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ECEN 380
2/11/2026

PS06: 2.66(b), 2.68(b), 2.69(a), 2.70(b), 2.72(a),
MATLAB 2.94

[illegible]

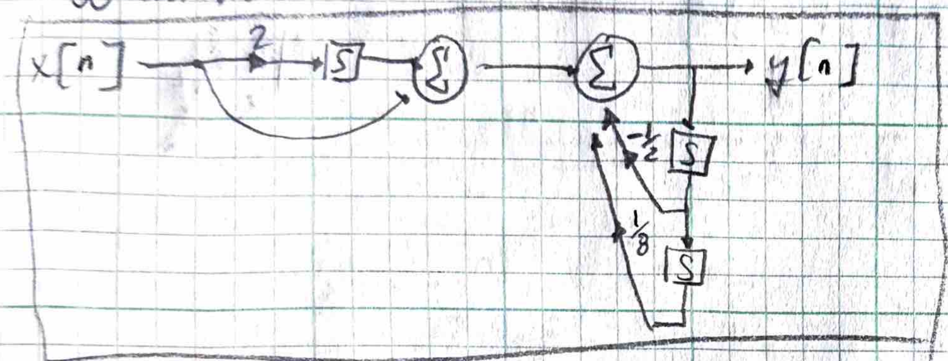
1/5

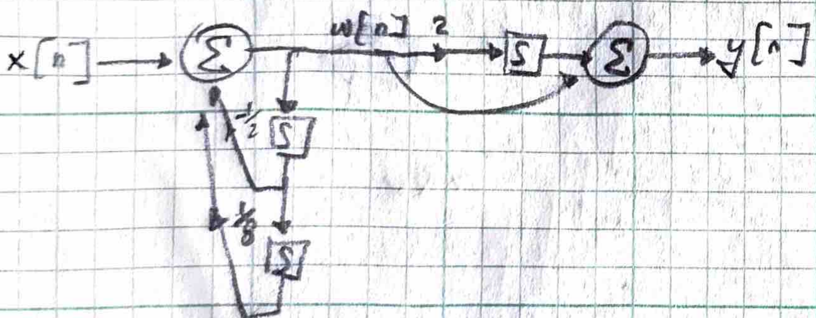
(2.66(b)) Draw direct form I and II for:

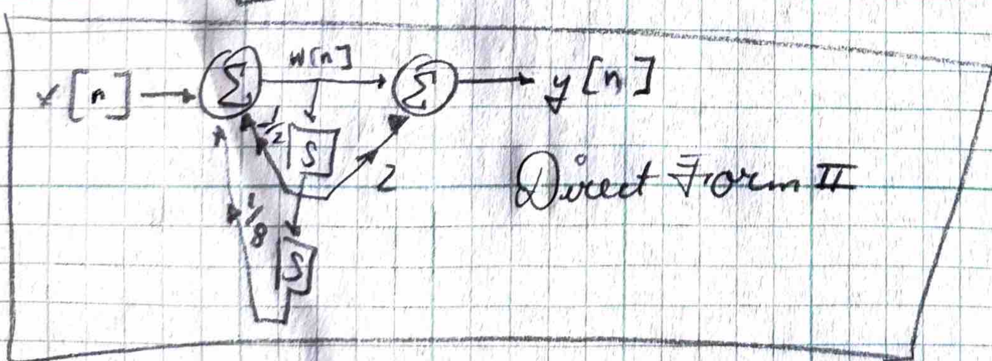
$$y[n] + \tfrac{1}{2}y[n-1] - \tfrac{1}{8}y[n-2] = x[n] + 2x[n-1]$$

