MODELARE ŞI SIMULARE - 2024

LABORATOR NR. 4 – SISTEME MECANICE (3), SISTEME NELINIARE(1), MATLAB(4), SIMULINK (3)

4.1 Pentru sistemul dinamic cu intrarea *u* şi ieşirea *x*:

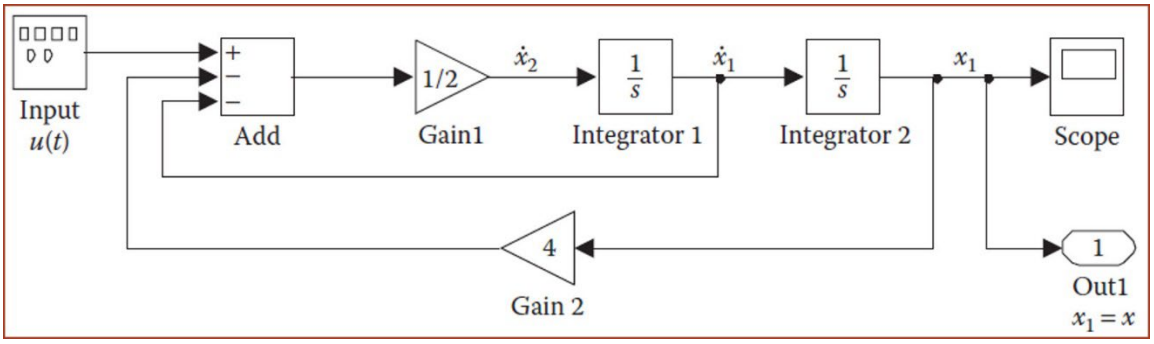
$$2\ddot{x} + \dot{x} + 4x = u(t)$$

1. **Deduceţi ecuaţiile de stare.**
2. **Construiţi o diagramă bloc.**
3. **Construiţi un model Simulink pe baza diagramei de la pct. 2**

$$\begin{cases} \dot{x}_1 = x_2 \\ \dot{x}_2 = \frac{1}{2}(-4x_1 - x_2 + u)' \end{cases} \quad y = x_1$$

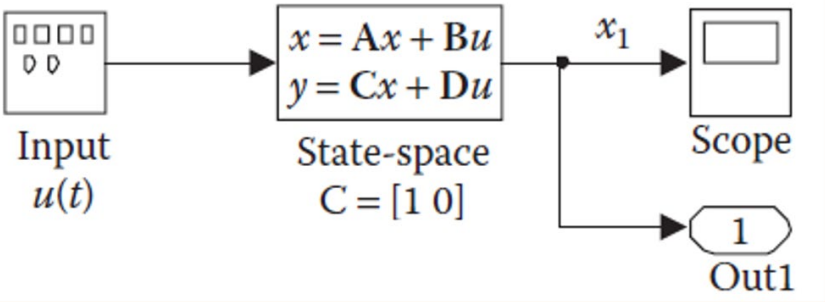
$$\begin{cases} \dot{\mathbf{x}} = \mathbf{A}\mathbf{x} + \mathbf{B}u \\ y = \mathbf{C}\mathbf{x} + Du \end{cases}$$

$$\mathbf{x} = \begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix}, \ \mathbf{A} = \begin{bmatrix} 0 & 1 \\ -2 & -\frac{1}{2} \end{bmatrix}, \ \mathbf{B} = \begin{bmatrix} 0 \\ \frac{1}{2} \end{bmatrix}, \ \mathbf{C} = \begin{bmatrix} 1 & 0 \end{bmatrix}, \ D = 0, \ u = u(t)$$



