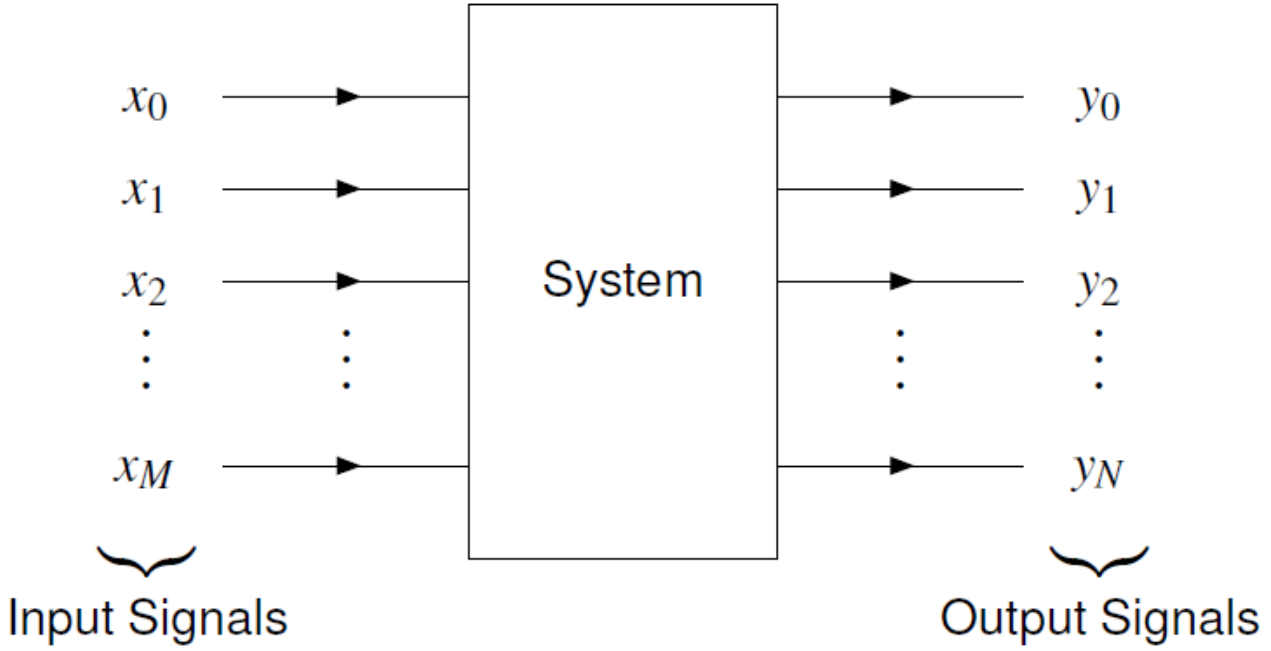
Pertemuan 10

Sistem

- A **system** is an entity that processes one or more input signals in order to produce one or more output signals.

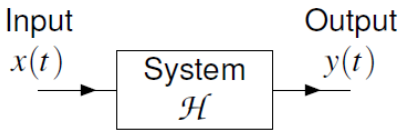


Klasifikasi Sistem

- Number of inputs:
  - A system with ***one*** input is said to be **single input (SI)**.
  - A system with ***more than one*** input is said to be **multiple input (MI)**.
- Number of outputs:
  - A system with ***one*** output is said to be **single output (SO)**.
  - A system with ***more than one*** output is said to be **multiple output (MO)**.
- Types of signals processed:
  - A system can be classified in terms of the ***types of signals*** that it processes.
  - Consequently, terms such as the following (which describe signals) can also be used to describe systems:
    - one-dimensional and multi-dimensional,
    - continuous-time (CT) and discrete-time (DT), and
    - analog and digital.
  - For example, a continuous-time (CT) system processes CT signals and a discrete-time (DT) system processes DT signals.

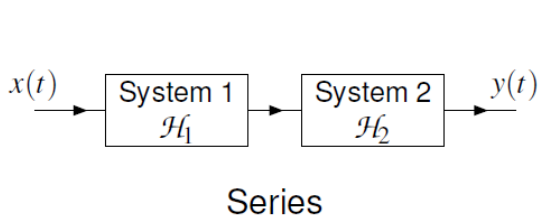
Block Diagram Representations

- Often, a system defined by the operator $\mathcal{H}$ and having the input x and output y is represented in the form of a ***block diagram*** as shown below.

