Choose any four out of five problems.

*Please specify which four listed below to be graded:*

1) _____; 2) _____; 3) _____; 4) _____;

Name: ______________________________

Student ID: ______________________________

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**Problem 1:**
The differential equation given below represents a linear time-invariant system, where \( r(t) \) denotes the input and \( y(t) \) the output. Find the transfer function, \( \frac{Y(s)}{R(s)} \).

\[
\begin{align*}
\frac{d^3 y(t)}{dt^3} + 10 \frac{d^2 y(t)}{dt^2} + 2 \frac{dy(t)}{dt} + y(t) + \int_0^t y(\tau)d\tau &= \frac{dr(t)}{dt} + 2r(t)
\end{align*}
\]
Problem 2:
Using block diagram reduction technique to rearrange the following block diagram into the equivalent $H$ and $G$ configurations of the feedback control system shown below.

H Configuration

G Configuration
Problem 3:
Apply the gain formula to the SFG shown below to find the transfer functions of
\[ \frac{Y_6}{Y_1} \bigg|_{Y_1=0} \quad \text{and} \quad \frac{Y_7}{Y_7} \bigg|_{Y_7=0} \].
Problem 4:
Figure below shows the block diagram of a dc-motor control system (note the dc-motor is represented by \( G(s) = \frac{K(s + 3)}{s(s + 1)(s + 2)} \)). The signal \( N(s) \) denotes the frictional torque at the motor shaft.

a) Find the transfer function \( H(s) \) so that the output \( Y(s) \) is not affected by the disturbance torque \( N(s) \).

b) With \( H(s) \) as determined in part a), find the value of \( K \) so that the steady-state value of \( e(t) \) is equal to 0.1 when the input is a unit-ramp function, \( r(t) = tu(t) \) and \( N(s) = 0 \). Apply the final-value theorem.
Problem 5:
For the system described by input-output differential equation given below,

\[ c\ddot{y} = (a + 1)y + \dot{y} - b\dot{y} + 2u + \dot{u} + \ddot{u}, \]

find the state space representation in the form of

\[ \dot{x}(t) = Ax(t) + bu(t) \]
\[ y(t) = cx(t) + du(t) \]

where input is \( u(t) \) and output is \( y(t) \).