5. For a unity feedback control system with the open-loop transfer function:

$$G(s) = \frac{k\left(s + \frac{4}{3}\right)}{s^2(s+12)}$$

construct the root locus.

6. Determine the stability and frequency response characteristics of a system with the transfer function:

$$G(s) = \frac{50}{s(s+4)(s+10)}$$

by plotting its Bode diagram and calculating the gain and phase margins.

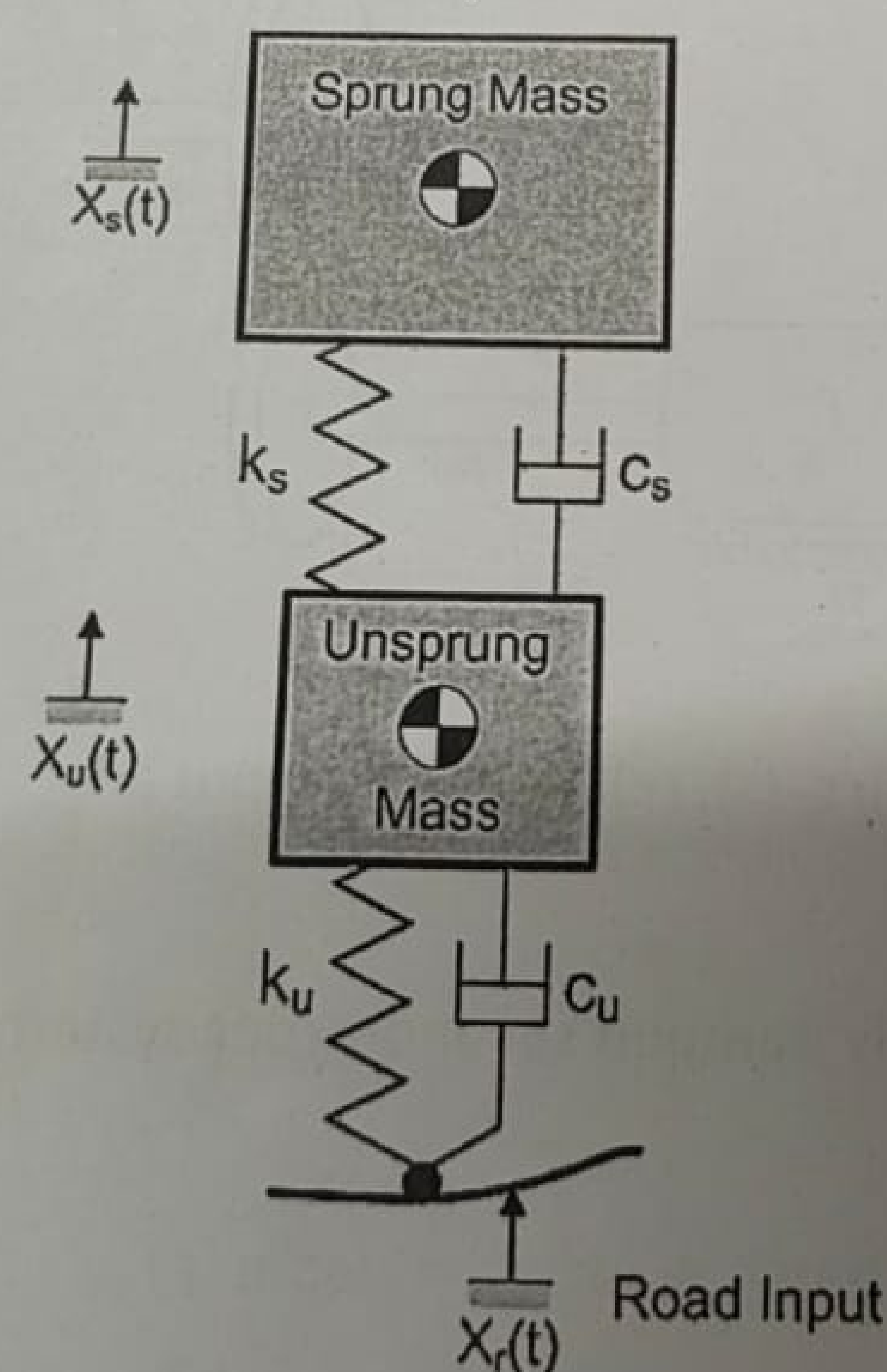
7. Determine the stability of a feedback control system using the Nyquist criterion for a system with the open-loop transfer function:

$$G(s)H(s) = \frac{100}{(s+2)(s+5)(s+10)}$$

Construct the Nyquist plot and analyze the number of closed-loop poles in the right-half s-plane.