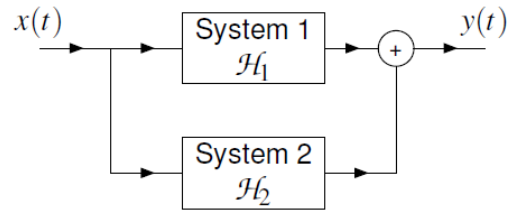


Interconnection of Systems

- ***Two basic ways*** in which systems can be interconnected are shown below.



Series



Parallel

- A **series** (or **cascade**) connection ties the output of one system to the input of the other.
- The overall series-connected system is described by the equation

$$y = \mathcal{H}_2\{\mathcal{H}_1\{x\}\}.$$

- A **parallel** connection ties the inputs of both systems together and sums their outputs.
- The overall parallel-connected system is described by the equation

$$y = \mathcal{H}_1\{x\} + \mathcal{H}_2\{x\}.$$

- Sistem dapat direpresentasikan dalam beberapa bentuk, yaitu :

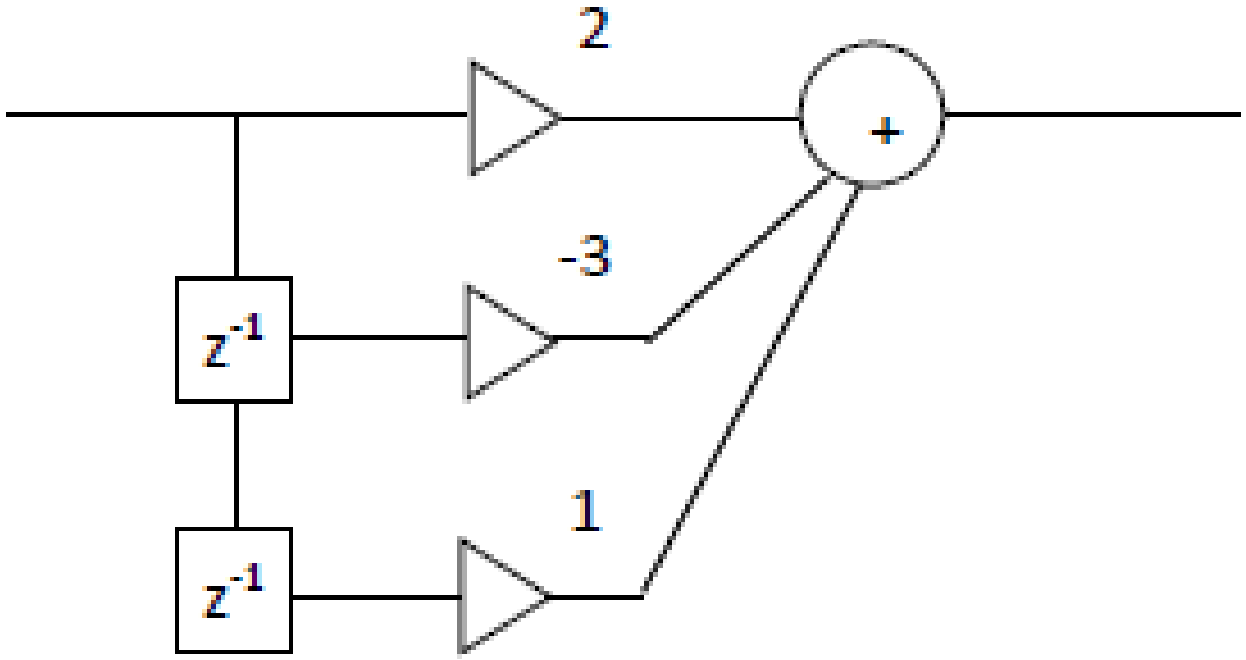
1. **Respons Impuls**
2. **Struktur Realisasi**
3. **Persamaan Selisih**
4. **Fungsi Transfer H(z)**

Representasi Sistem

- Sistem dapat direpresentasikan dalam beberapa bentuk, yaitu :
  1. Respons Impuls

     Contoh : $h(n) = 2\delta(n) - 3\delta(n-1) + \delta(n-2)$
  2. Struktur Realisasi

     Contoh :

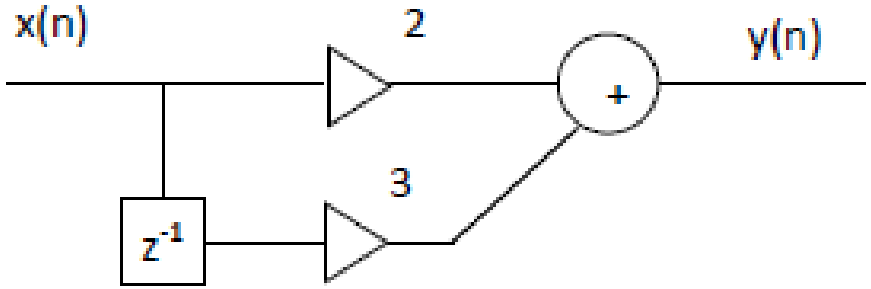


Representasi Sistem

- Sistem dapat direpresentasikan dalam 4 bentuk, yaitu :

