$\frac{1}{\frac{1}{R}+CS}$ = 1+CSR

Rout = $\frac{1}{\frac{1}{R}+CS}$

Rin = R

Minor-I Examination on Control Theory and Applications (MCL212)

TF = $\left(\frac{1}{R}+CS\right)R$

= $\frac{1}{1+CRS}$

Full Marks: 30

Time: 1 hour

Problem-1

A lumped-parameter model of an electromechanical system is shown in figure-1, where the coil is modelled by its resistance R and inductance L and a current i(t) is driven through it when subject to a time varying e.m.f. e(t), 't' being the time. The coil is placed between the poles of a stationary permanent magnet (N-S). So the coil experiences a force F_C, which is supposed to be proportional to the coil current such that $F_C = K_C * i(t)$, K_C being the coil constant. Under the influence of the force, the coil moves and so a back e.m.f. is also induced in the coil and is given by $E_b(t) = K_b\, dx(t)/dt$, where K_b is the back e.m.f. constant and x(t) is the motion of the coil with respect to the fixed magnetic poles. This force on the coil, which is on a core, is utilized to excite a mechanical system, represented by its mass M, stiffness K and a viscous damping constant C, where $F_d(t)$ is any time varying disturbance force acting on the system.

(a) Write the equations in the Lapalace domain and draw the block diagram of the electro-mechanical system to show how the inputs E(s) and $F_d(s)$ generate the displacement X(s) of the mass.

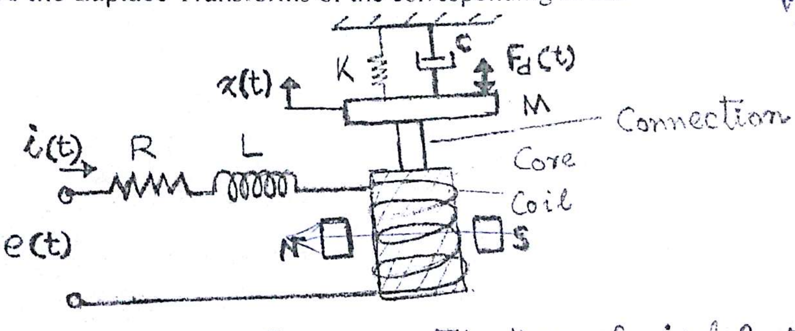
(4+6)

(b) Find the transfer function X(s)/E(s), considering $F_d(s) = 0$ (5)

(c) Find the Transfer function $X(s)/F_d(s)$, considering E(s) = 0 (5)

E(s), $F_d(s)$, X(s) are the Laplace Transforms of the corresponding terms.