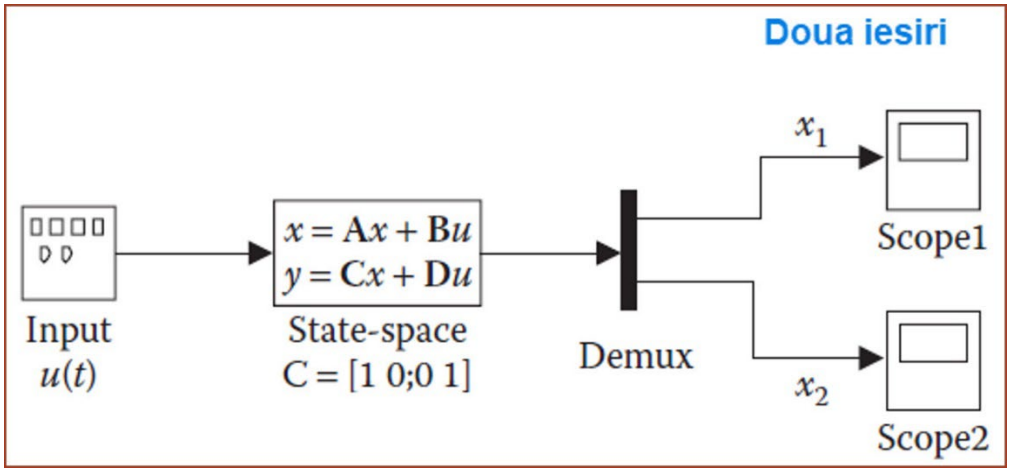
Blocul state-space din Simulink:

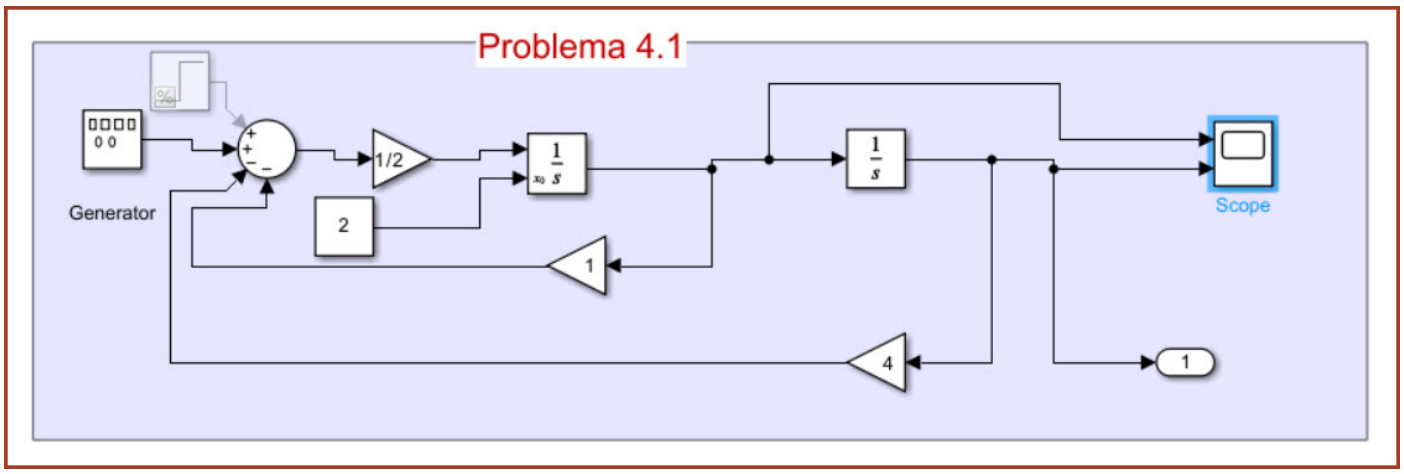
O singura iesire



Când sunt două ieşiri, cum se schimbă modelul?

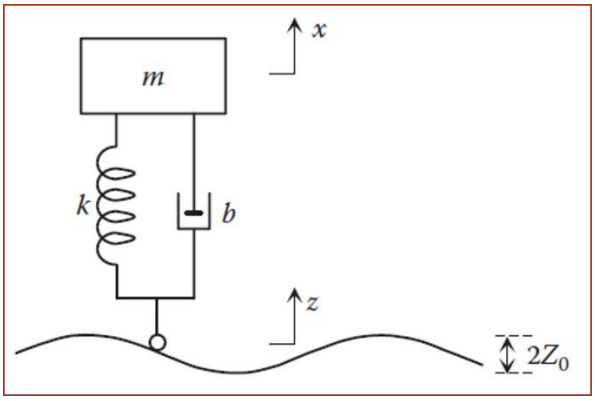
$$\mathbf{y} = \mathbf{C}\mathbf{x} + \mathbf{D}u, \quad \mathbf{y} = \begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix}, \quad \mathbf{C} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}, \quad \mathbf{D} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}, \quad u = u(t)$$


