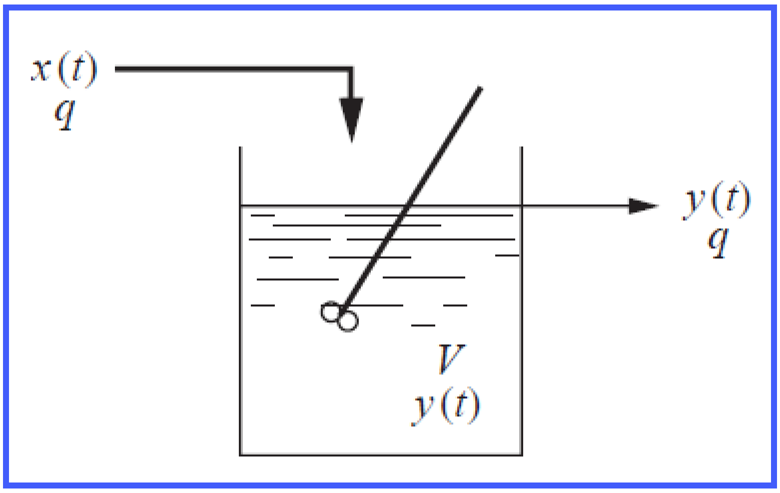
MODELARE ŞI SIMULARE- 2024

LABORATOR NR. 6 – SISTEME FLUIDICE (2), SIMULINK (5)

6.1 Se dă procesul de amestecare de mai jos. Concentraţia de sare la intrare este *x* şi variază cu timpul. Mărimea de ieşire este concentraţia la ieşire, *y*. Se cere funcţia de transfer corespunzătoare. Volumul (*V*) este constant. Se cere modelul Simulink cu vizualizarea lui *x* si *y* in Matlab.



ECHILIBRUL MASIC, REGIM STATIONAR, DEVIATII, FUNCTIE DE TRANSFER, CONSTANTA DE TIMP

1

$$qx - qy = \frac{d(Vy)}{dt} = V\frac{dy}{dt}$$

2

$$qx_s - qy_s = 0$$

3

$$X = x - x_s$$
$$Y = y - y_s$$

$$qX - qY = V\frac{dY}{dt}$$

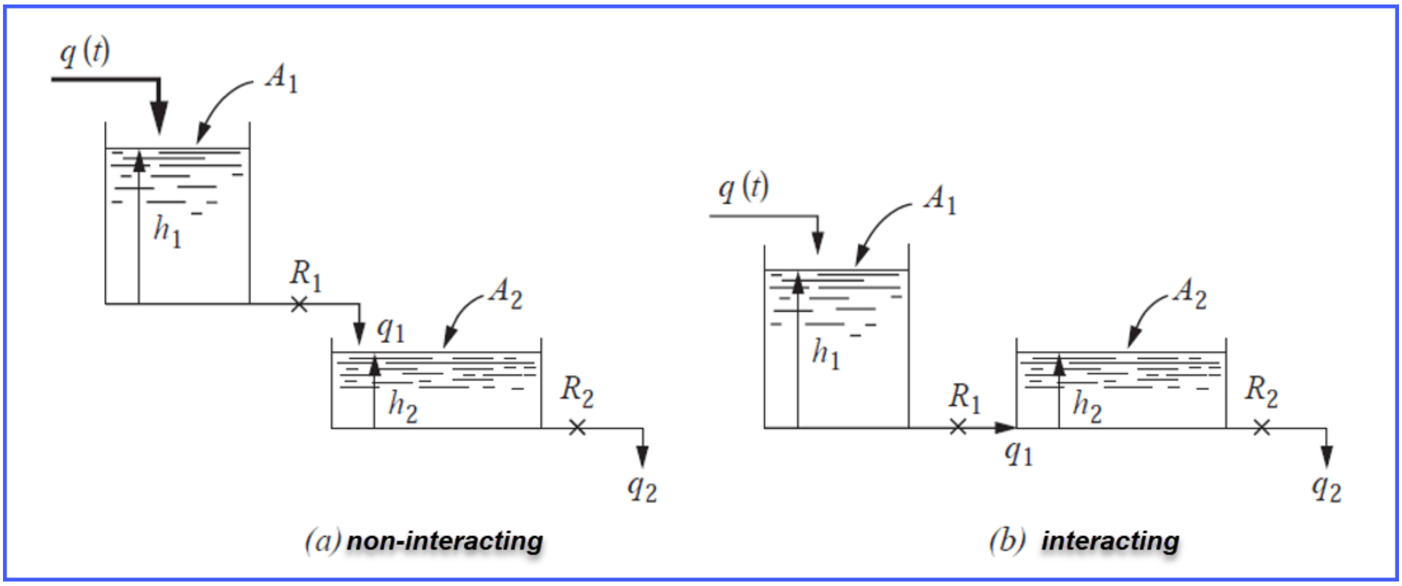
4

$$\frac{Y(s)}{X(s)} = \frac{1}{\tau s + 1}$$

5

$$\tau = V/q$$

6.2 Deduceţi modelul matematic (funcţia de transfer) pentru sistemele fluidice de mai jos. Realizaţi modelele Simulink corespunzătoare.



