Modeling assignment

BENHA UNIVERSITY

Faculty of engineering

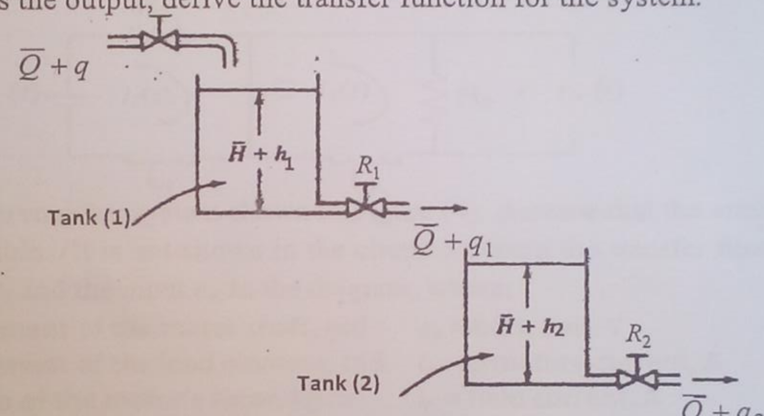
Mechanical engineering department

Automatic control

4th year (Power) 2013/2014

Assignment (3)

1- For the liquid-level system shown in figure (1), the steady-state flow rate through the tanks is $\overline{Q}$ and steady-state heads of tank 1 and tank 2 are $\overline{H}_1$ and $\overline{H}_2$ respectively. At $t = 0$ the inflow rate is changed from $\overline{Q}$ *to* $\overline{Q} + q_1$, where q is a small change in the inflow rate. The corresponding changes in the heads (h_1 and h_2) and changes in flow rates (q_1 and q_2) are assumed to be small. The capacitances of tank 1 and tank 2 are C_1 and C_2, respectively. The resistance of the valve between the tanks is R_1 and that of the outflow valve is R_2. Assuming q as the input and q_2 as the output, derive the transfer function for the system.



2- Refer to the mechanical system shown in fig. 2-a,b. Obtain the transfer function relating mass displacement y, to the applied force $f_o(t)$.

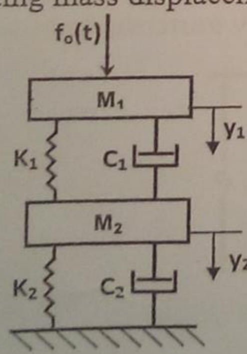


Figure (2-a)

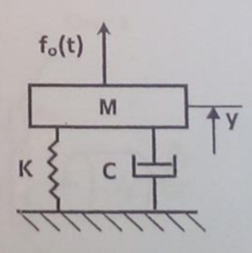


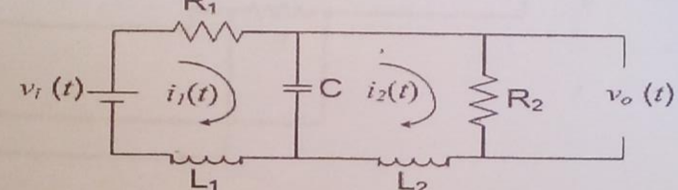
Figure (2-b)

Modeling assignment

3- Consider the electrical system shown in figure (3). At t = 0 the input voltage is changed from v_i to $\bar{V}_i + v_i$, where v_i is a small change in the input voltage. The corresponding changes in the currents (i_1 and i_2) are assumed to be small. The resistance and inductance in each loop of the circuit are R_1, L_1 and R_2, L_2 respectively.

- Write the governing equation assuming zero initial condition.
- Draw the corresponding block diagram.
- Derive the transfer function of the system when v_i as the input and v_o as the output.

