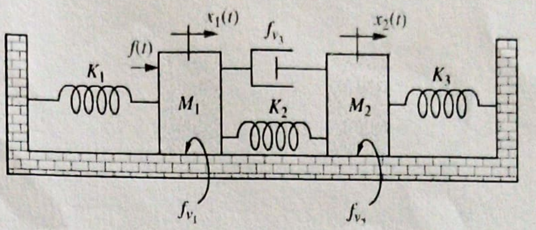
Mid Sem (2024): Systems Thinking

Total Marks: 100, Time Duration: 90 min

1. Consider the following system in the following figure:



where f_{v1} and f_{v2} are viscous friction coefficients and f_{v3} is damping constant. For this system

(1) Derive the transfer function $G(s) = \frac{X_2(s)}{F(s)}$. [15]

(2) Derive a state-space model with x_1 as output. **[note that states should not be taken as a combination of position and/or velocity of M_1, M_2]** [15]

2. 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 for (i) underdamped and (ii) critically damped situations. [20+20]

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

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

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 $k_p > 0$. [5]
  - proportional (gain $k_p > 0$) + derivative control is used with derivative gain $k_d > 0$. [5]
  - proportional (gain $k_p > 0$) + integral control is used with integral gain $k_i > 0$. [5]
  - PID control is used with gains as above. [10]

$\int_0^\infty t e^{-st} dt$ $\left(\frac{e^{-st}}{-s}\right)_0^\infty$ $0 + \left(\frac{1}{-s}\right)$