  3. Persamaan Selisih

Contoh :



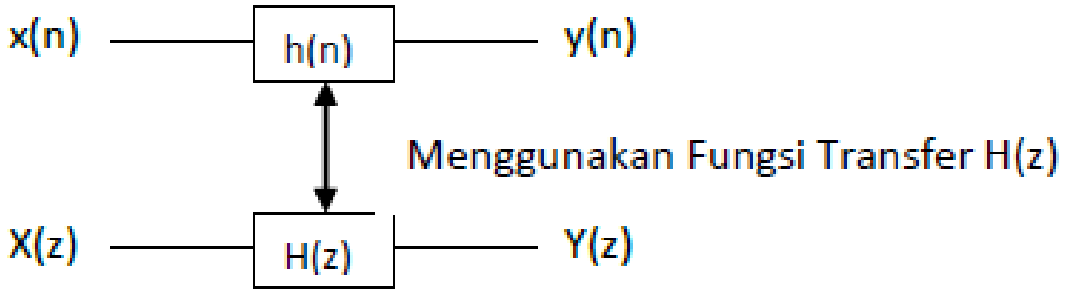
Persamaan selisih : $y(n) = 2x(n) + 3x(n-1)$

$h(n) = 2\delta(n) + 3\delta(n-1)$

Representasi Sistem

- Sistem dapat direpresentasikan dalam 4 bentuk, yaitu :

  4. Fungsi Transfer H(z)



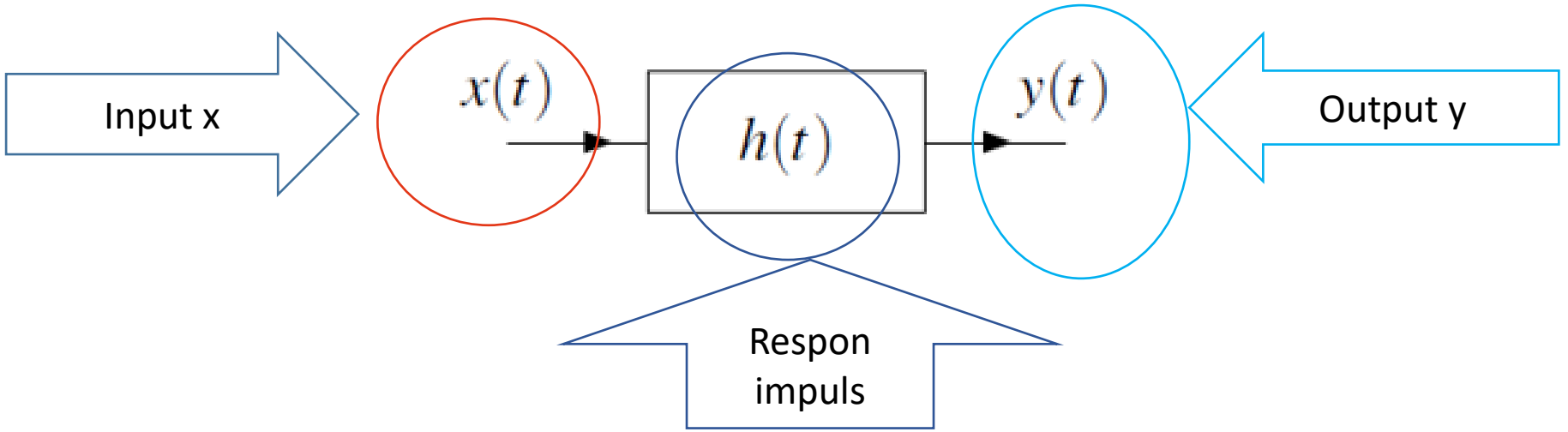
Pengertian H(z) sebagai fungsi transfer, yaitu :

- H(z) adalah transformasi z dari respon impuls h(n)
- H(z) adalah pembagian **transformasi z output Y(z)** dengan **transformasi z input X(z)**

Sistem LTI ?

LTI Systems

- Dua sifat sistem yang sangat penting adalah sifat linearitas dan sifat waktu invarian.
- Sistem yang mempunyai kedua sifat penting ini disebut dengan sistem linear waktu invarian (Linear Time Invariance atau LTI).
- Berbagai pemrosesan fisik dapat dinyatakan sebagai sistem LTI.
- Seringnya, lebih mudah untuk mewakili sistem Continuous-Time (LTI) dalam bentuk diagram blok.
  - karena sistem seperti itu sepenuhnya dicirikan oleh respons impulsnya, kita sering memberi label sistem dengan respons impulsnya



Why Linear Time-Invariant (LTI) Systems ?