Figure (3)



4- Consider the dc servomotor system shown in Figure (4). Assume that the armature inductance is negligible. (It is not shown in the circuit.) Obtain the transfer function between the output θ_2 and the input e_a. In the diagram, where;

θ_1 = angular displacement of the motor shaft, rad

θ_2 = angular displacement of the load element, rad

J_1 =moment of inertia of the motor's rotor, kg-m^2

J_2 = moment of inertia of the load, kg-m^2

T = torque developed by the motor, N-m

e_a =applied armature voltage, V

e_b = back emf. V

i_a = armature current, A

i_f = field current, A

n_1 = number of teeth of gear 1

n_2 =number of teeth of gear 2

R_a = armature resistance, Ω

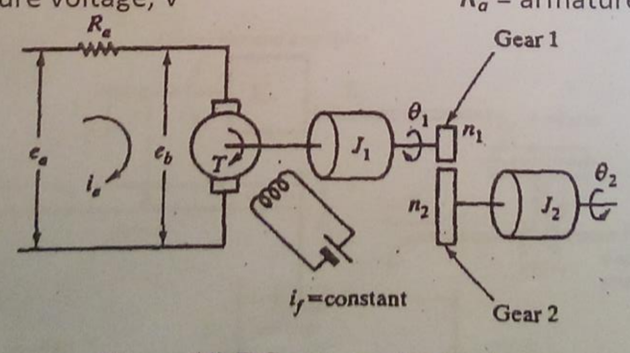


Figure (4) DC servomotor system

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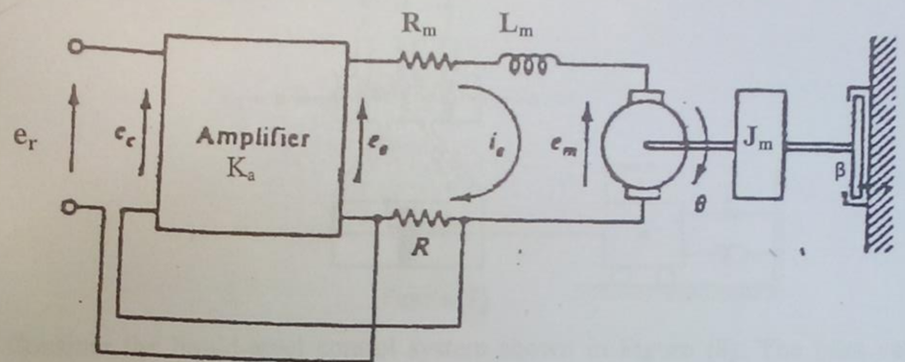
5- An armature controlled -dc motor with a resistance R added in the armature loop is used in speed control system shown in figure(5). Obtain the transfer function of the system relating the input e_r to the output speed ω.



6- Consider the Water-Level Control System shown in figure (6) The level C is measured by means of a float, and a lever is used as a summing junction to determine a measure e of the error with the desired level r. From this mechanical input, the controller and amplifier set a pneumatic output pressure P_o of sufficient power to operate the pneumatic actuator, which adjusts the control valve opening x to control inflow q of the tank. Assume the pneumatic actuator transfer function is $\frac{P_o}{x} = \frac{A/K}{R_f\ C_f + 1}$ Determine the overall transfer function $\frac{C(s)}{R(s)}$.

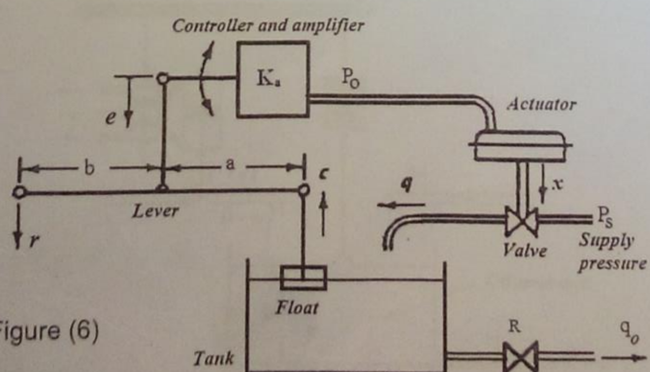


Figure (6)

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7- Consider the hydraulic servo system shown in Figure (7). Assuming the load reaction forces is not negligible. Drive a mathematical model of the system. Assume also the mass of the power piston is included in the load mass m.