$$y[n] = x[n] + 2x[n-1] - \tfrac{1}{2}y[n-1] + \tfrac{1}{8}y[n-2]$$

Direct Form I

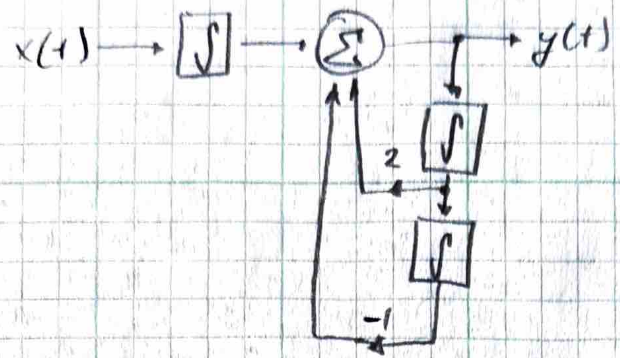






Direct Form II

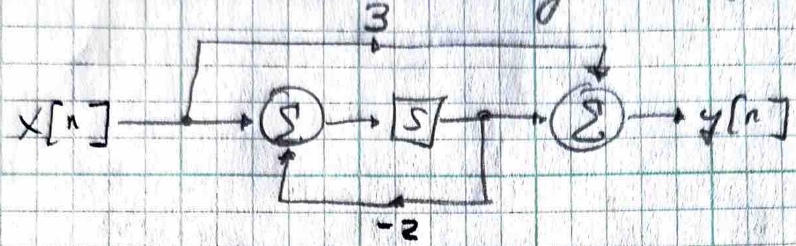
2.68 (b) Find differential-equation description for the system below:

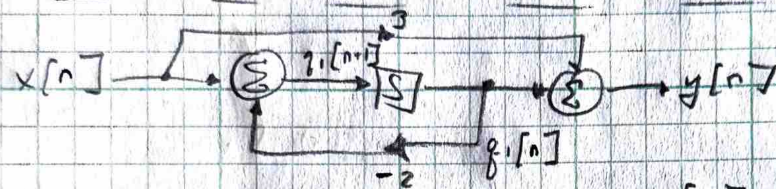


$y(t) = x^{(1)}(t) + 2y^{(1)}(t) - y^{(2)}(t)$ ← w/ integrals

$\boxed{y''(t) = x'(t) + 2y'(t) - y(t)}$ ← w/ derivatives

2.69(a) Determine a state-variable description for the discrete-time system below:





$$q_1[n+1] = -2q_1[n] + x[n] \quad ; \quad y[n] = q_1[n] + 3x[n]$$

define $q = \begin{bmatrix} q_1[n] \\ 0 \end{bmatrix}$

$A = -2$; $b = 1$

$C = 1$; $D = 3$

$$\longrightarrow \quad \boxed{\begin{aligned} q[n+1] &= Aq[n] + bx[n] \\ y[n] &= Cq[n] + Dx[n] \end{aligned}}$$

2.70 (b) Draw block diagram representation of the following state-variable description of LTI system:

$$A = \begin{bmatrix} 1 & -\frac{1}{2} \\ \frac{1}{3} & 0 \end{bmatrix}; \quad b = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$$

$$c = [1, -1]; \quad D = [0]$$

General Form State Variable Descriptions:

$$q[n] = \begin{bmatrix} q_1[n] \\ q_2[n] \end{bmatrix}; \quad q[n+1] = Aq[n] + b\,x[n];$$

$$y[n] = c\,q[n] + D\,x[n]$$

substitute vectors:

$$\begin{bmatrix} q_1[n+1] \\ q_2[n+1] \end{bmatrix} = \begin{bmatrix} 1 & -\frac{1}{2} \\ \frac{1}{3} & 0 \end{bmatrix} \begin{bmatrix} q_1[n] \\ q_2[n] \end{bmatrix} + \begin{bmatrix} 1 \\ 2 \end{bmatrix} x[n];$$