8. In an industrial liquid level control system, a tank with a uniform cross-sectional area A has an inlet flow rate q and an outlet flow rate q_o, controlled by a constant flow pump. Derive the transfer function H(s)/Q(s) and analyse the performance of P, PI, and PID controllers in regulating the liquid level. Discuss their impact on stability, steady-state error, and response time, and identify the most suitable controller for handling disturbances in real-world applications.

9.a) Derive the mathematical model for the transfer function of an automobile suspension system using a quarter-car model. Consider the dynamics of the sprung and unsprung masses, damping, and stiffness. Obtain the transfer function relating the displacement of the car body to the road disturbance input.



OR

BH/D/TY

Reg. No: 22BME0189

VIT
Vellore Institute of Technology

Final Assessment Test – April 2025

Course: BMEE330L - Control Systems

Class NBR(s): 3925 / 3927 / 3967 / 4116

Slot: C2+TC2

Time: Three Hours

Max. Marks: 100

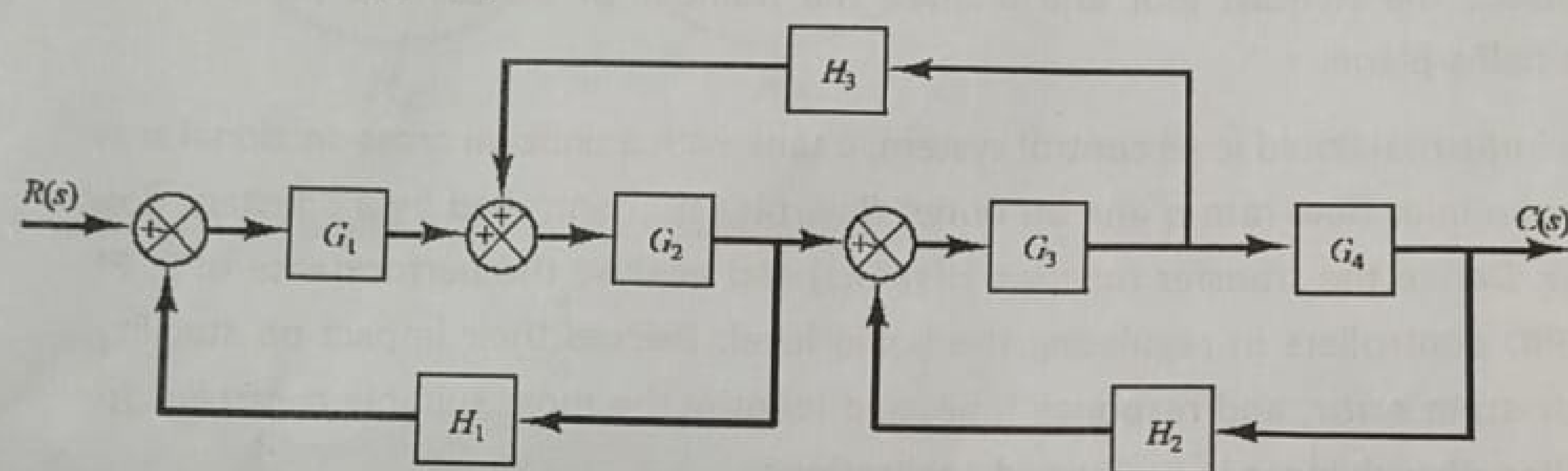
- KEEPING MOBILE PHONE/ANY ELECTRONIC GADGETS, EVEN IN 'OFF' POSITION IS TREATED AS EXAM MALPRACTICE
- DON'T WRITE ANYTHING ON THE QUESTION PAPER