- In engineering, linear-time invariant (LTI) systems play a very important role.
- Very powerful mathematical tools have been developed for analyzing LTI systems.
- LTI systems are much easier to analyze than systems that are not LTI.
- In practice, systems that are not LTI can be well approximated using LTI models.
- So, even when dealing with systems that are not LTI, LTI systems still play an important role.

Metoda Analisis Sistem Linear

Metoda langsung

- Konvolusi
- Persamaan beda (Difference Equation)

Metoda tidak langsung

- Transformasi Z

Impulse Response

- The response h of a system $\mathcal{H}$ to the input δ is called the **impulse response** of the system (i.e., $h = \mathcal{H}\{\delta\}$).
- For any LTI system with input x, output y, and impulse response h, the following relationship holds:

$$y = x * h.$$

- In other words, a LTI system simply ***computes a convolution***.
- Furthermore, a LTI system is ***completely characterized*** by its impulse response.
- That is, if the impulse response of a LTI system is known, we can determine the response of the system to any input.
- Since the impulse response of a LTI system is an extremely useful quantity, we often want to determine this quantity in a practical setting.
- Unfortunately, in practice, the impulse response of a system cannot be determined directly from the definition of the impulse response.

Respon Impuls merupakan respon sistem h(n) ketika input x(n) diberi sinyal impuls.

Respon Impuls h(n) akan sama dengan output y(n) jika x(n) diberi input sinyal impuls δ(n)

$$h(n) = y(n)\Big|_{x(n)=\delta(n)}$$

Contoh:

Tentukan respon impuls $h(n)$ jika diketahui persamaan beda sistem dibawah ini :

a. $y(n) = x(n) + x(n-1)$

b. $y(n) = 2x(n-1) - x(n-3)$

Jawab :

a. $h(n) = y(n)|_{x(n)=\delta(n)} = \delta(n) + \delta(n-1)$

b. $h(n) = y(n)|_{x(n)=\delta(n)} = 2\delta(n-1) - \delta(n-3)$

Persamaan Beda

Persamaan Beda merupakan Model Matematis yang menggambarkan hubungan input-output sebuah sistem diskrit.

Dengan **x(n)** merupakan **input sistem** dan **y(n)** adalah **output sistem**, bentuk umum persamaan beda untuk sistem diskrit dengan **orde-N** dapar dituliskan sebagai berikut :

$$a_0y(n)+a_1y(n-1)+ \dots +aNy(n-N) = b_0x(n)+ b_1x(n-1)+ \dots + bMx(n-M)$$

dimana $a_0 \neq 0$

a) y(n) = 2 x(n)

Artinya output y(n) didapatkan dengan mengalikan input x(n) dengan konstanta bernilai 2

Atau

Output y(n) merupakan input x(n) yang diperbesar 2x

b) $y(n) = x(n-1)$

Artinya output y(n) merupakan sinyal x(n) yang terdelay sejauh 1 satuan

c) $y(n) = x(n) + x(n-1)$

Artinya output y(n) merupakan penjumlahan input x(n) dengan input x(n) yang terdelay sejauh 1 sampel

d) $y(n) - y(n-1) = x(n)$

$y(n) = y(n-1) + x(n)$

Artinya output y(n) merupakan penjumlahan sinyal x(n) dan sinyal output y(n) pada waktu sebelumnya

Diketahui persamaan beda sistem diskrit sbb :

$$y(n) = x(n) - x(n-1) + 2x(n-2)$$

a) Tentukan respon impuls h(n)

b) Dengan sistem yang sama, jika sistem diberikan input x(n)=δ(n-1). Tentukan output y(n)

Jawab :

a) $\mathrm{h(n)} = \mathrm{y(n)}|_{\mathrm{x(n)}=\delta(\mathrm{n})} = \delta(n) - \delta(n-1) + 2\delta(n-2)$

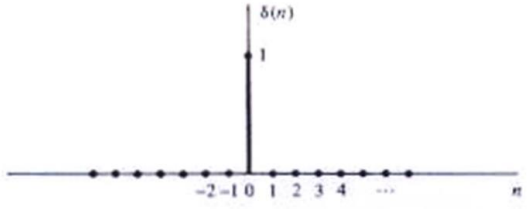
b) $x(n) = \delta(\mathrm{n}-1) = [\underline{0}, 1]$