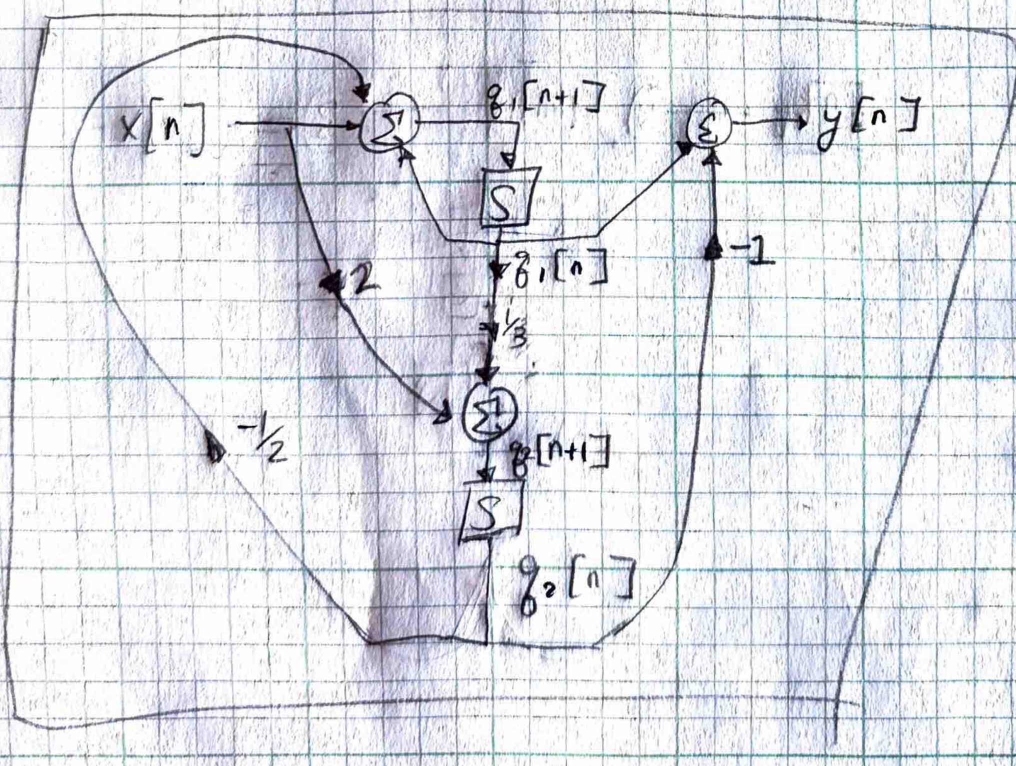
$$y[n] = [1, -1] \begin{bmatrix} q_1[n] \\ q_2[n] \end{bmatrix} + [0]\,x[n]$$

expanded:

$$q_1[n+1] = q_1[n] - \tfrac{1}{2} q_2[n] + x[n]$$

$$q_2[n+1] = \tfrac{1}{3} q_1[n] + 2x[n]$$

$$y[n] = q_1[n] - q_2[n]$$



2.72(a)

Draw the block diagram representation corresponding to the continuous time state-variable description of the following system:

$$A = \begin{bmatrix} \frac{1}{3} & 0 \\ 0 & -\frac{1}{2} \end{bmatrix}; \quad b = \begin{bmatrix} -1 \\ 2 \end{bmatrix}; \quad c = \begin{bmatrix} 1 & 1 \end{bmatrix}; \quad D = [0]$$

General form: $q(t) = \begin{bmatrix} q_1(t) \\ q_2(t) \end{bmatrix}$; $\frac{d}{dt}q(t) = Aq(t) + bx(t)$