Doua iesiri
Input
u(t)
x = Ax + Bu
y = Cx + Du
State-space
C = [1 0;0 1]
Demux
x1
x2
Scope1
Scope2


Problema 4.1
Generator
1/2
2
1
4
1
Scope

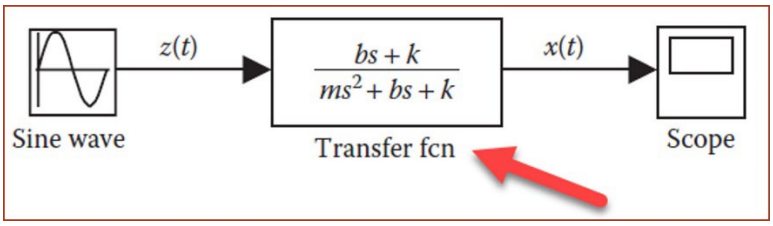
4.2 Construiţi modelul Simulink (in cel putin trei variante) pentru sistemul mecanic de mai jos. Se cunosc:

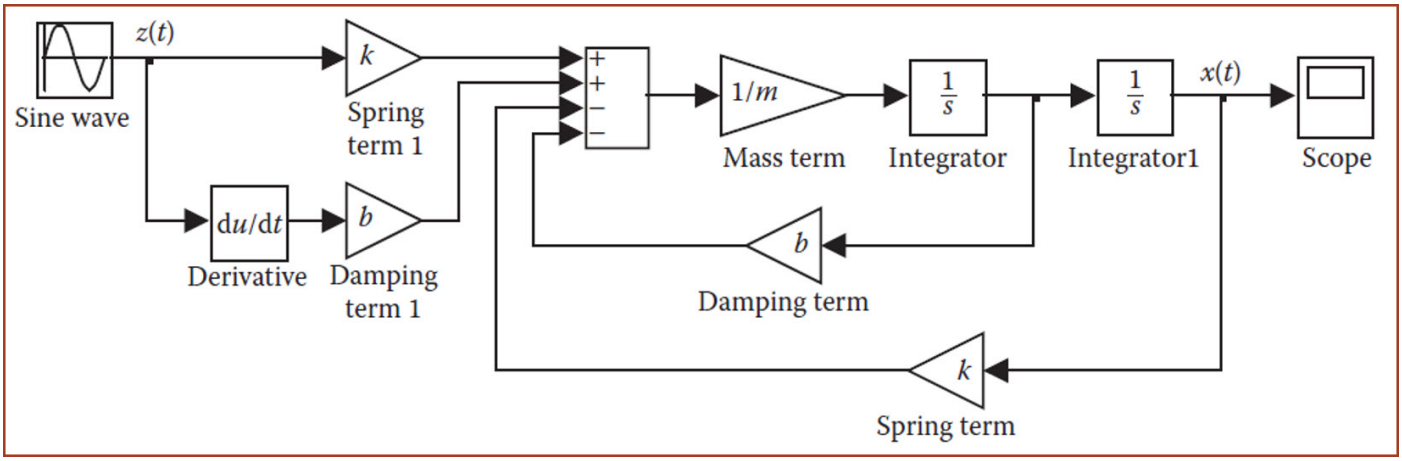
$$z(t) = Z_0 \sin(\omega t), Z_0 = 0.01\ m, \omega = \frac{3.5 rad}{s}, m = 3000\ kg, b = 2000\ N\frac{s}{m}, k = 50\frac{kN}{m}.$$