a. (non-interacting, cascada)

FUNCTII DE TRANSFER PENTRU FIECARE REZERVOR

1

$$q - q_1 = A_1 \frac{dh_1}{dt}$$

2

$$q_1 - q_2 = A_2 \frac{dh_2}{dt}$$

3

$$q_1 = \frac{h_1}{R_1}$$

$$q_2 = \frac{h_2}{R_2}$$

4

$$\frac{Q_1(s)}{Q(s)} = \frac{1}{\tau_1 s + 1}$$

5

$$Q_1 = q_1 - q_{1s}, \quad Q = q - q_s, \qquad \tau_1 = R_1 A_1.$$

6

$$\frac{H_2(s)}{Q_1(s)} = \frac{R_2}{\tau_2 s + 1}$$

$$H_2 = h_2 - h_{2s} \qquad \tau_2 = R_2 A_2.$$

$$\boxed{\frac{H_2(s)}{Q(s)} = \frac{1}{\tau_1 s + 1} \frac{R_2}{\tau_2 s + 1}}$$

Se dau valorile de mai jos şi se cere răspunsul sistemului la o intrare treaptă unitară. Se cere modelul Simulink (cu două şi cu un singur rezervor).

$$\tau_1 = 0.5, \tau_2 = 1, R_2 = 1$$

RASPUNSUL SISTEMULUI LA INTRARE TREAPTA UNITARA

1

$$\frac{H_2(s)}{Q(s)} = \frac{R_2}{(\tau_1 s + 1)(\tau_2 s + 1)}$$

2

$$H_2(s) = \frac{1}{s}\frac{R_2}{(\tau_1 s + 1)(\tau_2 s + 1)}$$

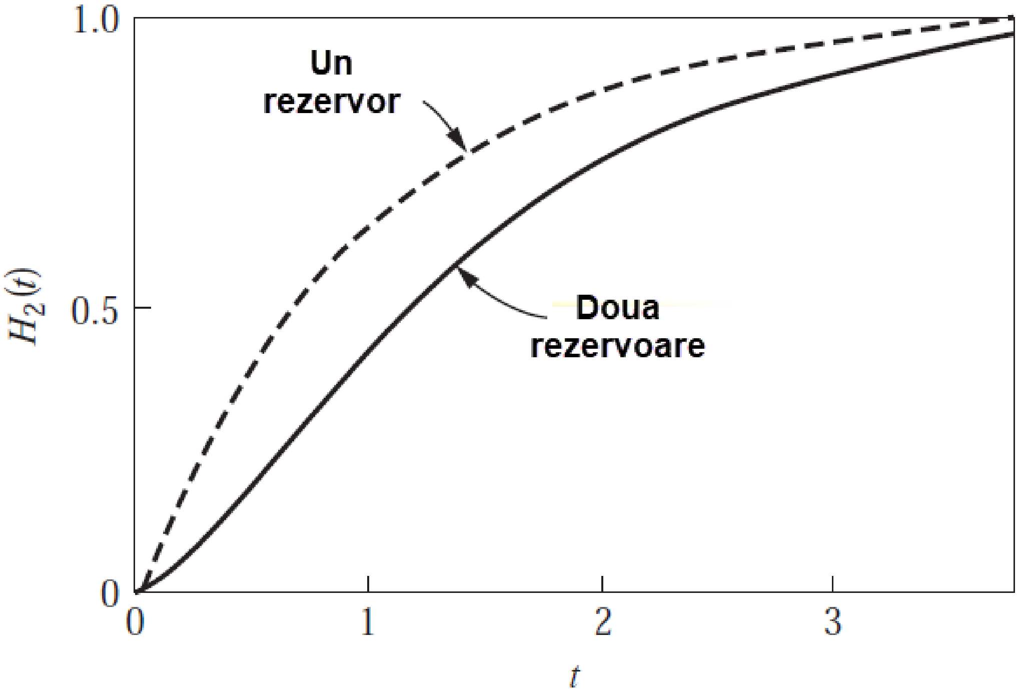
3

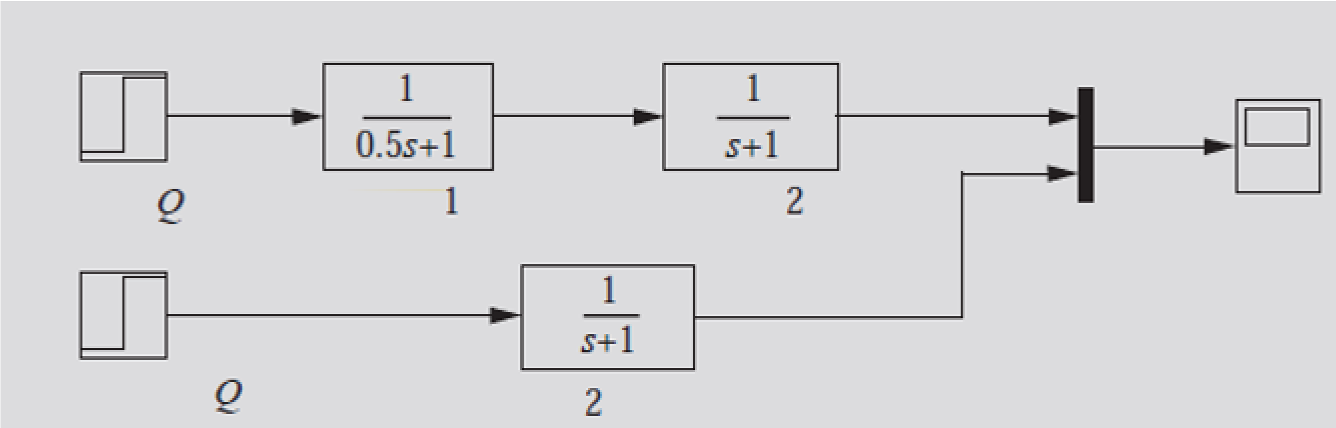
$$H_2(t) = R_2\left[1 - \frac{\tau_1\tau_2}{\tau_1 - \tau_2}\left(\frac{1}{\tau_2}e^{-t/\tau_1} - \frac{1}{\tau_1}e^{-t/\tau_2}\right)\right]$$

4

$$H_2(t) = 1 - \left(2e^{-t} - e^{-2t}\right)$$

5





Generalizare:

GENERALIZARE

1

$$\frac{X_1(s)}{X_0(s)} = \frac{k_1}{\tau_1 s + 1}$$

$$\frac{X_2(s)}{X_1(s)} = \frac{k_2}{\tau_2 s + 1}$$

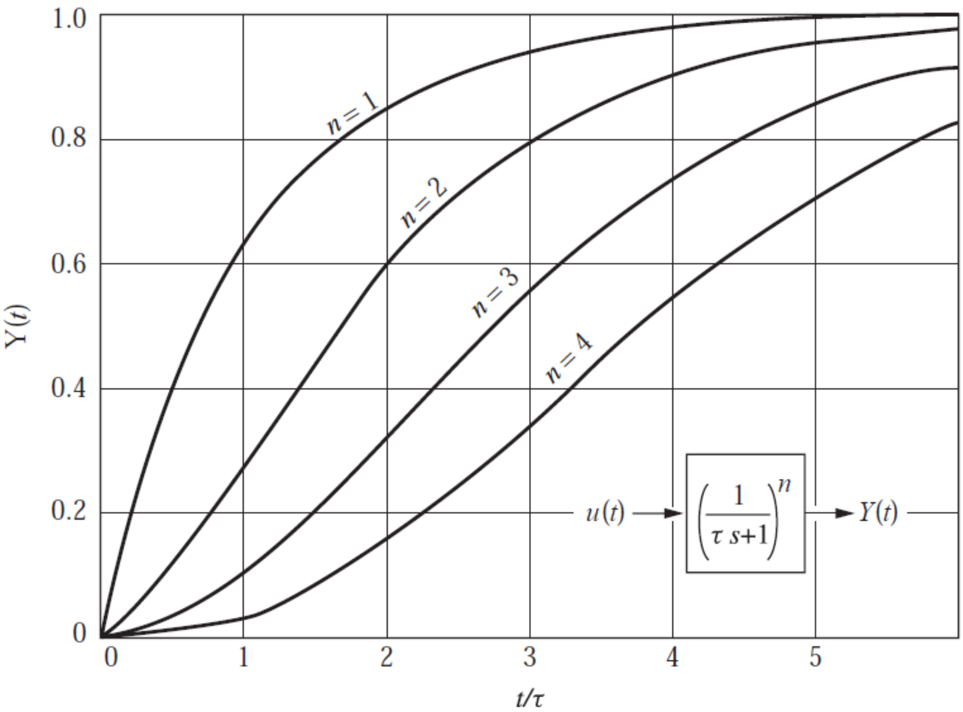
etc.

