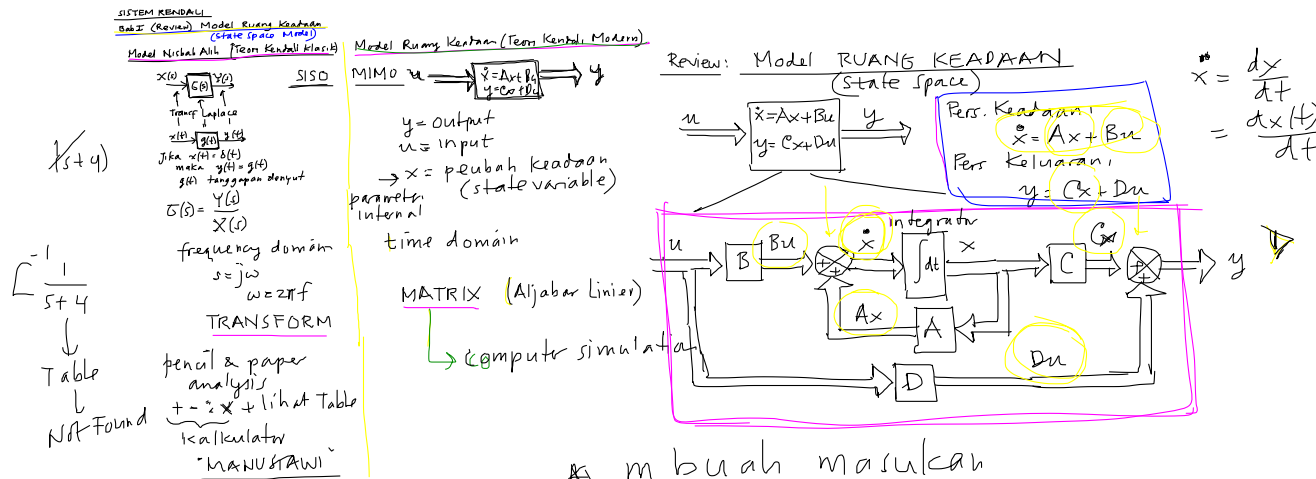


- * Jika semua matrix A, B, C dan D hanya berisi konstanta $\rightarrow$ LTI systems (linear time invariant)
- * Jika ada matrix A, B, C dan/atau D berubah dengan waktu $t \rightarrow$ LTV (linear time varying) systems
- * Selain di atas $\rightarrow$ SYSTEM TAK LTI/IER



Dimensi matrix A, B, C dan D sudah tertentu tergantung pada m, n, k :

Pers. keadaaan : $[n \times m]$ $[m \times 1]$

$$\overset{0}{X} = A x + B u$$

Diagram illustrating matrix dimensions for the equation $\overset{0}{X} = A x + B u$:

- $\overset{0}{X}$ is a $[n \times 1]$ column vector.
- A is a $[n \times 1]$ matrix.
- x is a $[1 \times n]$ row vector.
- B is a $[n \times 1]$ matrix.
- u is a $[1 \times 1]$ scalar.

Arrows indicate the compatibility of dimensions for matrix multiplication:

- A pink arrow points from the $[1 \times n]$ dimension of x to the $[n \times 1]$ dimension of A .
- A yellow arrow points from the $[1 \times 1]$ dimension of u to the $[n \times 1]$ dimension of B .

Perj. Keharman

$$y \in \underbrace{[K \times 1]}_{P \times 1} + \underbrace{[K \times 1]}_{D \times 1}$$

$$u = \begin{bmatrix} u_1 \\ u_2 \\ \vdots \\ u_m \end{bmatrix} \text{ ; vector } [m \times 1]$$

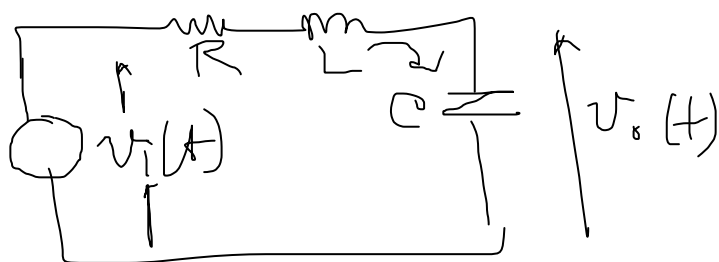
* n buah pembal keadaaan

$$X = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix}; \text{vektor } [n \times 1]$$

