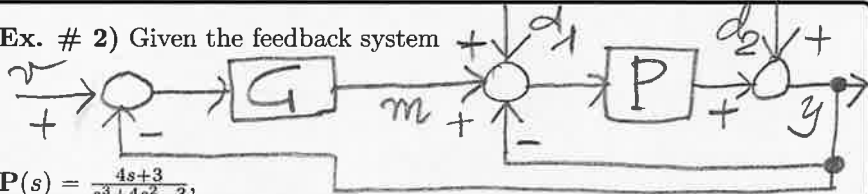
Ex. # 1) Given the feedback system



with $P(s) = \frac{1}{s(s+1)}$, design controllers $G_1(s)$ and $G_2(s)$ such that

- (i) $G_2(s)$ is minimal dimensional and the internal control loop $\frac{G_2(s)P(s)}{1+G_2(s)P(s)}$ is asymptotically stable with all real negative poles
- (ii) the feedback system (from v to y) is asymptotically stable (use Nyquist criterion for assessing stability) with steady-state output response $|y_{ss}(t)| \leq 0.01$ to disturbances $d(t) = t$ and steady-state error response $e_{ss}(t) \equiv 0$ to inputs $v(t) = 1$ and $v(t) = t$
- (iii) the open-loop system (from e to y) has crossover frequency $\omega_t^* = 10$ rad/sec.

Ex. # 2) Given the feedback system



$$P(s) = \frac{4s+3}{s^3+4s^2-3}$$

- (i) determine a minimal dimensional controller $G(s)$ such that the feedback system is asymptotically stable with real poles equal to -1 , $y_{ss}(t) = 0$ to constant disturbances $d_2(t)$ and constant and non-zero $y_{ss}(t)$ to disturbances $d_1(t) = t$
- (ii) determine the constant and non-zero value of $y_{ss}(t)$ to disturbances $d_1(t) = t$.
- (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 $P_1(s) = \gamma$ and $P_2(s) = \frac{K}{s+p}$, determine for which values of $\gamma, K, p \in \mathbb{R}$ the steady state response to an input $v(t) = \frac{1}{K} + t$ is $y_{ss}(t) = 10t$ and the 5% settling time of the output response $y(t)$ (with input $v(t) = 1$) is at most 0.1sec.