$$\frac{X_n(s)}{X_{n-1}(s)} = \frac{k_n}{\tau_n s + 1}$$

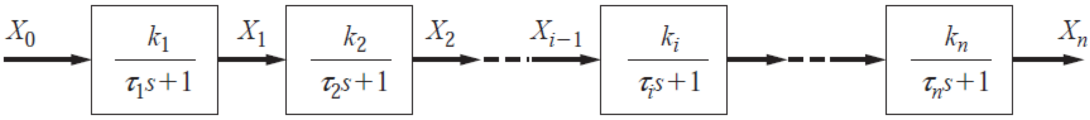
2

$$\frac{X_n(s)}{X_0(s)} = \prod_{i=1}^{n} \frac{k_i}{\tau_i s + 1}$$

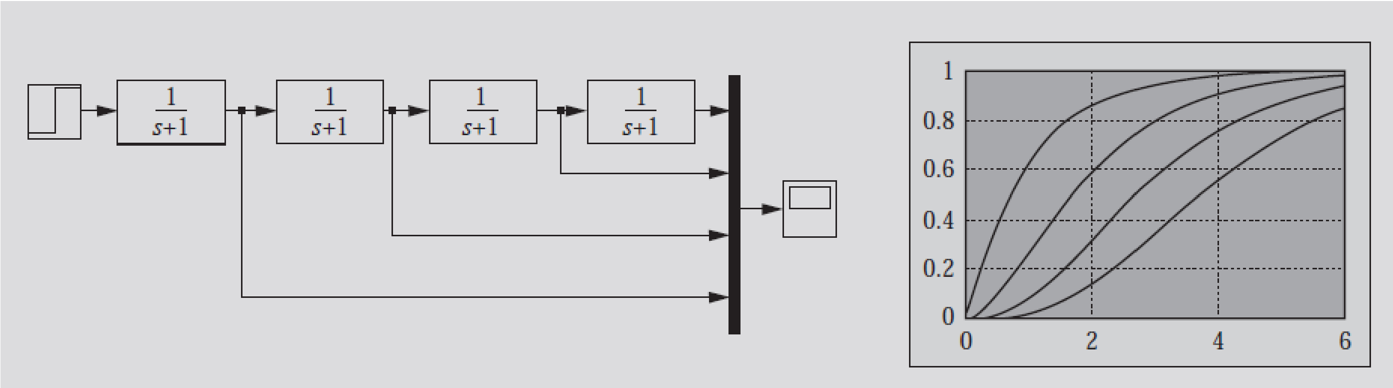
3



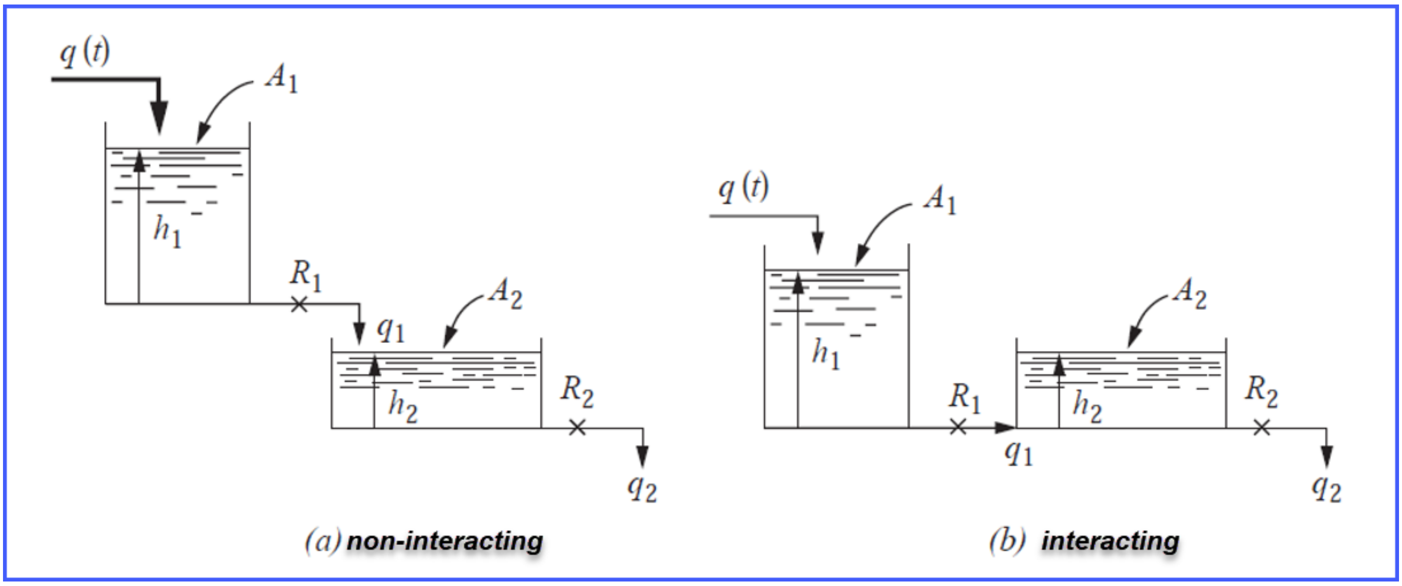
4



Modelul Simulink pentru 4 funcţii de transfer.