$$y(t) = cq(t) + Dx(t)$$

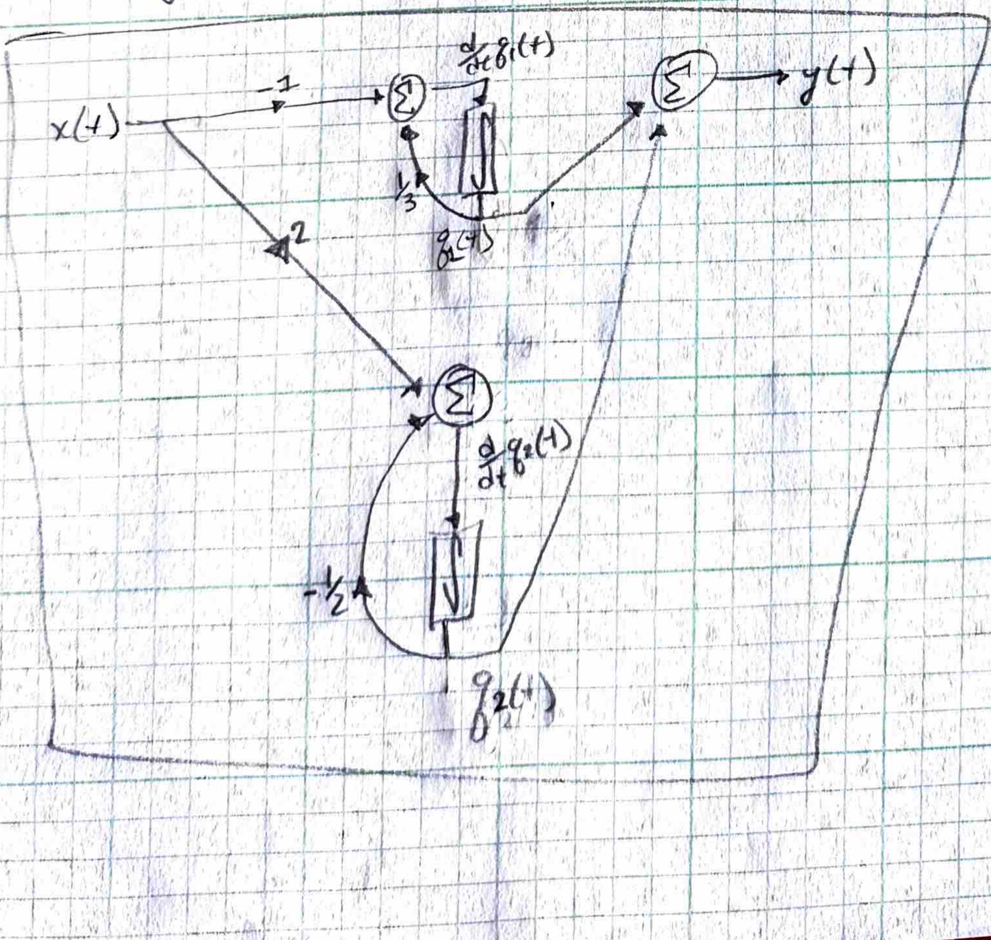
substitute vectors: $\begin{bmatrix} \frac{d}{dt}q_1(t) \\ \frac{d}{dt}q_2(t) \end{bmatrix} = \begin{bmatrix} \frac{1}{3} & 0 \\ 0 & -\frac{1}{2} \end{bmatrix} \begin{bmatrix} q_1(t) \\ q_2(t) \end{bmatrix} + \begin{bmatrix} -1 \\ 2 \end{bmatrix} x(t)$

$$y(t) = [1 \;\; 1] \begin{bmatrix} q_1(t) \\ q_2(t) \end{bmatrix} + [0]x(t)$$

expanded: $\frac{d}{dt}q_1(t) = \frac{1}{3}q_1(t) - x(t)$

$$\frac{d}{dt}q_2(t) = -\frac{1}{2}q_2(t) + 2x(t)$$

$$y(t) = q_1(t) + q_2(t)$$



z_2[n] = 2q_1[n].

Repeat Part (a) for the transformed system.

Clarification from assignment module:

Typo Fix: z1[n] = q1[n] + q2[n] and z2[n] = 2q1[n]-q2[n]