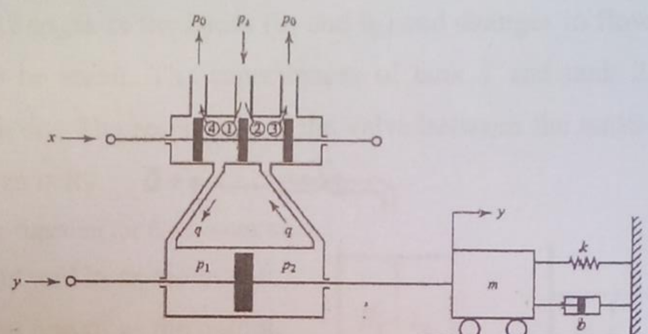

Figure (7)

8- Consider the liquid-level control system shown in Figure (8). The inlet valve is controlled by a hydraulic integral controller. Assume also that the disturbance inflow q_d, which is a small quantity, is applied to the water tank at t=0, This disturbance head causes the head to change in from $\overline{H}$ to $\overline{H}+h$. This change results in a change in the outflow rate by q_o. Through the hydraulic controller, the change in head caused a change in inflow rate from $\overline{Q}$ to $\overline{Q}+q_i$. The integral controller tends to keep the head. Assume that the change in the inflow rate q_i is negatively proportional to the change in the valve opening y. Obtain the transfer function $H(s)/Q_d(s)$.

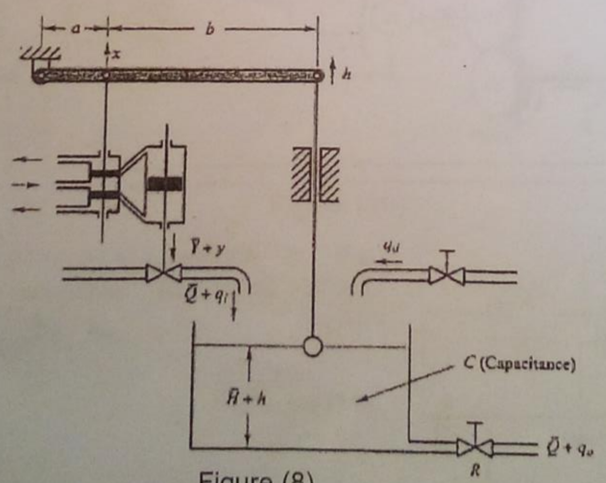

Figure (8)

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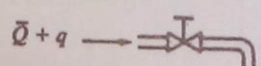
9- Consider the liquid-level system shown in figure 9. At $t = 0$ the inflow rate is changed from Q to $\bar{Q}+q_1$, where q is a small change in the inflow rate. The corresponding changes in the heads (h_1 and h_2) and changes in flow rates (q_1 and q_2) are assumed to be small. The capacitances of tank 1 and tank 2 are $C_1 = A_1$ and $C_2 = A_2$, respectively. The resistance of the valve between the tanks is R_1 and that of the outflow valve is R_2.



Derive the transfer function for the system when:

a- q as the input and h_2 as the output.

b- q as the input and q_2 as the output.

c- q as the input and h_1 as the output.

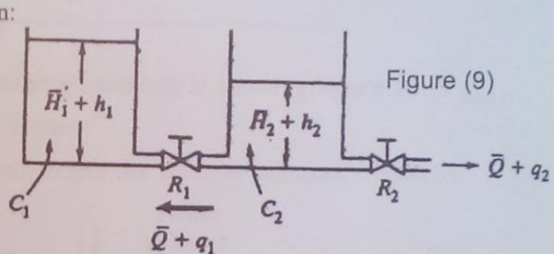


Figure (9)

10- Consider the DC servomotor system shown in Figure (10).

Drive the equations describing the system in time and s-domain, then draw the corresponding block diagram, and obtain the transfer function $(\mathbf{E}_o / \mathbf{E}_i)$.