b. (interacting, loading, in serie)



ECUATII DE ECHILIBRU SI FUNCTII DE TRANSFER

1

$$q - q_1 = A_1 \frac{dh_1}{dt}$$

$$q_1 - q_2 = A_2 \frac{dh_2}{dt}$$

2

$$q_1 = \frac{1}{R_1}(h_1 - h_2)$$

$$q_2 = \frac{h_2}{R_2}$$

3

$$q_s - q_{1_s} = 0$$

$$q_{1_s} - q_{2_s} = 0$$

4

$$Q - Q_1 = A_1 \frac{dH_1}{dt}$$

$$Q_1 - Q_2 = A_2 \frac{dH_2}{dt}$$

5

$$Q_1 = \frac{H_1 - H_2}{R_1}$$

$$Q_2 = \frac{H_2}{R_2}$$

6

$$Q(s) - Q_1(s) = A_1 s H_1(s)$$

$$Q_1(s) - Q_2(s) = A_2 s H_2(s)$$

$$R_1 Q_1(s) = H_1(s) - H_2(s)$$

$$R_2 Q_2(s) = H_2(s)$$

$$\boxed{\frac{H_2(s)}{Q(s)} = \frac{R_2}{\tau_1 \tau_2 s^2 + (\tau_1 + \tau_2 + A_1 R_2) s + 1}}$$

Comparaţi răspunsul unui sistem cu două rezervoare identice ($\tau_1 = \tau_2 = \tau, A_1 = A_2$) **în cazul a) şi în cazul b).**