$\mathrm{h(n)} = \delta(n) - \delta(n-1) + 2\delta(n-2) = [\underline{1}, -1, 2]$

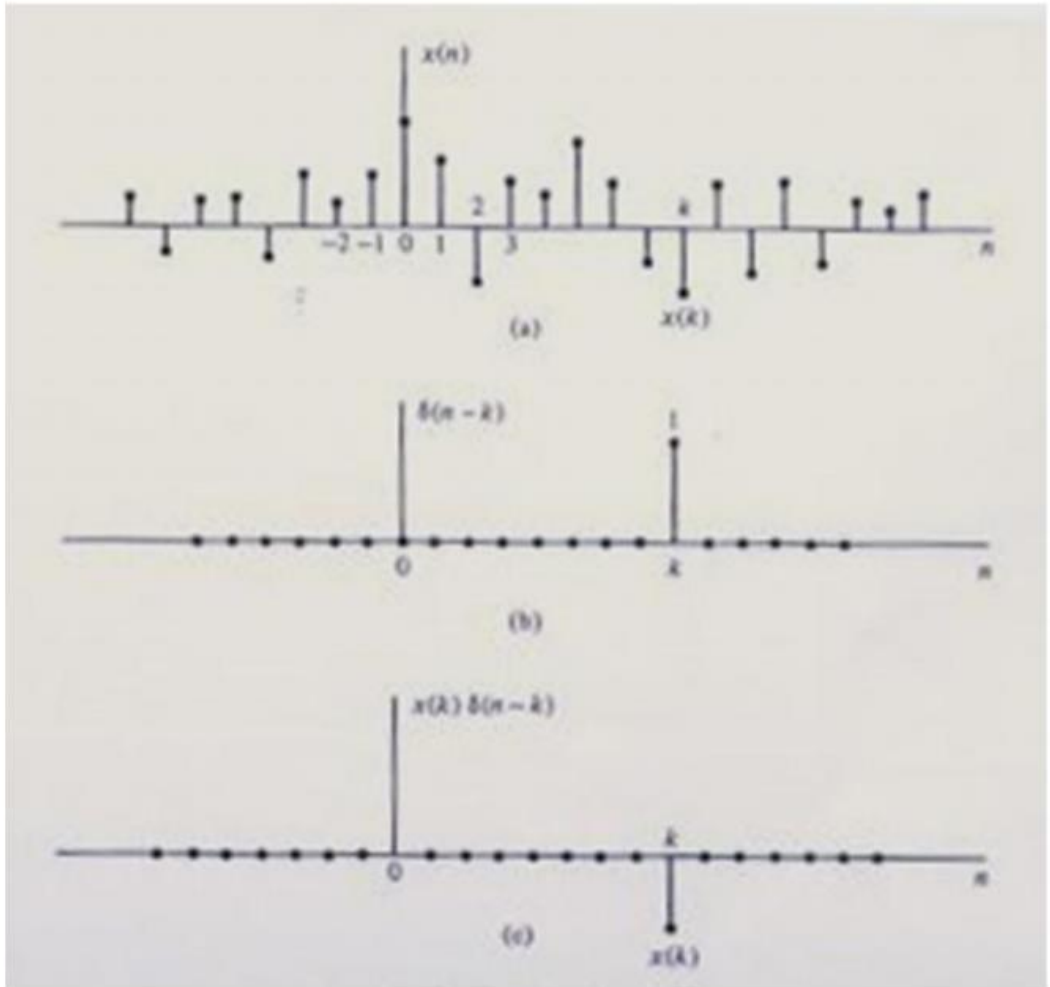
$y(n) = x(n) * h(n)$ — Konvolusi

$y(n) = [\underline{0}, 1, -1, 2]$

Unit impulse signal



$$\delta(n) = \begin{cases} 1, & n = 0 \\ 0, & n \neq 0 \end{cases}$$



$$x_k(n) = \delta(n - k)$$

$$x(n)\delta(n - k) = x(k)\delta(n - k)$$

$$x(n) = \sum_{k=-\infty}^{\infty} x(k)\delta(n - k)$$

Sinyal dalam Unit Impuls

Diketahui sinyal dengan durasi terbatas $x(n) = \{2, 4, 0, 3\}$

Nyatakan sinyal ini dalam unit impuls

Jawab :

$$x(n) = \sum_{k=-1}^{2} x(k)\delta(n-k)$$

$$x(n) = x(-1)\delta(n+1) + x(0)\delta(n) + x(1)\delta(n-1) + x(2)\delta(n-2)$$

$$x(n) = 2\delta(n+1) + 4\delta(n) + 3\delta(n-2)$$

Respon impuls suatu sistem LTI adalah :