* k buah Keluaran 1

$$y = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_k \end{bmatrix} \text{ vektor } [k \times 1]$$

* Contoh Elektrik *



Masukan : $u \triangleq v_i(t)$
 Keluaran : $y \triangleq v_o(t)$

$x_1 \triangleq i(t)$
 $x_2 \triangleq v_o(t)$

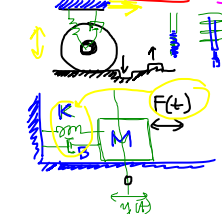
SISO

Contoh 2

* Contoh "matematis" Tentukan dimensi matriks A, B, C dan D dari sebuah sistem yang punya 3 masukan, 4 penbali keadaan dan 5 keluaran

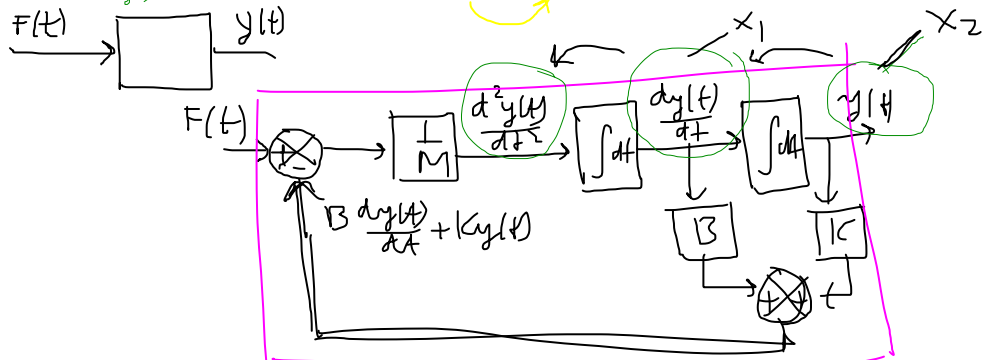
Jawab $m=3, n=4, k=5 \rightarrow A[4 \times 4] \quad C[5 \times 4]$
 $B[4 \times 3] \quad D[5 \times 3]$

* Contoh "mekanik" : Spring-Mass-Damper System



$$F(t) = M \frac{d^2 y(t)}{dt^2} + B \frac{dy(t)}{dt} + K y(t)$$

$\uparrow$ percepatan $\uparrow$ kecepatan $\uparrow$ posisi
 $\frac{d^2 y(t)}{dt^2} = \frac{1}{M} [F(t) - [B \frac{dy(t)}{dt} + K y(t)]]$



Ditanyakan : Model RUANG KEADAAN sistem di atas !

* SISO $\rightarrow m=1, k=1 \quad u \triangleq F(t)$
 $n=2 \quad y \triangleq y(t)$
 $A[2 \times 2] \quad C[1 \times 2]$
 $B[2 \times 1] \quad D[1 \times 1]$
 $x = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} \frac{dy(t)}{dt} \\ y(t) \end{bmatrix}$
 2 penbali keadaan
 → kecepatan
 → posisi

Model Ruang Keadaannya :

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \dot{x} = \begin{bmatrix} -\frac{B}{M} & -\frac{K}{M} \\ 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} \frac{1}{M} \\ 0 \end{bmatrix} u$$

$A[2 \times 2] \quad B[2 \times 1]$

$$\begin{aligned} \frac{d^2 y(t)}{dt^2} = \dot{x}_1 &= \frac{1}{M} [F(t) - [B \frac{dy(t)}{dt} + K y(t)]] \\ &= \frac{1}{M} [u - B x_1 - K x_2] \\ &= -\frac{B}{M} x_1 - \frac{K}{M} x_2 + \frac{1}{M} u \end{aligned}$$

$$y = \begin{bmatrix} 0 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \end{bmatrix} u$$

$C[1 \times 2] \quad D[1 \times 1]$

$\frac{dy(t)}{dt} = \dot{x}_2 = x_1$