Answer ALL Questions

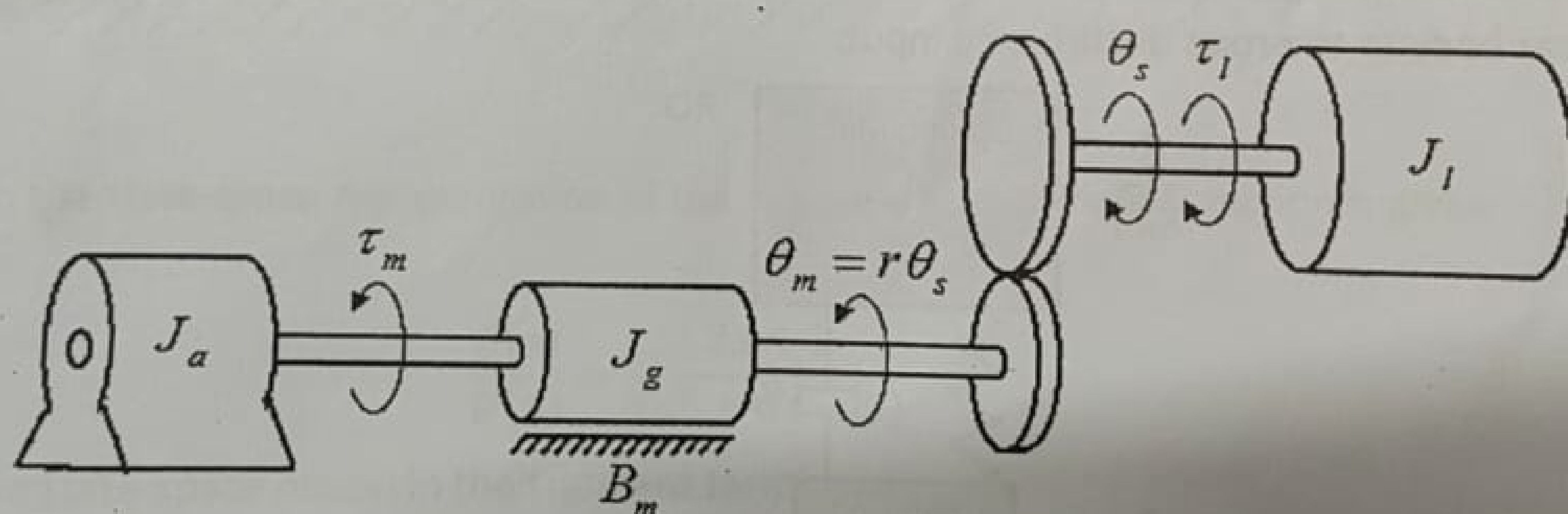
(10 X 10 = 100 Marks)

1. Explain the classification of control systems with their types, advantages, and disadvantages.

2. Simplify the block diagram shown in Figure below. Then, obtain the closed-loop transfer function C(s)/R(s).



3. A robot joint (as shown below) is driven by a motor (J_a) through a gear transmission with a ratio of r:1



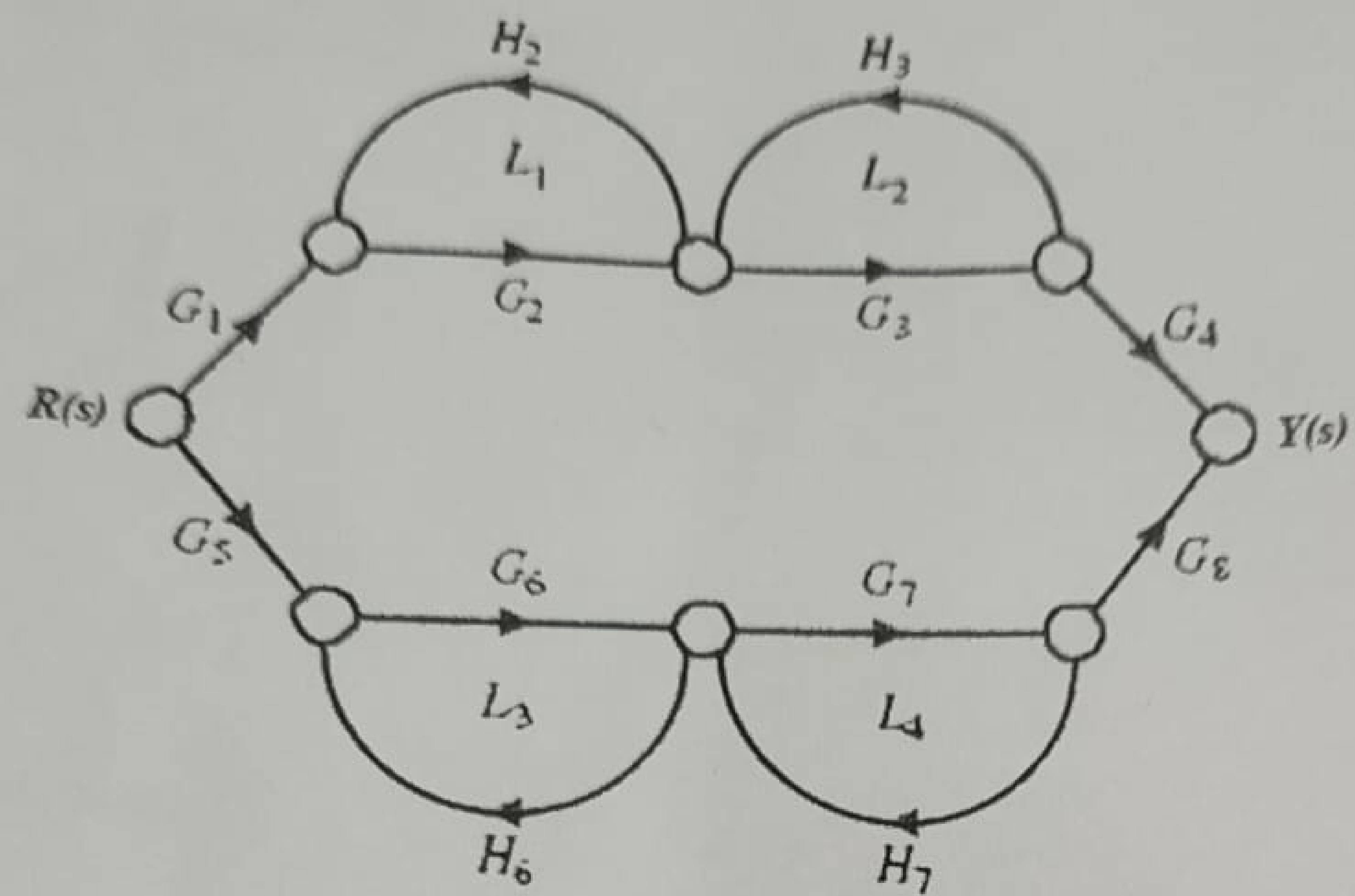
Derive the transfer function $\theta_s(s)/\tau_m(s)$, relating the output angular position (θ_s) of the joint to the applied torque (τ_m)