$$h(n) = \{1, \underset{\uparrow}{2}, 1, -1\}$$

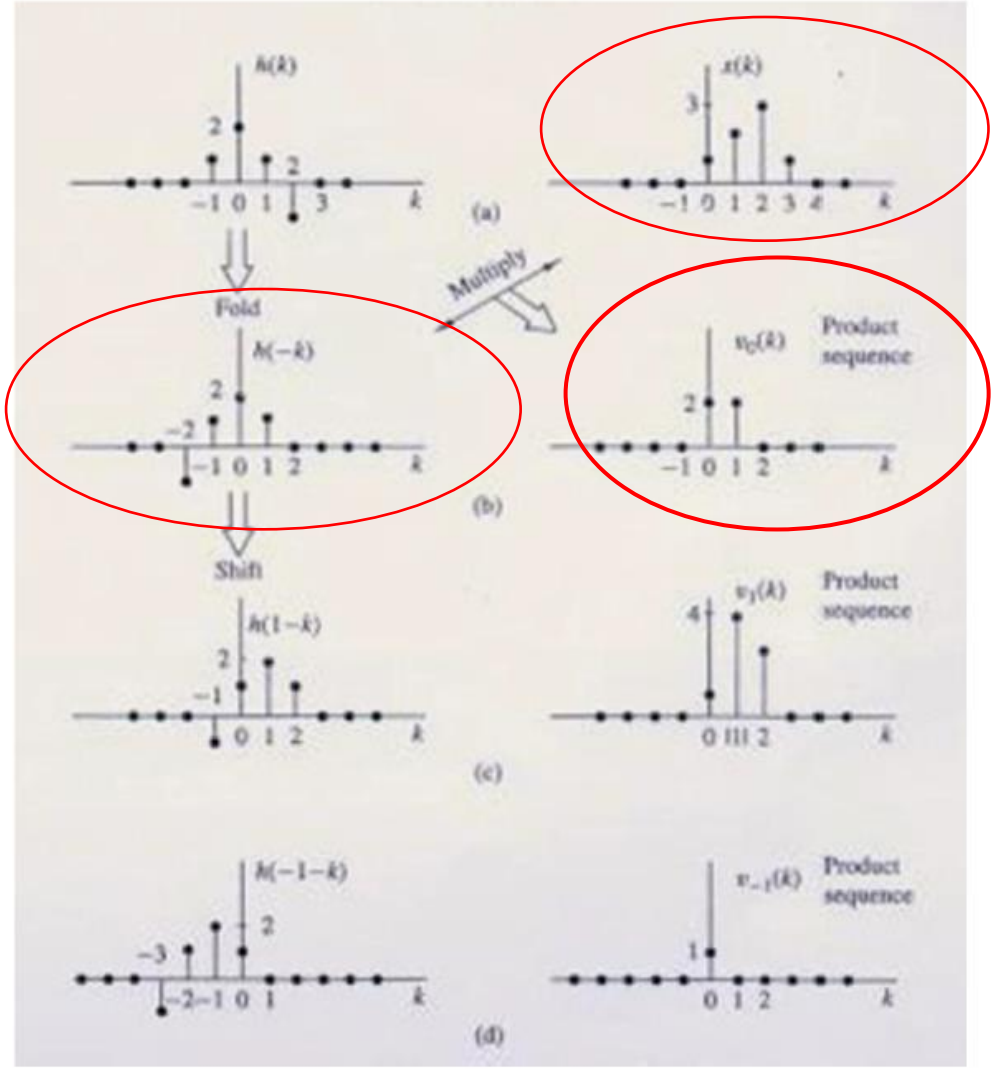
Tentukan respon dari sistem bila inputnya :

$$x(n) = \{\underset{\uparrow}{1}, 2, 3, 1\}$$

Jawab :

$$v_n(k) = x(k)h(n-k)$$

$$y(n) = \sum_{k=-\infty}^{\infty} x(k)h(n-k) = \sum_{k=-\infty}^{\infty} v_n(k)$$