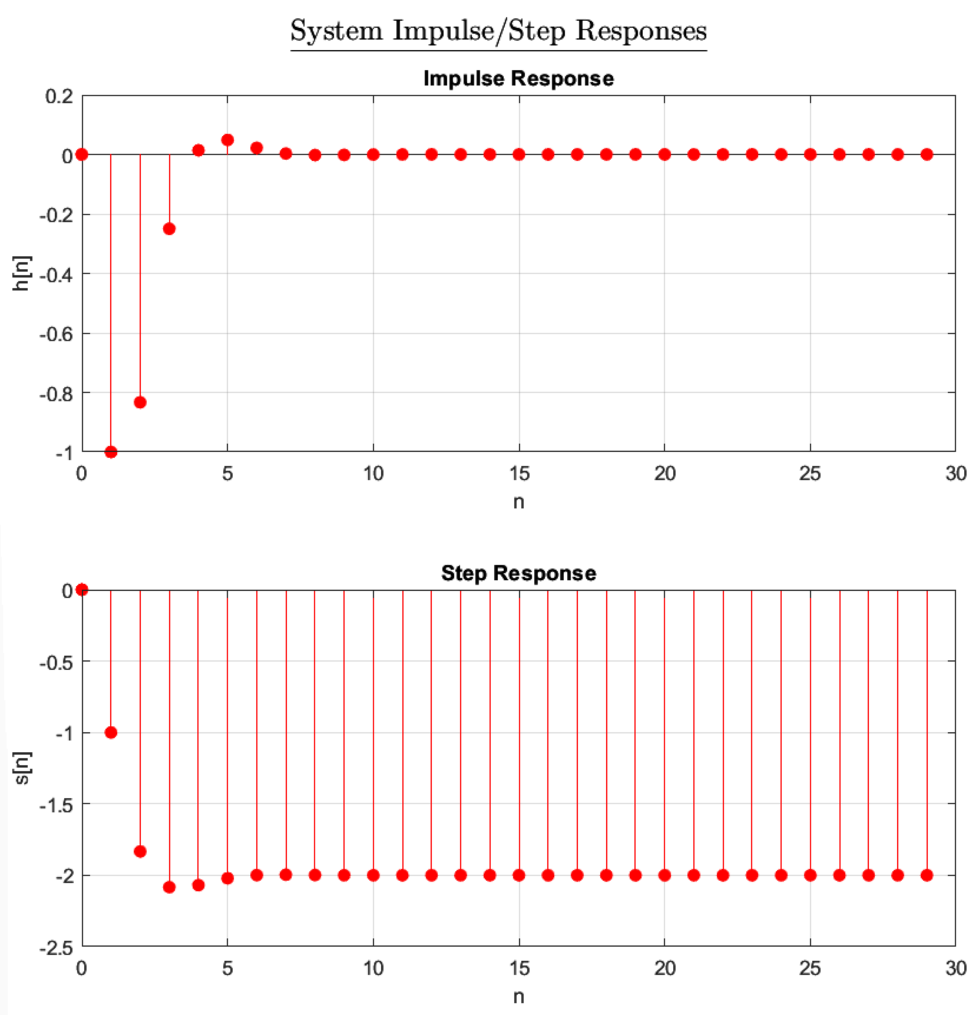
Part (a)

```
A = [1/2, -1/2; 1/3, 0];
b = [1; 2];
c = [1, -1];
D = 0;
n = 0:29;
u = ones(1,30);

subplot(2, 1, 1);
sys = ss(A,b,c,D,-1);
h = impulse(sys,30);
stem(n, h(1:30),'filled','Color','r') % First 30 of impulse response
title('Impulse Response');
xlabel('n');
ylabel('h[n]');
grid on;

subplot(2, 1, 2);
s = lsim(sys, u); % Step response
stem(n, s(1:30),'filled','Color','r') % First 30 of step response
title('Step Response');
xlabel('n');
ylabel('s[n]');
grid on;

sgtitle('\underline{System Impulse/Step Responses}', 'Interpreter', 'latex'); % Overall Title
```



MATLAB R2022b - academic use

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problem_2_point_86.mlx | lab2_matlab.mlx | state_variable_description_problem294.mlx *

```
    xlabel('n');
    ylabel('s[n]');
    grid on;

    sgtitle('\underline{System Impulse/Step Responses}', 'Interpreter', 'latex'); % Overall Title
```

Part (b)

```
clf; % Clear current figure (so can run multiple subplots at once)
A = [1/2, -1/2; 1/3, 0];
b = [1; 2];
c = [1, -1];
D = 0;
T = [1 1; 2 -1]; % Transformation matrix
n = 0:29;
u = ones(1,30);

subplot(2, 1, 1);
sys = ss(A,b,c,D,-1);
sysT = ss2ss(sys, T);

h = impulse(sysT,30);
stem(n, h(1:30),'filled','Color','b') % First 30 of impulse response
title('Impulse Response');
xlabel('n');
ylabel('h[n]');
grid on;

subplot(2, 1, 2);
s = lsim(sysT, u); % Step response
stem(n, s(1:30),'filled','Color','b') % First 30 of step response
title('Step Response');
xlabel('n');
ylabel('s[n]');
grid on;

sgtitle('\underline{Transformed System Impulse/Step Responses}', 'Interpreter', 'latex'); % Ove
```

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