Minor1 Minor2



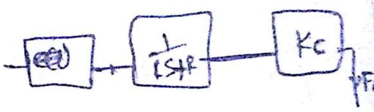


Figure-1: Electromechanical System

Problem-2

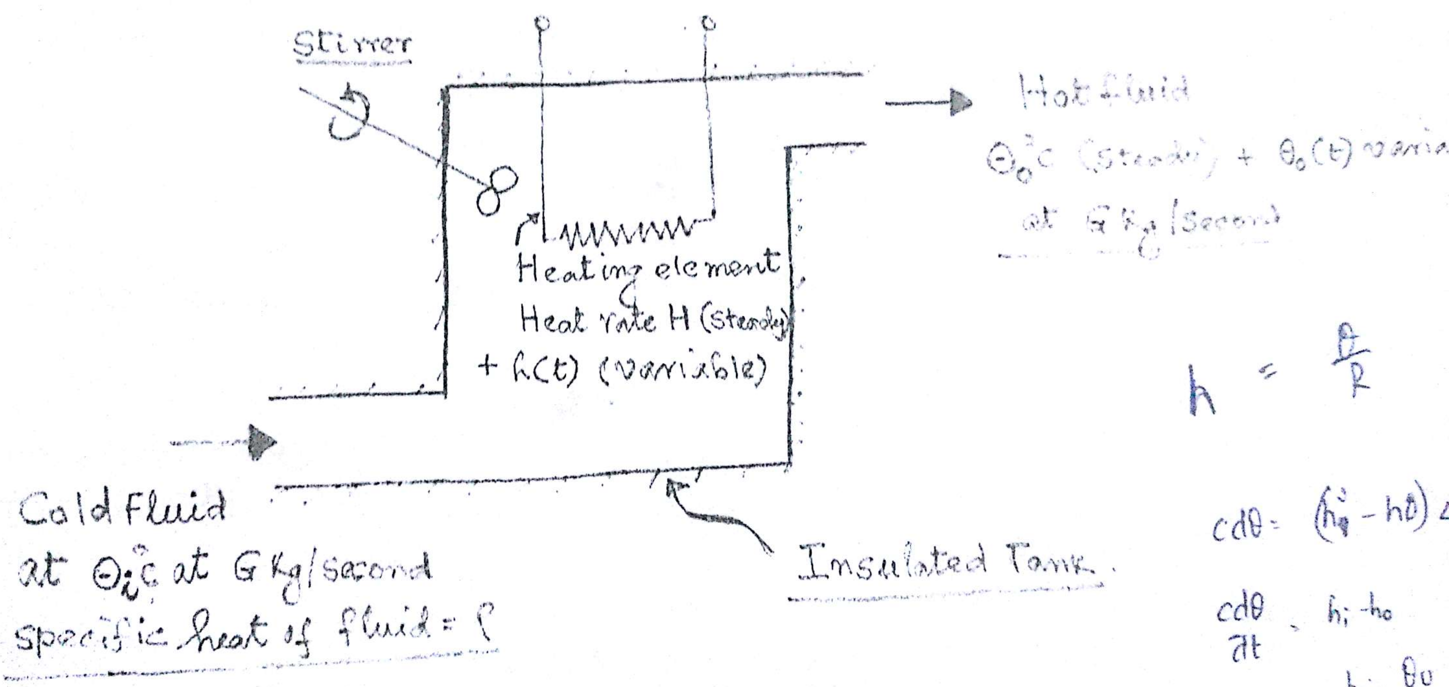
Figure-2 shows the schematic diagram of a thermal system, an insulated fluid heater, which is initially in the steady state, gets a fluid (of specific heat ρ) at a flow rate of G Kg/second and at a constant temperature Θ_i, heats it with the heat added by a heating element at a constant rate H and discharges fluid (at a rate G Kg/second) at a temperature Θ_o. A stirrer is used to ensure that the fluid is heated uniformly such that the temperature of the fluid everywhere inside the tank is Θ_o. Suppose that the heat input from the heating element changes with respect to time, and at any instant 't' it is given by H + h(t) and all other conditions remain same. The temperature of the outgoing fluid also undergoes a change and, at the instant 't' it is given by $\Theta_o + \theta_o(t)$.

P.T.O.

(a) Supposing that the heat capacitance of the system as C = 503000 Joule/°C and the resistance of the system as R = 0.01°C/J/second, find out the transfer function between the output $\theta_o(s)$ and the input h(s), where $\theta_o(s)$ and h(s) are the Laplace transforms of $\theta_o(t)$ and h(t) respectively. (5)

(b) Draw an equivalent op-amp circuit to simulate the same transfer function between the output voltage $E_o(s)$ and input voltage $E_i(s)$. Give a set of possible values of the electrical elements (resistance, capacitance) for this purpose. (3+2)

$C = m\rho$



$h = \frac{\theta}{R}$

$c\,d\theta = (h_i - h_o)$

$\frac{c\,d\theta}{dt} = h_i - h_o$

$= h_i - \frac{\theta_o}{R}$

$C(\theta_o + \theta(t) - \theta_i) = (H + h(t))$

$C\left(\frac{d\theta(t)}{dt}\right) = \Delta h$

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