# Mid Sem (M25): Systems Thinking

**Total Marks: 100** **Time Duration: 90 min**

1. Consider the following open-loop system:

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

where $\zeta$ is the damping ratio and $\omega_n$ is the natural frequency.

For a unit step input, find the system responses under unity feedback for the following cases:

(i) Underdamped case ($0 < \zeta < 1$)

(ii) Critically damped case ($\zeta = 1$)

(iii) Overdamped case ($\zeta > 1$)

[30]

2. Consider a system having open-loop transfer function

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

For the above system, find the steady-state errors for the inputs:

(i) $t\,u(t)$

(ii) $t^2 u(t)$

where $u(t)$ is the unit step input. [15]

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

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

where $a$ and $b$ are constants. Under unity 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:

  (i) Only proportional control is used with gain $k_p > 0$ [10]

(ii) Proportional ($k_p > 0$) and derivative control is used with derivative gain $k_d > 0$ [10]

(iii) Proportional ($k_p > 0$) and integral control is used with integral gain $k_i > 0$ [10]

(iv) PID control is used with gains as above [20]