RASPUNSUL LA TREAPTA UNITARA IN CELE DOUA CAZURI

1

$$\frac{Q_2(s)}{Q(s)} = \left(\frac{1}{\tau s + 1}\right)^2$$

2

$$Q_2(t) = 1 - e^{-t/\tau} - \frac{t}{\tau}e^{-t/\tau}$$

3

$$\frac{Q_2(s)}{Q(s)} = \frac{1}{\tau^2 s^2 + 3\tau s + 1}$$

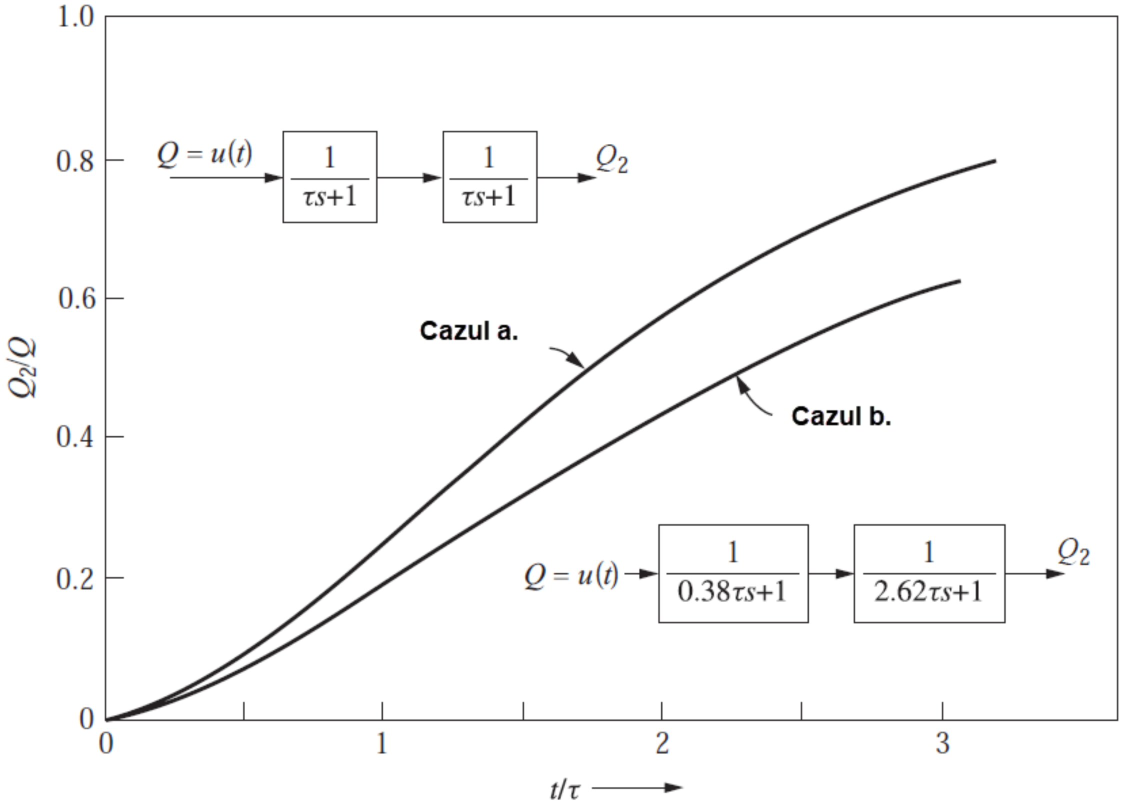
4

$$\frac{Q_2(s)}{Q(s)} = \frac{1}{(0.38\tau s + 1)(2.62\tau s + 1)}$$

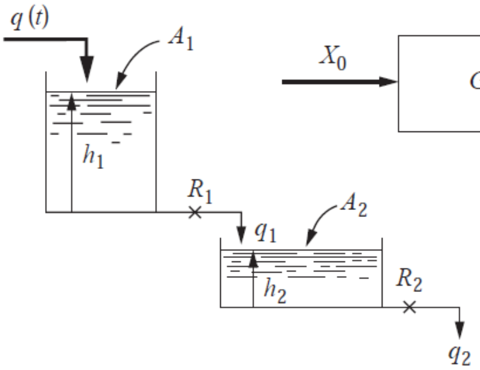
5

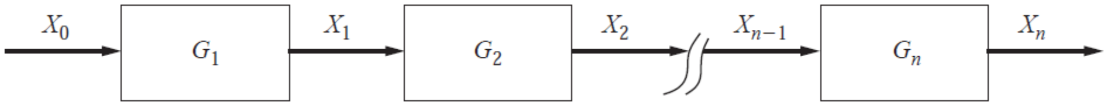
$$Q_2(t) = 1 + 0.17e^{-t/0.38\tau} - 1.17e^{-t/2.62\tau}$$

