EECE 5610: Homework #1

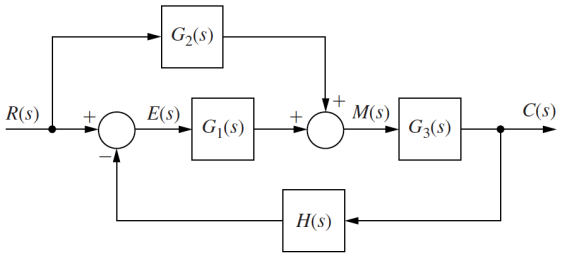
Due on September 22, 2022 at 2:50pm
Homework should be submitted via Canvas before the beginning of the class. Late submission is not accepted.

Professor Milad Siami

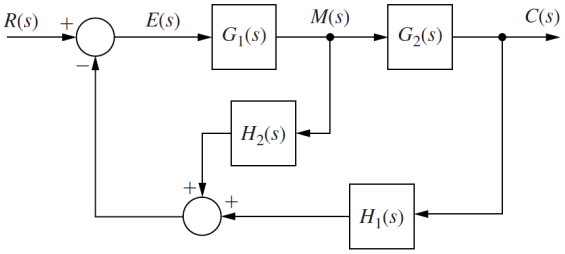
Problem 1

Calculate the transfer function $\frac{C(s)}{R(s)}$ for the following systems:

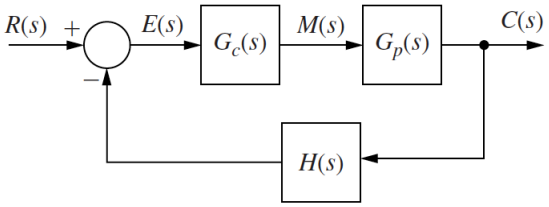
(a)



(b)



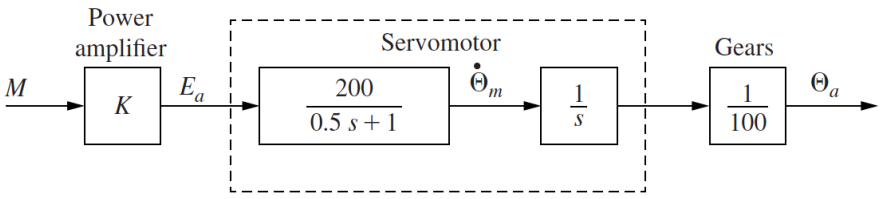
(c)



Hint: You can calculate the transfer functions by writing algebraic equations and eliminating variables, or by using Mason's gain formula (see Appendix II of the textbook or your lecture note#3).

Problem 2

Consider the following block diagram of one joint of a robot arm. This system is described in Section 1.5 and "our second and thired lectures." The input $M(s)$ is the controlling signal, $E_a(s)$ is the servomotor input voltage, $\Theta_m(s)$ is the motor shaft angle, and the output $\Theta_a(s)$ is the angle of the arm. The inductance of the armature of the servomotor has been neglected such that the servomotor transfer function is second order. The servomotor transfer function includes the inertia of both the gears and the robot arm.



(a) Derive the transfer functions $\frac{\Theta_a(s)}{M(s)}$ and $\frac{\Theta_a(s)}{E_a(s)}$.

(b) Suppose that the units of $e_a(t)$ are volts, the units of both $\theta_m(t)$ and $\theta_a(t)$ are degrees, and the units of time are seconds. If the servomotor is rated at 24 V [the voltage $e_a(t)$ should be less than or equal to 24 V], find the rated rpm of the motor (the motor rpm, in steady state, with 24 V applied).

(c) Find the maximum rate of movement of the robot arm, in degrees per second, with a step voltage of $e_a(t) = 24u(t)$ volts applied.

(d) Assume that $e_a(t)$ is a step function of 24 V. Give the time required for the arm to be moving at 99 percent of the maximum rate of movement found in part (b).

(e) Suppose that the input $m(t)$ is constrained by system hardware to be less than or equal to 10 V in magnitude. What value would you choose for the gain K? and why?