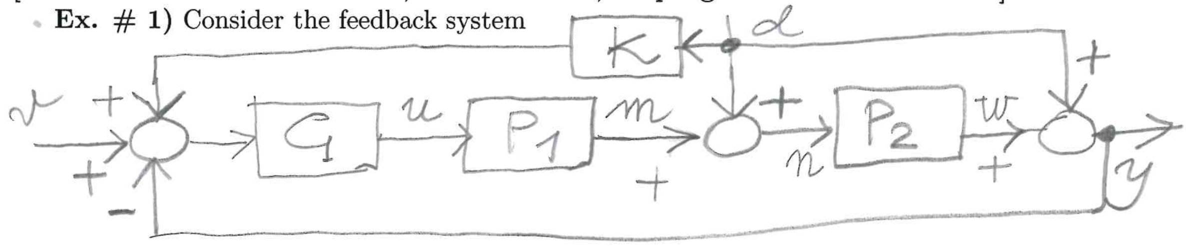
CONTROL SYSTEMS - 17/6/2022

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

Ex. # 1) Consider the feedback system



with $\mathbf{P}_1 : \dot{\mathbf{x}} = -10\mathbf{x} - 8\mathbf{u},\ \mathbf{m} = \mathbf{x} + \mathbf{u}$ and $\mathbf{P}_2 : \dot{\mathbf{z}} = -\mathbf{z} + \mathbf{n},\ \mathbf{w} = \mathbf{z}$. Design $\mathbf{G}(s)$ such that, with $\mathbf{d} = 0$,

(i) the closed-loop system is asymptotically stable (check with Nyquist criterion) with steady-state error response $\mathbf{e}_{ss}(t) = 0$ to constant inputs $\mathbf{v}(t) = \delta^{(-1)}(t)$,

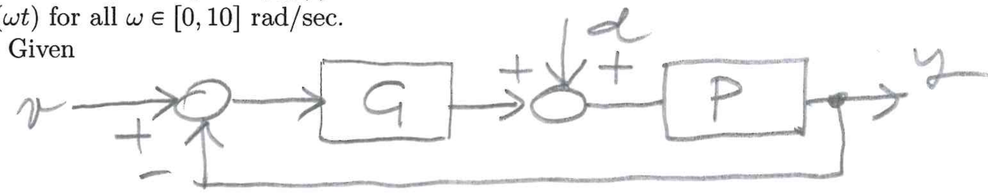
(ii) the open-loop system has crossover frequency $\omega_t \geqslant 10$ rad/sec.

Moreover, let $\mathbf{d} \neq 0$ and design $\mathbf{K}(s)$ in such a way that, with $\mathbf{v} = 0$,

(i) steady-state output response $\mathbf{y}_{ss}(t) = 0$ to constant disturbances $\mathbf{d}(t) = \delta^{(-1)}(t)$

(ii) steady-state output response $\mathbf{y}_{ss}(t)$ in absolute value $\leqslant 0.01$ to disturbances $\mathbf{d}(t) = \sin(\omega t)$ for all $\omega \in [0, 10]$ rad/sec.

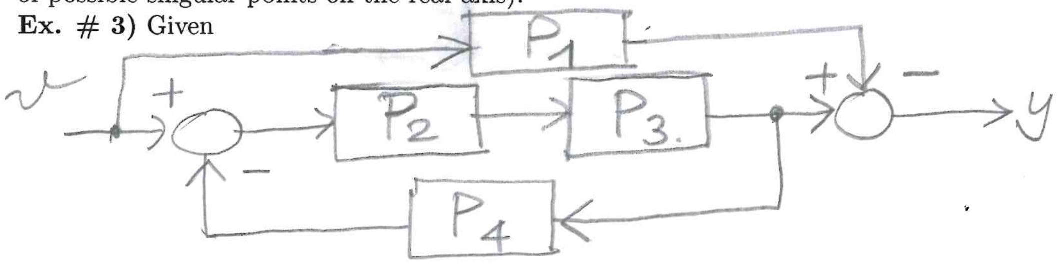
Ex. # 2) Given



where $\mathbf{P}(s) = \frac{s-1}{s(s-17)}$, design a controller $\mathbf{G}(s)$ with minimal dimension such that the feedback system $\mathbf{W}(s) = \frac{\mathbf{PG}(s)}{1+\mathbf{PG}(s)}$ is asymptotically stable and its steady state output response to a constant disturbance is 0.

Draw the root locus of $\mathbf{PG}$ (use the Routh criterion to determine the intersections with the imaginary axis and take accurately into account the presence of possible singular points on the real axis).

Ex. # 3) Given



where $\mathbf{P}_1(s) = \frac{1}{s+10}$, $\mathbf{P}_2(s) = \frac{s-1}{s+2}$, $\mathbf{P}_3(s) = \frac{1}{s-1}$ and $\mathbf{P}_4(s) = -\frac{8}{s+9}$, calculate the transfer function from v to y, the output response and the steady state output response to a constant input v. Study the observability/controllability properties of the series $\mathbf{P}_2(s)$ with $\mathbf{P}_3(s)$.