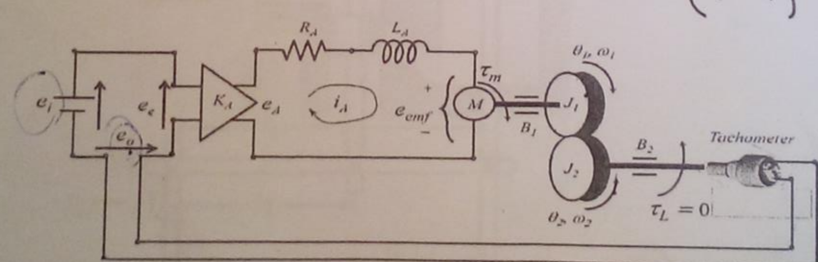


Figure (10)

11- Derive the transfer function of the operational amplifier (Op-amp) circuit relating $\mathbf{E}_o / \mathbf{E}_i$.

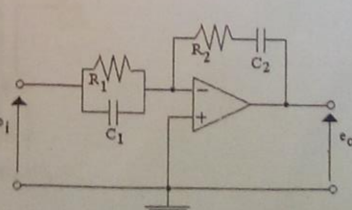


Figure (11)

Modeling assignment

12- Derive the transfer function of the electronic controller consisting of operational amplifiers (Fig. 12).

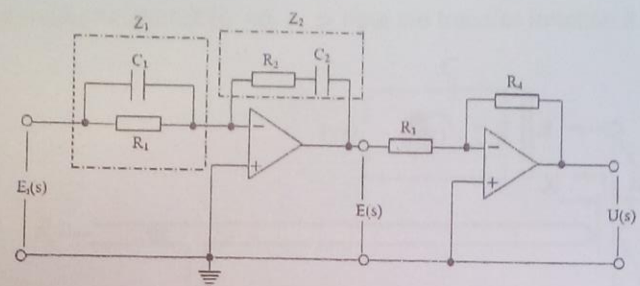


Figure (12)

13- A hydraulic servomechanism with mechanical feedback is shown in figure 13.

- Obtain the equations describing the system.
- Draw the corresponding block diagram to find the transfer function Y(S)/X(S)

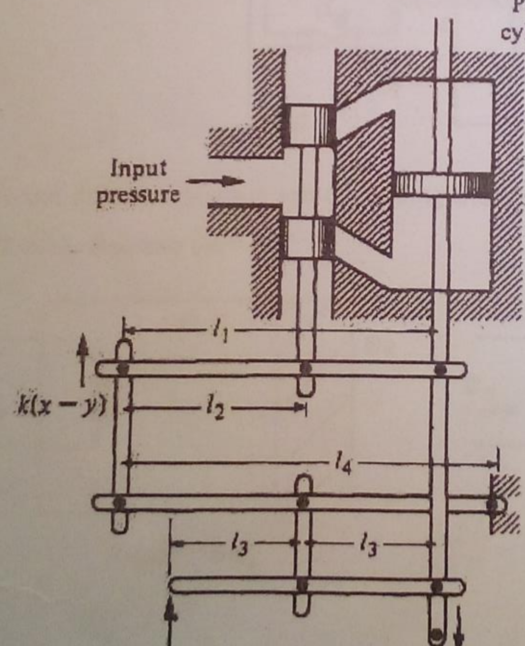


Figure (13)

Modeling assignment

14- For the Pneumatic controller of the nozzle-flapper type shown in figure (14),

a- Deduce the equations relating the system elements in time domain and s-domain.

b- Find the transfer function if R_i =0, c- Find the transfer function if $R_i = \infty$

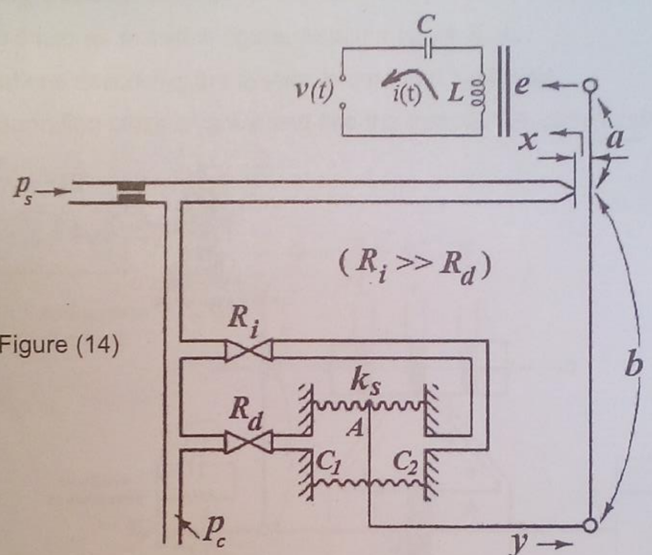


Figure (14)