4. Derive the response of a critically damped second-order system for a unit step input. Given the system equation:

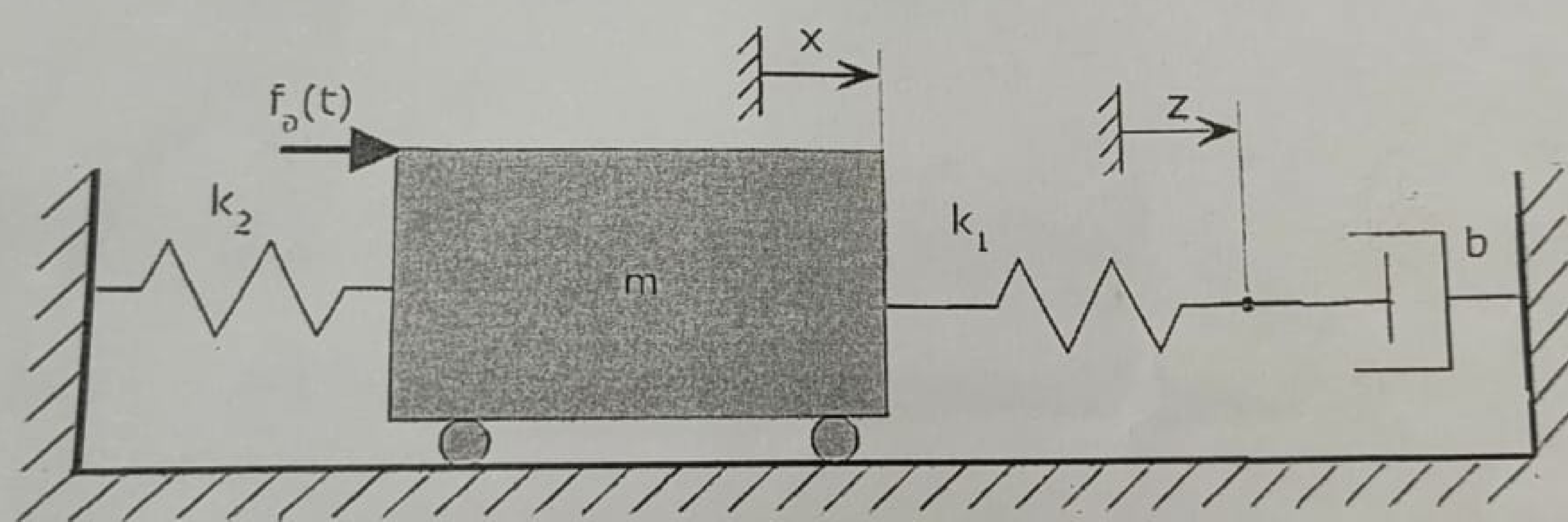
$$\ddot{x} + 2\omega n\dot{x} + \omega_n^2 x = \omega_n^2 u(t)$$

where ω_n is the natural frequency. Solve the differential equation for a unit step input u(t)=1 for t≥0 with initial conditions x (0) = 0 and $\dot{x}$ (0) = 0. Derive the complete time-domain response x(t).

9.b) Apply Mason's Rule to calculate the transfer function of the system represented by following Signal Flow Graph.



10.a) Derive a state space model for the system shown below.



OR

10.b) Obtain the state-space representation of the system whose transfer function is given by:

$$\frac{C(s)}{R(s)} = \frac{2s+3}{(s^2+4s+5)}$$

Find the state-space model in the standard form.

⇔⇔⇔ BH/D/TY ⇔⇔⇔