Mid Sem (2023): Systems Thinking

Total Marks: 100, Time Duration: 90 min

1. Consider the following open loop system:

$$G(s) = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s}, \tag{1}$$

where ζ is the damping ratio and ω_n is the natural frequency. For a unit step input, find the system responses under unity feedback under (i) overdamped and (ii) critically damped situations. [30]

2. Consider a system having open loop transfer function

$$G(s) = \frac{150(s+1)}{(s+5)(s+3)(s+2)} \tag{2}$$

For the above system, find the steady-state errors for the inputs (i) $tu(t)$ and (ii) $t^2u(t)$ where $u(t)$ is the step input. [15]

3. Consider the following system having open-loop transfer function:

$$G(s) = \frac{1}{s^2 + as + b}, \tag{3}$$

where a, b are two constants. Under unit feedback and unit step input, answer the following:

- What is the 'type' of the system. [5]
- Comment on the changes in transient and steady-state performances (derive steady-state error) when
  - only proportional control is used with gain $k_p > 0$. [10]
  - proportional (gain $k_p > 0$) + derivative control is used with derivative gain $k_d > 0$. [10]
  - proportional (gain $k_p > 0$) + integral control is used with integral gain $k_i > 0$. [10]
  - PID control is used with gains as above. [20]