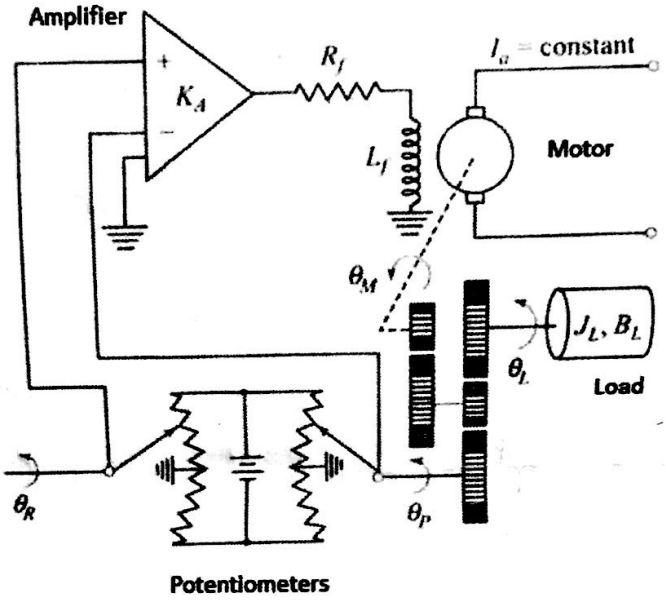
Department of Mechanical Engineering, Indian Institute of Technology Delhi
Control Theory and Applications (MCL 212) (Jan-May 2019)
Minor 1

Max marks: 45 Time 1 Hour

Note: Make suitable assumptions, if necessary, giving justification.

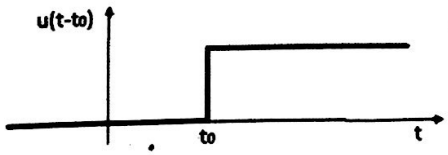
Q1. Figure shows a servo system for position control of a load. Make a functional block diagram of the system and briefly explain the working of the close loop control system. (10)

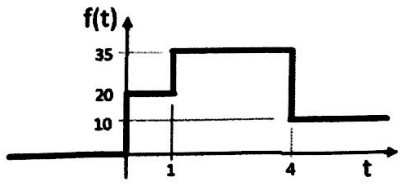


Q2. a) The Laplace transform of $u(t - t_0)$ (a step signal delayed by a time t_0 seconds, shown in the figure below) is given by ,

$$L(u(t - t_0)) = e^{-t_0 s}.L(u(t))$$

Find the Laplace transform of the signal f(t) shown in the figure below. (4)

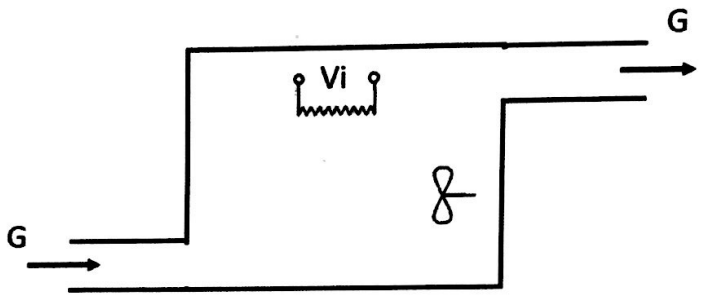




b) Find the inverse Laplace transform of g(s), where,

$$g(s) = \frac{2s^2+s+18}{s^2+9}$$ (4)

Q3. A liquid heating system is shown in the figure below. Liquid enters the chamber at a rate G Kg/sec. Use symbols θ_i and θ_o to represent temperatures of the incoming and outgoing liquids. Assume that the walls of the chamber are perfectly insulated. The Liquid is heated through an electric coil of electrical resistance R. V_i is the voltage input to the coil. A stirrer is used to ensure that the temp is uniform throughout the chamber. The thermal capacitance of the coil is C_h and the thermal resistance between the coil and the liquid is R_h. M and C_p are the mass and specific heat of the liquid in the chamber, respectively. Assume any other variables of the system, if needed.



a) Develop the mathematical model of the system in the form of differential equations to predict temperature of the outgoing liquid due to perturbation in the input voltage to the electric heating coil. **(10)**

b) Obtain the transfer function between the temperature of the outgoing fluid as the output variable and the voltage input to the coil as the input variable. ***(5)***

Q4. A lumped parameter model of an electro-mechanical system (an electromagnetic vibration exciter) is shown in the figure below. Assume that the coil has a back EMF $e_b = k_b.\frac{dx}{dt}$ and the coil current produces a force $F_c = k_f.i$ on the mass M. F_d is a disturbing force on the mass M. N-S is the permanent magnet.

a) Develop the mathematical model of the system in the form of differential equations **(8)**

b) Draw a block diagram of the system **(4)**