15- Write the differential equation describing the thermal systems shown in figures (15-a,b), Assume Θa = 0

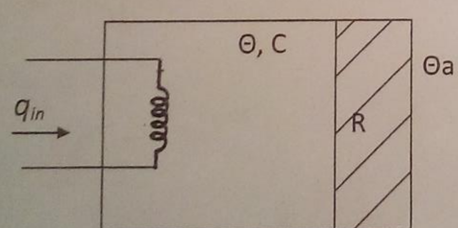


Figure (15-a)

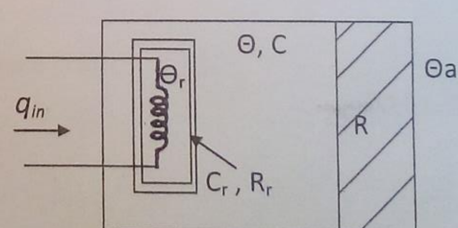


Figure (15-b)

Modeling assignment

16- A hydraulic servomechanism controlled by electro-mechanical feedback as shown in figure 1. The armature controlled DC-motor which rotate at constant speed is used to adjust the actuating displacement *e(t)* via the rack and pinion in order to convert the rotary displacement into linear as shown in figure. Assume $v_{emf} = k_b\,\dot{\theta}_1$

- Obtain the equations describing the system in time and s-domain
- Draw the corresponding block diagram and find the transfer function $V_i(s)/V_o(s)$

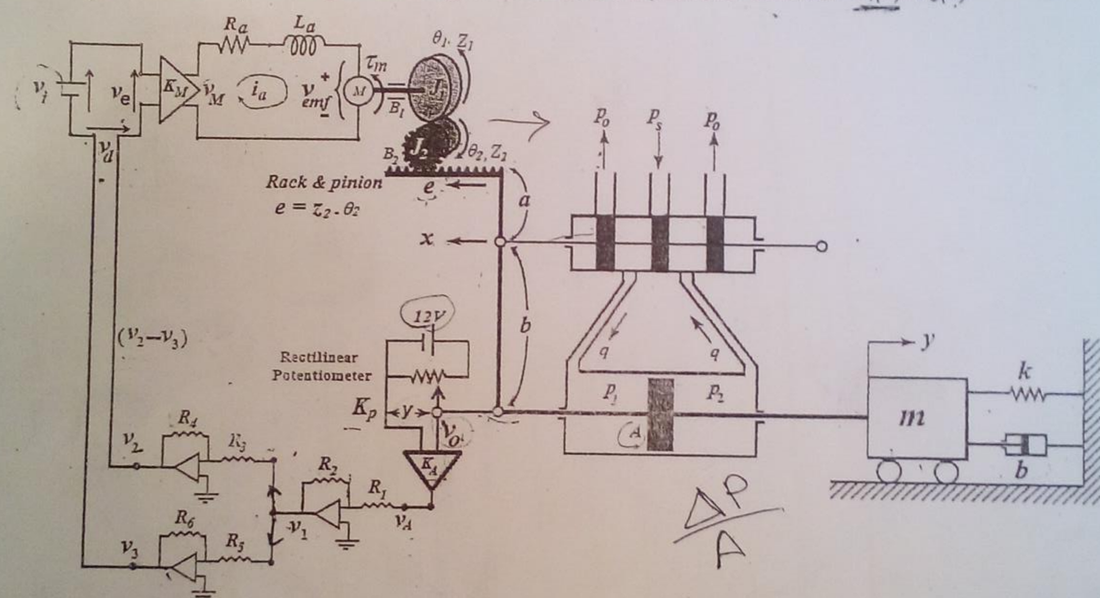


Figure (16)