$$\ddot{x} = \frac{1}{m}(kz + b\dot{z} - kx - b\dot{x})$$

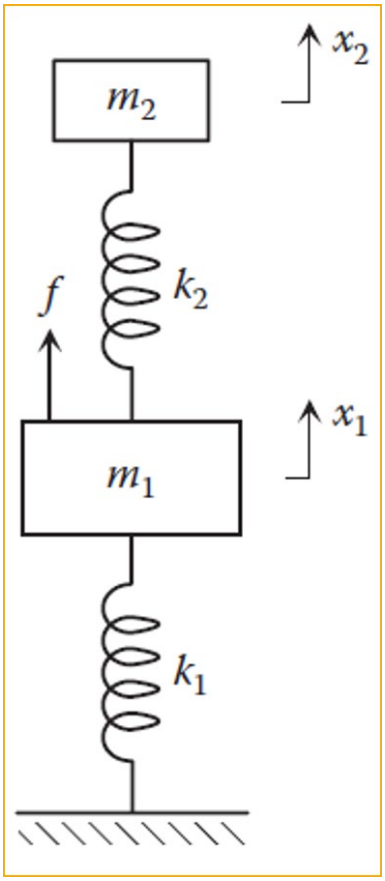
$$\frac{X(s)}{Z(s)} = \frac{bs+k}{ms^2+bs+k}$$




z(t)
Sine wave
k
Spring
term 1
du/dt
Derivative
b
Damping
term 1
+
+
−
−
1/m
Mass term
1/s
Integrator
1/s
Integrator1
x(t)
Scope
b
Damping term
k
Spring term

4.3 Construiţi diagrama bloc si modelul Simulink pentru sistemul mecanic din figura de mai jos.

Se cunosc: $m_1 = 6\ kg, k_1 = 6000\frac{N}{m}, m_2 = 1.65\ kg, k_2 = 800\frac{N}{m}, f = 70\sin(7\pi t)$.