6



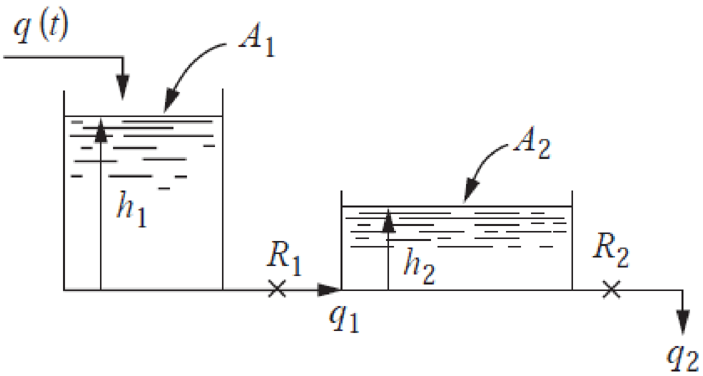
Rezumat





$$\frac{X_n(s)}{X_0(s)} = \prod_{i=1}^{n} G_i$$

$$\frac{H_2(s)}{Q(s)} = \frac{1}{\tau_1 s + 1}\,\frac{R_2}{\tau_2 s + 1}$$

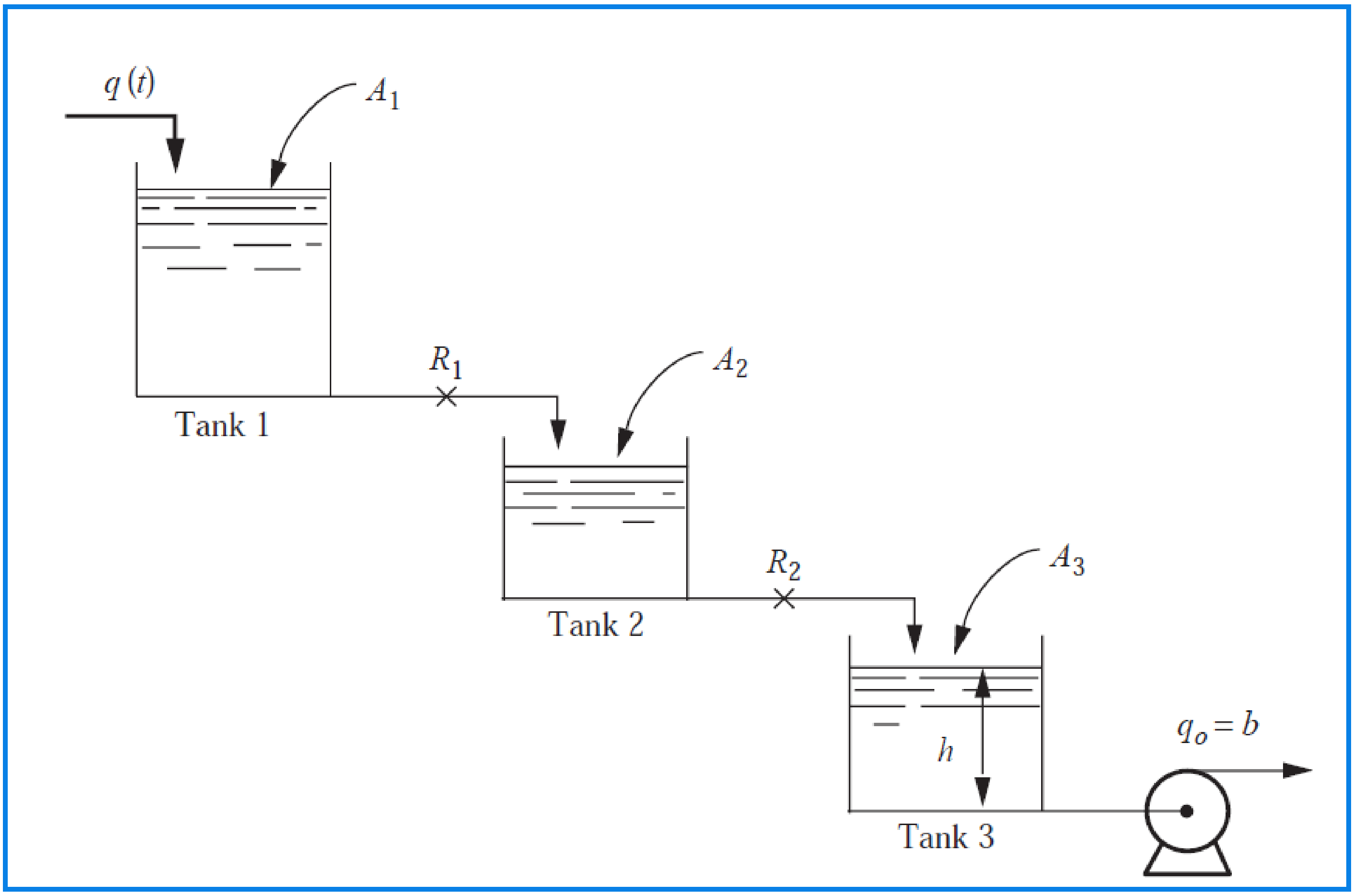


$$\frac{X_n(s)}{X_0(s)} \neq \prod_{i=1}^{n} G_i$$

$$\frac{H_2(s)}{Q(s)} = \frac{R_2}{\tau_1\tau_2 s^2 + (\tau_1 + \tau_2 + A_1R_2)s + 1}$$

Atentie la prezenta acestui termen (duce la incetinirea raspunsului sistemului)

PRO 6.3 Determinaţi funcţia de transfer a sistemului hidraulic de mai jos. Rezistenţele R_1 şi R_2 sunt liniare, iar debitul de ieşire din rezervorul 3 (b) este constant.

