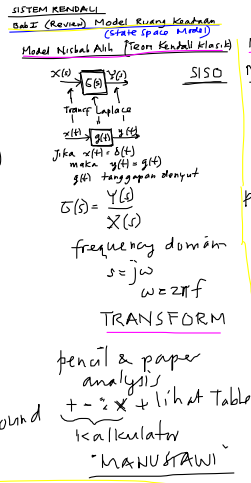
Catatan: * Jika semua matrix A, B, C dan D hanya berisi konstanta > LTI systems (linear time invariant)

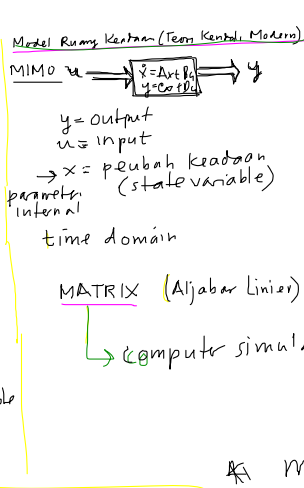
* Jika ada matrix A, B, C dan/atau D berubah dengan waktu t → LTV (linear time varying) systems

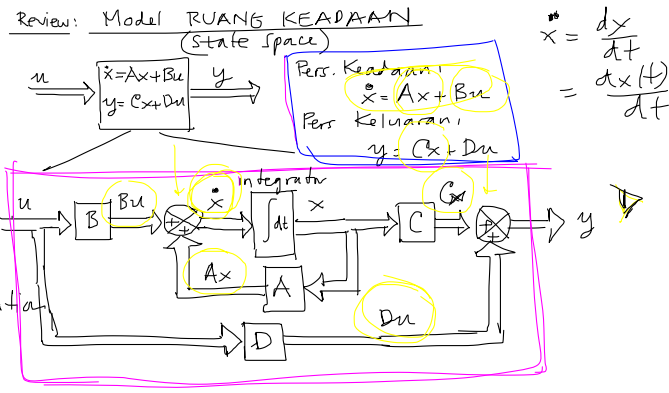
* Selain di atas → SISTEM TAK LINIER



$\frac{1}{s+4}$

$\mathcal{L}^{-1}\frac{1}{s+4}$ → Table → Not Found





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

Pers. keadaan: $\dot{x} = Ax + Bu$

$[n\times 1] = [n\times n][n\times 1] + [n\times m][m\times 1]$

$A[n\times n]$

$B[n\times m]$

Pers. Keluaran: $y = Cx + Du$

$[k\times 1] = [k\times n][n\times 1] + [k\times m][m\times 1]$

$C[k\times n]$

$D[k\times m]$

* m buah masukan

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

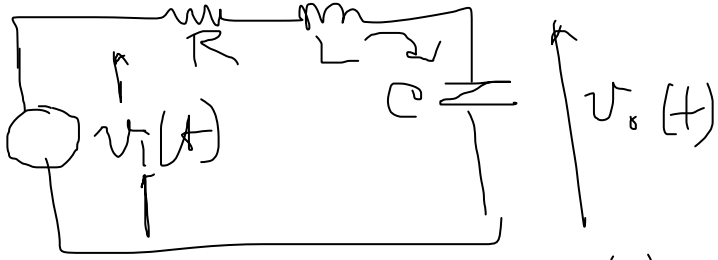
* n buah peubah keadaan

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

* k buah keluaran

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

* Contoh Elektrik.



Misalkan: $u \triangleq v_i(t)$

$y \triangleq v_o(t)$

$x_1 \triangleq i(t)$

$x_2 \triangleq v_o(t)$

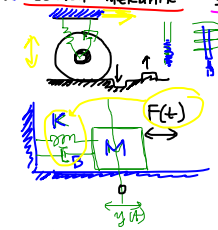
SISO.

Contoh:

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

Jawab: m=3, n=4, k=5 → A[4×4] C[5×4] B[4×3] D[5×3]

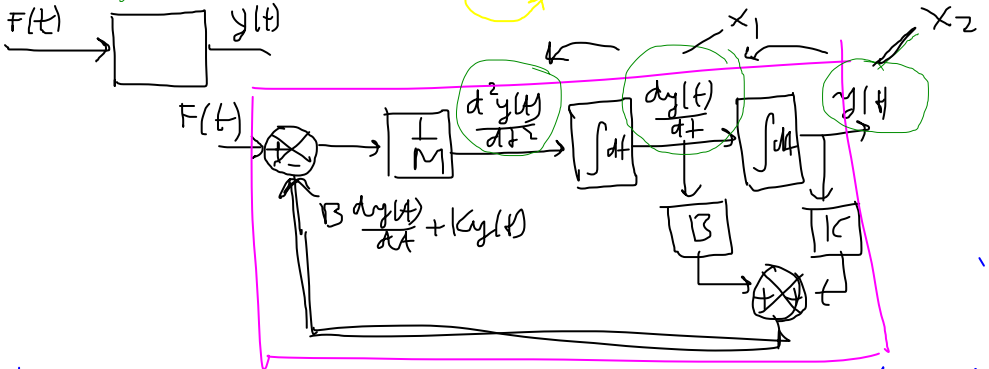
* Contoh "mekanik": Spring-Mass-Damper Systems



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

percepatan, kecepatan, posisi

$$\frac{d^2y(t)}{dt^2} = \frac{1}{M}\left\{F(t) - \left[B\frac{dy(t)}{dt} + Ky(t)\right]\right\}$$



Ditanyakan: Model RUANG KEADAAN sistem di atas!

* SISO → m = 1, k = 1, n = 2

$u \triangleq F(t)$

$y \triangleq y(t)$

$x = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} \frac{dy(t)}{dt} \\ y(t) \end{bmatrix}$ → kecepatan, posisi

2 peubah keadaan

A[2×2] C[1×2]

B[2×1] D[1×1]

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[2×2] B[2×1]

$$\frac{d^2y(t)}{dt^2} = \dot{x}_1 = \frac{1}{M}\left[F(t) - \left[B\frac{dy(t)}{dt} + Ky(t)\right]\right]$$

$$= \frac{1}{M}\left[u - Bx_1 - Kx_2\right]$$

$$= -\frac{B}{M}x_1 - \frac{K}{M}x_2 + \frac{1}{M}u$$

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

C[1×2] D[1×1]

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