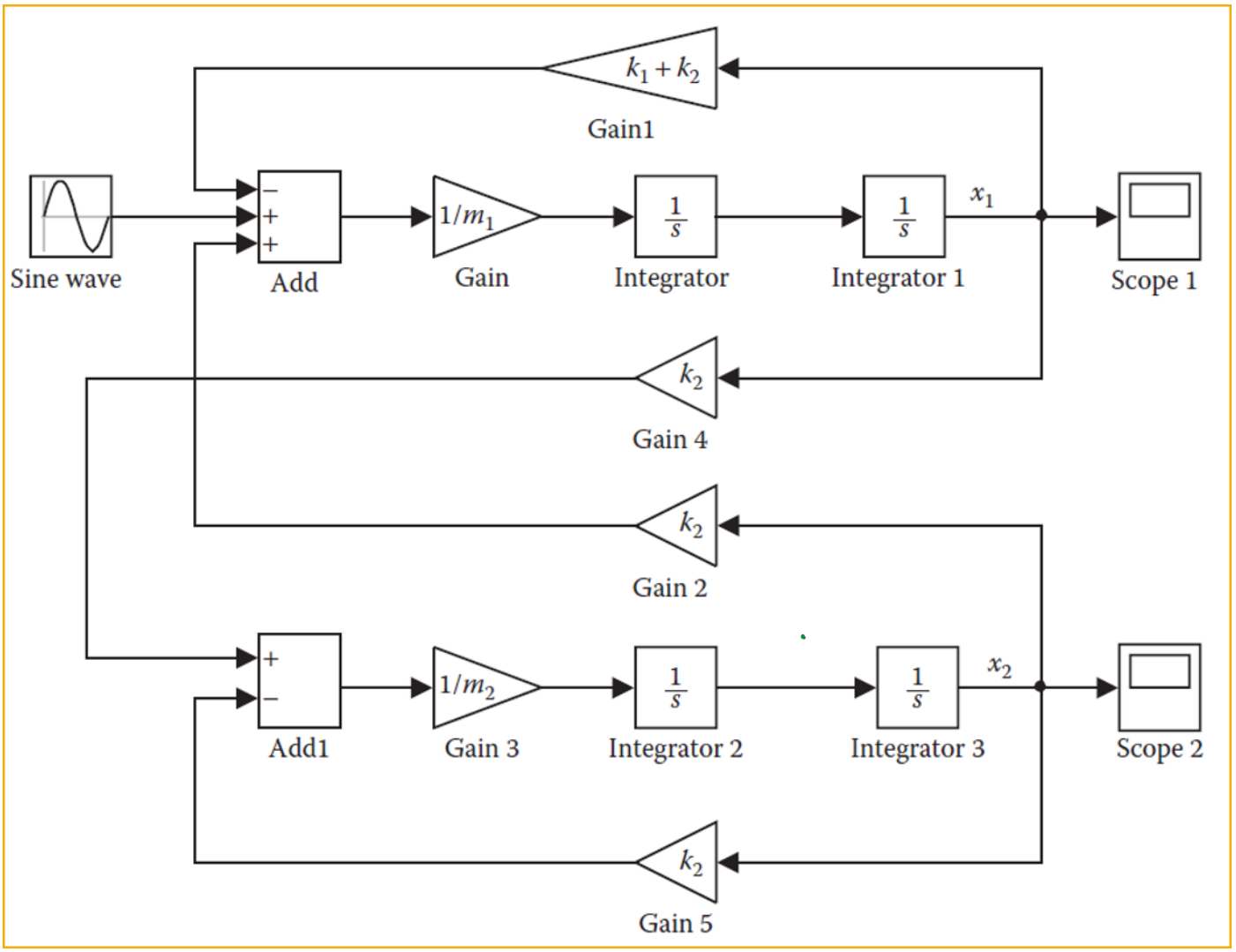


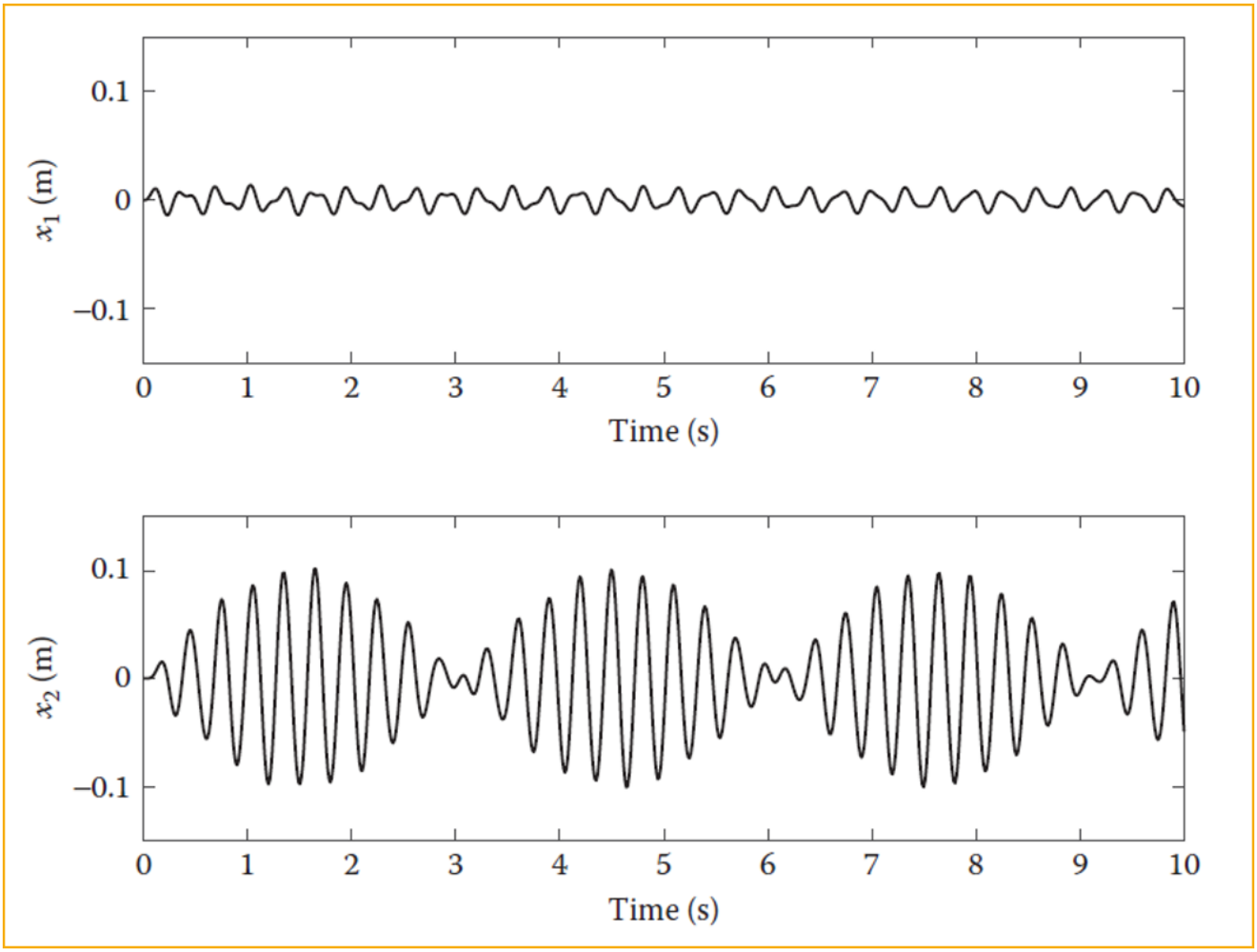
$$\ddot{x}_1 = \frac{1}{m_1}\left[f - (k_1 + k_2)x_1 + k_2 x_2\right]$$

