Homework – Block Diagrams and Transfer Functions
Due Next Week – No Electronic Copies will be graded

1. By writing algebraic equations and eliminating variables, calculate the transfer function \( C(s)/R(s) \) for the following systems (5 points each)

   ![Block Diagram A](image1)

   ![Block Diagram B](image2)

   ![Block Diagram C](image3)

2. A feedback control system diagram and plant transfer function are given below.

   ![Feedback Control System Diagram](image4)

   \[ G_p(s) = \frac{5}{0.2s + 1} \]

   a. Write the differential equation of the plant that relates \( c(t) \) and \( m(t) \) (5 points)

   b. Modify the equation of question (a) above to yield the system differential equation. This equation relates \( c(t) \) and \( r(t) \). The compensator and sensor transfer functions are given by

   \[ G_c(s) = 10 \text{ and } H(s) = 1 \] (5 points)

   c. Derive the system transfer function from the results of question (b) (5 points)

   d. It is shown in question 1-a that the closed-loop transfer function of the system in the above figure is given by

   \[ \frac{C(s)}{R(s)} = \frac{G_c(s)G_p(s)}{1 + G_c(s)G_p(s)H(s)} \]

   Use this relationship to verify the results in question (c) above (5 points)

   e. Recall that the transfer function pole term \((s + a)\) yields a time constant \( \tau = 1/\alpha \) where \( \alpha \) is a real number. Find the time constants for both the open-loop and closed-loop systems (5 points)
3. Repeat question 2 (a through e) with the following transfer functions (25 points)

\[ G_c(s) = 2 \quad G_p(s) = \frac{5}{s^2 + 2s + 2} \quad H(s) = 3s + 1 \]

4. A satellite is connected to the closed-loop control system shown below. The torque is directly proportional to the error signal

\[ \Theta(s) = \text{Torque} \]

Derive the transfer function \( \Theta(s) / \Theta_c(s) \) where \( \theta(t) = \ell^{-1}[\Theta(s)] \) is the commanded attitude angle (5 points)