SE 380 Introduction to Feedback Control
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HOMEWORK 3
Due date: November 3, 2023

1 Consider the following model of a DC motor:

$$G(s) = \frac{Y(s)}{U(s)} = \frac{K_m}{s(R_a(Js+b)+K_bK_m)},$$

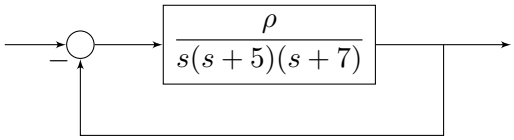
where the value of all parameters is positive, the input $u(t) = \mathcal{L}^{-1}(U(s))$ is the voltage supplied to the motor, and the output $y(t) = \mathcal{L}^{-1}(Y(s))$ is the angle of the motor axle. Assume a unit step input voltage is supplied.

a Find the transfer function between the angular speed—time derivative of the angle—and the input voltage.

b Find the steady-state angular speed of the motor axle.

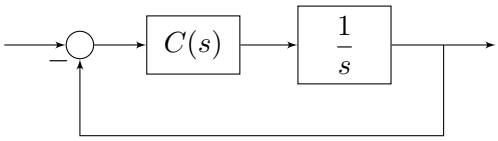
c How long does the motor take to reach 99% of its steady-state speed?

2 Consider the following feedback control system.



Find the values of ρ for which the closed-loop system is stable.

3 Consider the following feedback control system.



Design a *proportional controller*—i.e. a controller with transfer function $C(s) = K$ for some $K \in \mathbb{R}$—so that the closed-loop system satisfies the following specifications:

(i) It is stable

(ii) The steady-state gain is 1

(iii) The settling time is less than 100 ms