$$\ddot{x}_2 = \frac{1}{m_2}(k_2 x_1 - k_2 x_2)$$

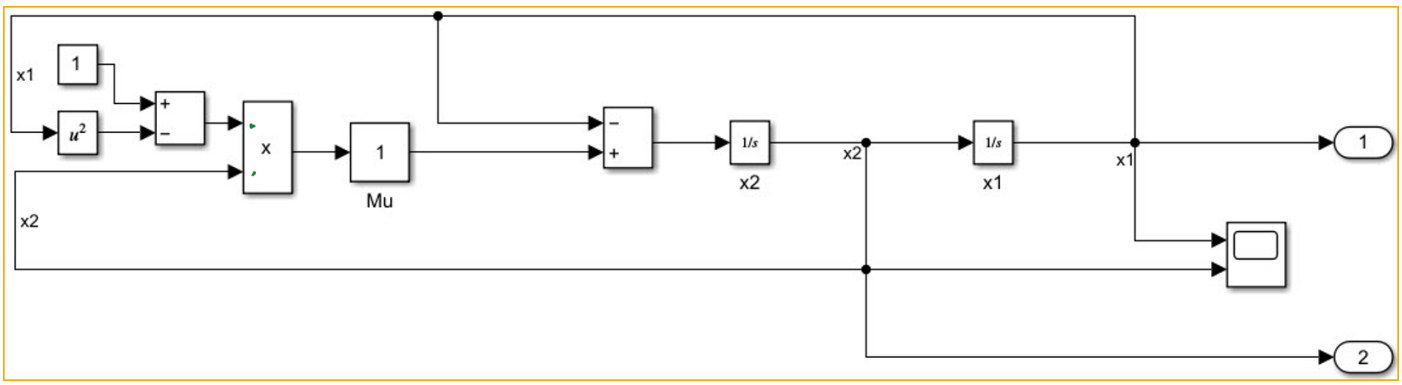
$$\mathbf{x} = \begin{Bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{Bmatrix} = \begin{Bmatrix} x_1 \\ x_2 \\ \dot{x}_1 \\ \dot{x}_2 \end{Bmatrix}, \qquad u = f, \qquad \mathbf{y} = \begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix}$$

$$\begin{Bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \\ \dot{x}_4 \end{Bmatrix} = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ -\dfrac{k_1+k_2}{m_1} & \dfrac{k_2}{m_1} & 0 & 0 \\ \dfrac{k_2}{m_2} & -\dfrac{k_2}{m_2} & 0 & 0 \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{Bmatrix} + \begin{bmatrix} 0 \\ 0 \\ \dfrac{1}{m_1} \\ 0 \end{bmatrix} u, \quad \mathbf{y} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{Bmatrix}$$