$$h(n) = \{1, 2, 1, -1\}$$

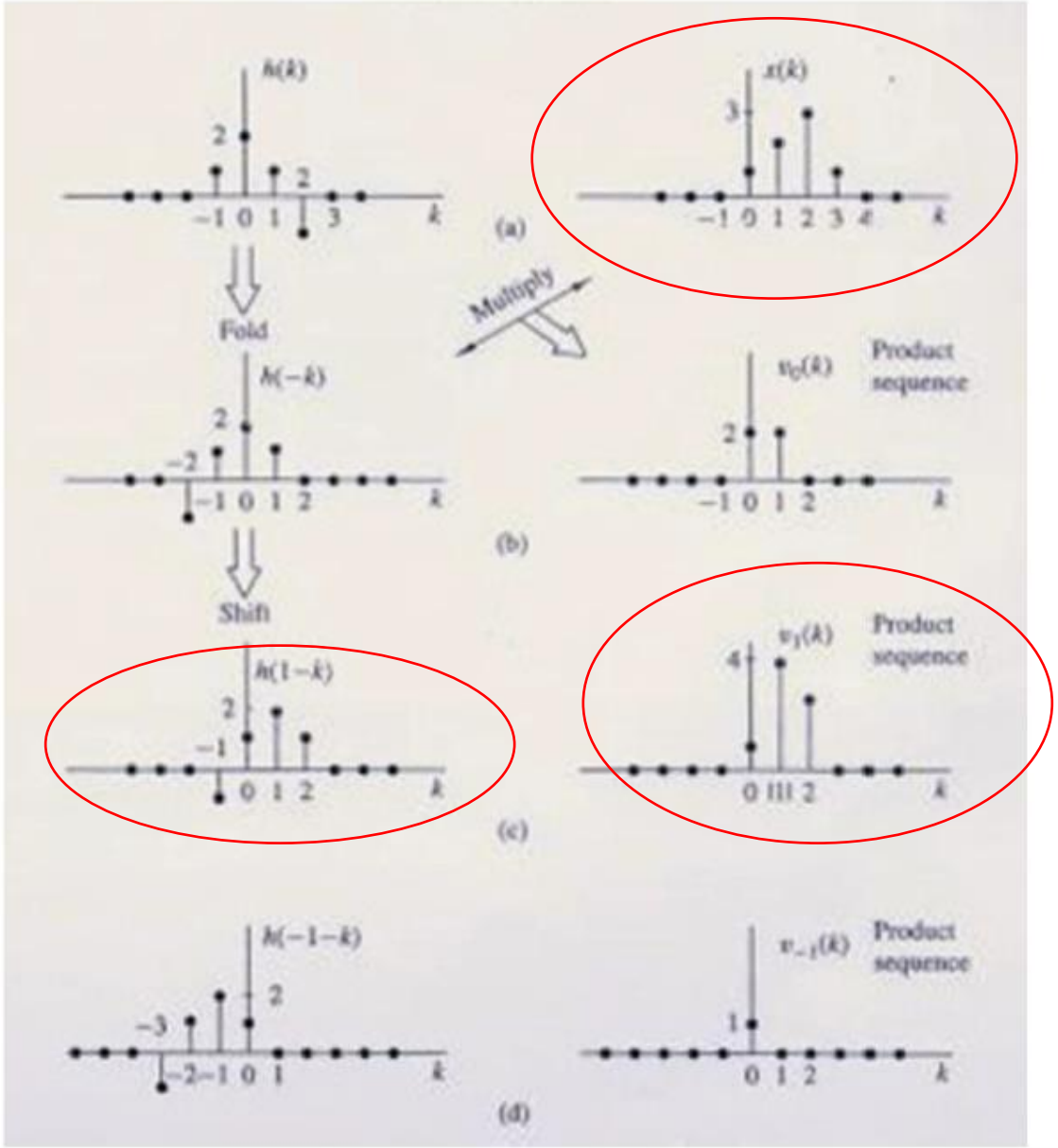
$$x(n) = \{1, 2, 3, 1\}$$

$$y(n) = \sum_{k=-\infty}^{\infty} x(k)h(n-k)$$

$$y(0) = \sum_{k=-\infty}^{\infty} x(k)h(-k)$$

$$v_0(k) = x(k)h(-k)$$

$$y(0) = \sum_{k=-\infty}^{\infty} v_0(k) = 4$$

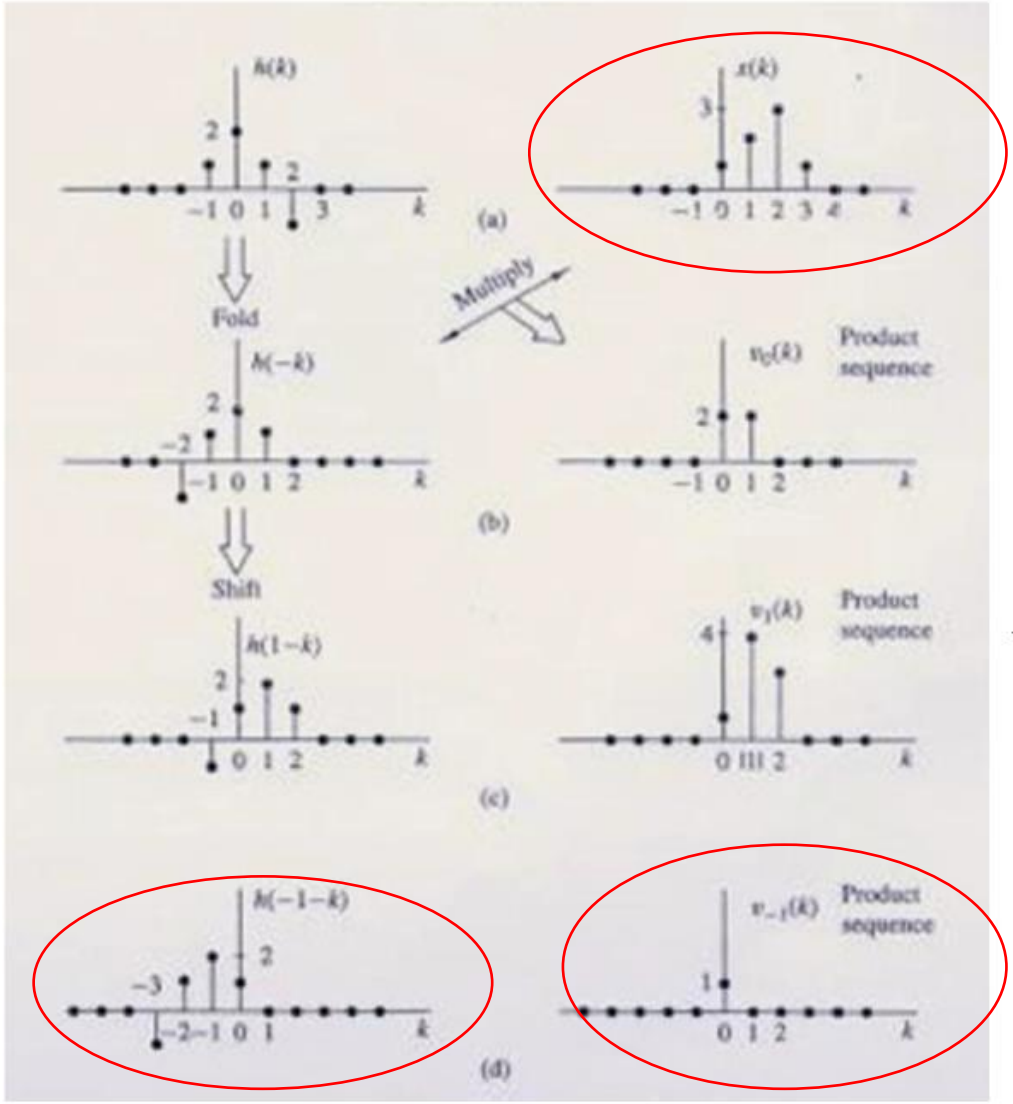


$$y(n) = \sum_{k=-\infty}^{\infty} x(k)h(n-k)$$

$$y(l) = \sum_{k=-\infty}^{\infty} x(k)h(l-k)$$

$$v_1(k) = x(k)h(l-k)$$

$$y(l) = \sum_{k=-\infty}^{\infty} v_1(k) = 8$$



$$y(n) = \sum_{k=-\infty}^{\infty} x(k)h(n-k)$$

$$y(-1) = \sum_{k=-\infty}^{\infty} x(k)h(-1-k)$$

$$v_{-1}(k) = x(k)h(-1-k)$$

$$y(-1) = \sum_{k=-\infty}^{\infty} v_{-1}(k) = 1$$

$$y(n) = \{\dots, 1, \mathbf{4}, 8, 8, 3, -2, -1, 0, \dots\}$$

Tentukan output y(n) dari sistem LTI dengan respon impuls :

$$\{3\ 2\ 1\}$$

bila inputnya :

$$\{1\ 2\ 2\ 1\ 1\}$$

Jawab :

$$y(n) = \{3\ 8\ 11\ 9\ 7\ 3\ 1\}$$

Tentukan output y(n) dari sistem LTI dengan respon impuls :

$$\{1\ 1\ 0\ 1\}$$

bila inputnya :

$$\{1\ 2\ 2\ 3\}$$

Jawab :

$$y(n) = \{1\ 3\ 4\ 6\ 5\ 2\ 3\}$$

TUGAS:
Tentukan output y(n) dari sistem LTI dengan :

- Respon impuls { tanggal bulan tahun lahir diri sendiri }
- Input : { NIM diri sendiri }

- Setelah mengerjakan, cek hasil dengan matlab.
  Kumpulkan hasil pengerjaan dan hasil pengecekan dengan matlab dalam 1 file pdf.