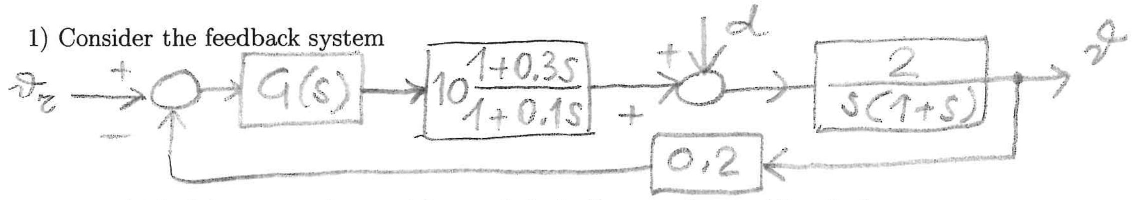
NAME, SURNAME AND STUDENT NUMBER (* required fields):

....

CONTROL SYSTEMS (A) - 2/7/2019

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

1) Consider the feedback system

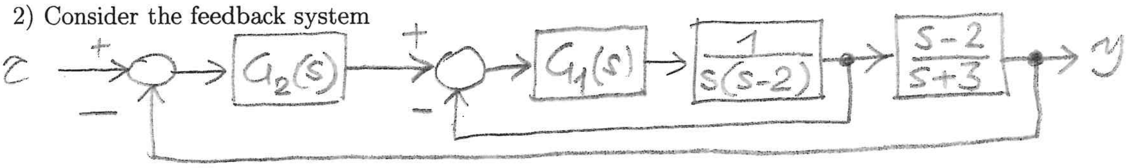


in which θ is an angular position and θ_r is the angular position to be tracked. Design a controller $G(s)$ such that

(i) the closed-loop system is asymptotically stable (use the Nyquist criterion with reasonable approximations for the Bode plots), the steady state angular position θ_{ss} to constant disturbances d is such that $|\theta_{ss}| \leq 0.02$ and the steady state error $e_{ss} = 5\theta_r - \theta_{ss}$ for an angular velocity $\dot{\theta}_r = 2$ rad/sec is such that $|e_{ss}| \leq 0.04$,

(iii) the open loop system has phase margin $m_\phi^* \geq 50°$ rad/sec.

2) Consider the feedback system



Design one dimensional controllers $G_1(s)$ and $G_2(s)$ such that the closed-loop system is asymptotically stable with zero steady state error to constant inputs r. Draw the root locus of the open-loop system.

3) Given the system $\dot{x} = Ax + Bu$, $y = Cx$, with

$$A = \begin{pmatrix} -1 & 0 \\ 1 & -2 \end{pmatrix}, \quad B = \begin{pmatrix} 1 \\ \beta \end{pmatrix}, \quad C = (1 \quad \alpha),$$

discuss the values of $\alpha, \beta \in \mathbb{R}$ for which there exists an output feedback controller (state feedback+state observer) such that the eigenvalues of the controlled system are all in -2 and the state observation error goes to zero at least as e^{-2t}.