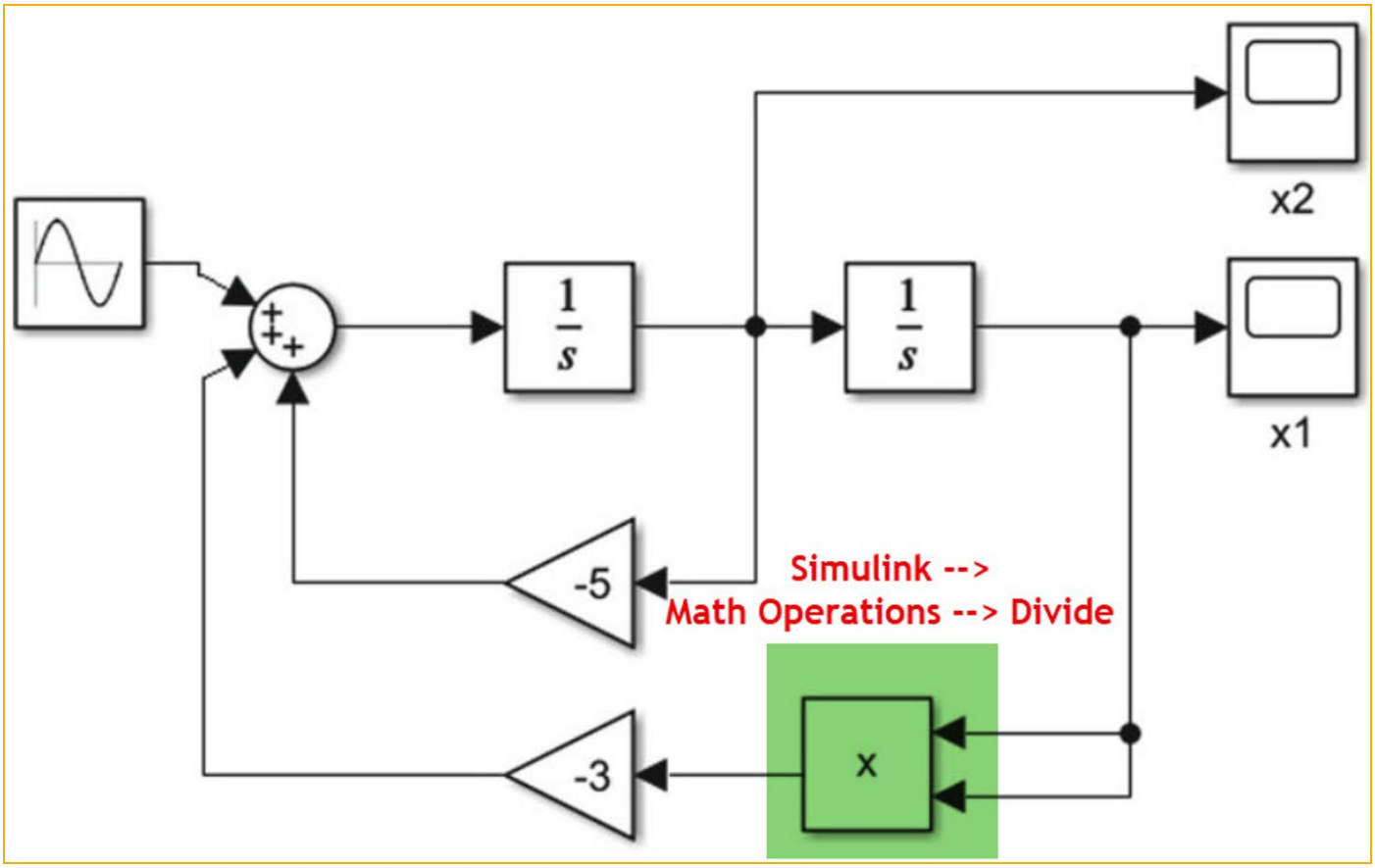

0.1
0
−0.1
x_1 (m)
0 1 2 3 4 5 6 7 8 9 10
Time (s)
0.1
0
−0.1
x_2 (m)
0 1 2 3 4 5 6 7 8 9 10
Time (s)

4.4 Care este ecuatia diferentiala modelata de diagrama Simulink de mai jos?



4.5 Modelati in Simulink urmatoarea ecuatie diferentiala.

$$\ddot{y}(t) + 5\dot{y}(t) + 3y(t)^2 = u(t),\ y(0) = 5,\ \dot{y}(0) = 2$$
$$u(t) = 3 + 0.7\sin\left(0.5t + \frac{\pi}{4}\right)$$



PRO 4.6. Pentru modelul de la problema 4.2, se cere afisarea pe un singur osciloscop (2 linii, 2 coloane, fundal alb) a marimilor (in ordine pe coloane: *z*, *z'*, *x*, *x'*), precum si utilizarea unui slider pentru introducerea din panoul de comanda a parametrului *m*.