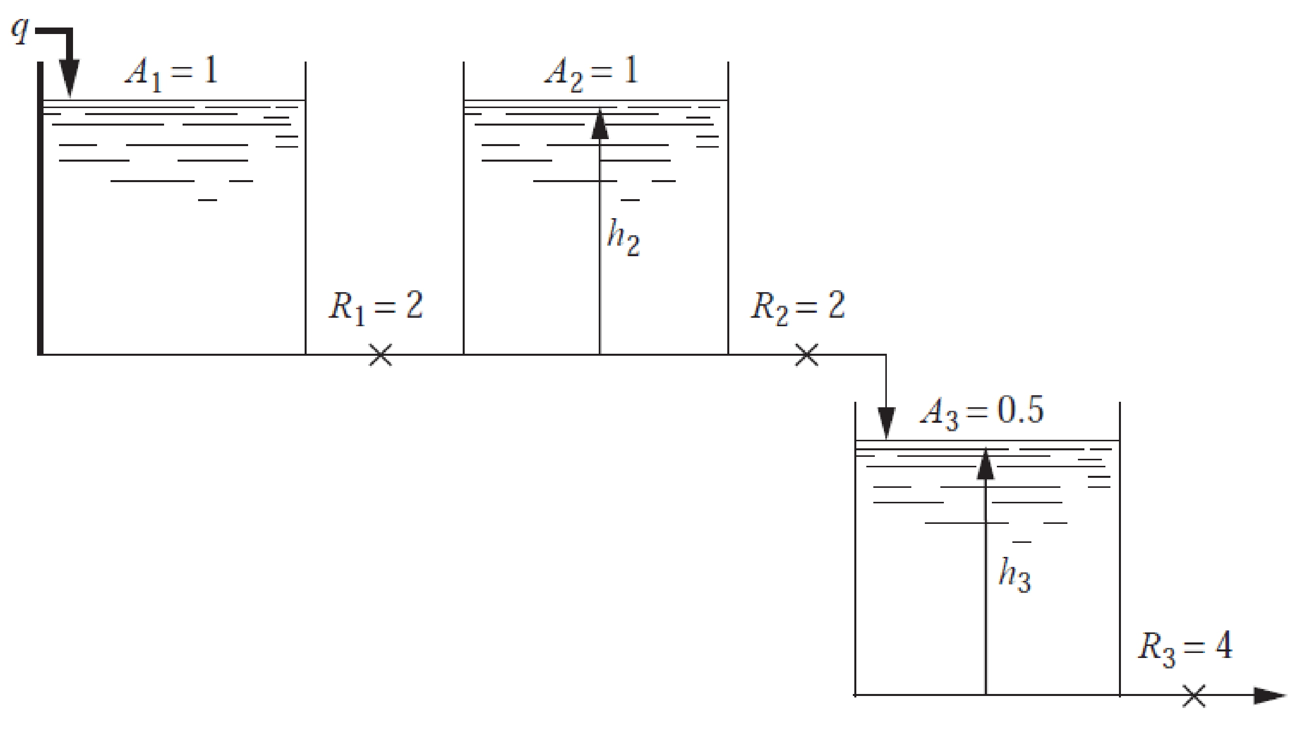


PRO 6.4 Se dă sistemul fluidic de mai jos.

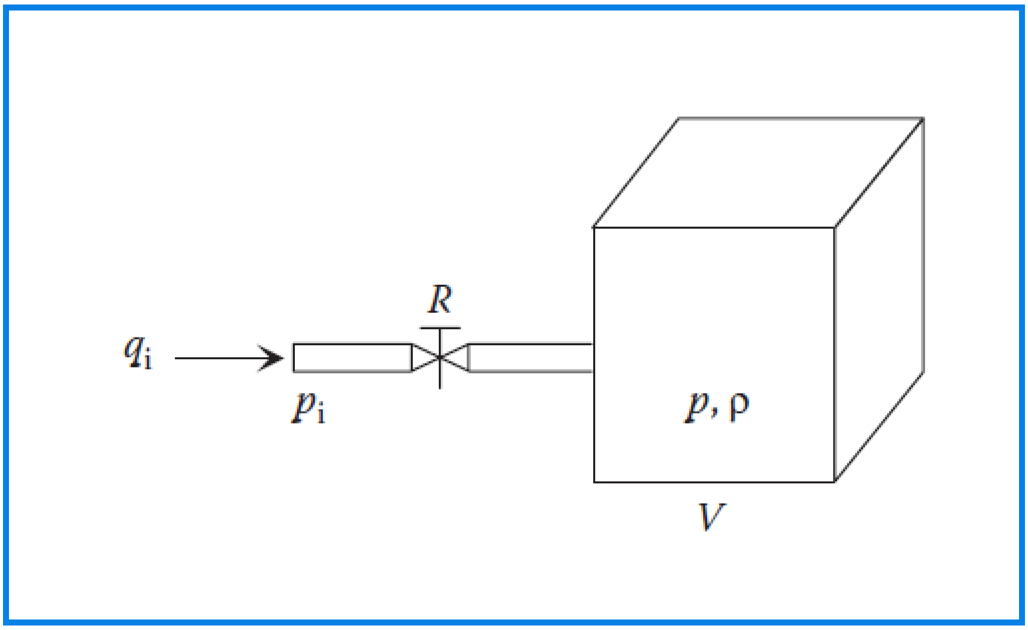
Se cer:

a. **Funcţiile de transfer $\frac{H_2}{Q}, \frac{H_3}{Q}$, unde mărimile indicate (H_2, H_3, Q) sunt deviaţii.**

b. **Pentru o variaţie treaptă a lui *q* (Q(s)=1/s), se cer $H_3(0), H_3(\infty)$, precum şi graficul lui $H_3(t)$.**



6.5 Determinaţi modelul matematic pentru dinamica presiunii p din rezervorul de mai jos. Aer cu temperatura de 20 grade Celsius intră în acel rezervor rigid de volum 1 mc. Presiunea p_i este constantă, rezistenţa este liniară, cu valoarea $R = 1000\ Pa * \frac{s}{kg}$. Procesul de umplere a rezervorului este izoterm.



CONSERVAREA MASEI, CAPACITATEA PNEUMATICA, MODELUL DINAMIC

1

$$\frac{dm}{dt} = \rho_i q_i$$

2

$$\frac{dm}{dt} = \frac{dm}{dp}\frac{dp}{dt} = C\frac{dp}{dt}$$

3

$$C = \frac{V}{R_{air}T}$$

4

$$R = \frac{p_i - p}{\rho_i q_i}$$

5

$$\frac{V}{R_{air}T}\frac{dp}{dt} = \frac{p_i - p}{R}$$

6

$$\frac{RV}{R_{air}T}\frac{dp}{dt} + p = p_i$$

$$RV/(R_{air}\,T) = 1000 \times 1^3/(287.06 \times 293) = 1.19 \times 10^{-2}\ \mathrm{s}.$$