CTRL 연구참여 1주차

- 자동 제어, 현대 제어 introduction

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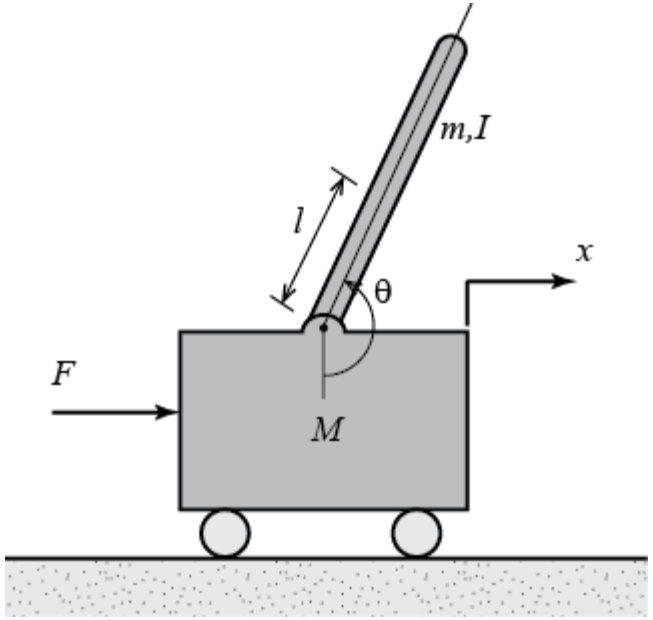
Contents

What is Control?

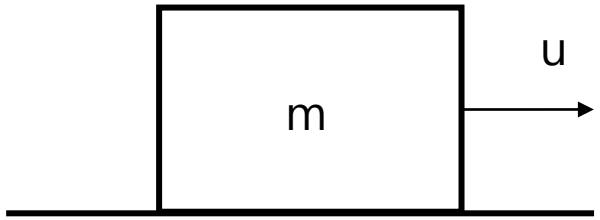
- Control Engineering



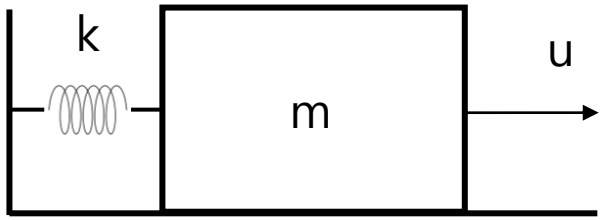
Inverted Pendulum

Robot

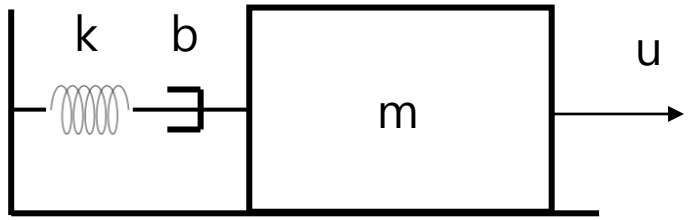
- Control theory



$$m\ddot{x} = u$$



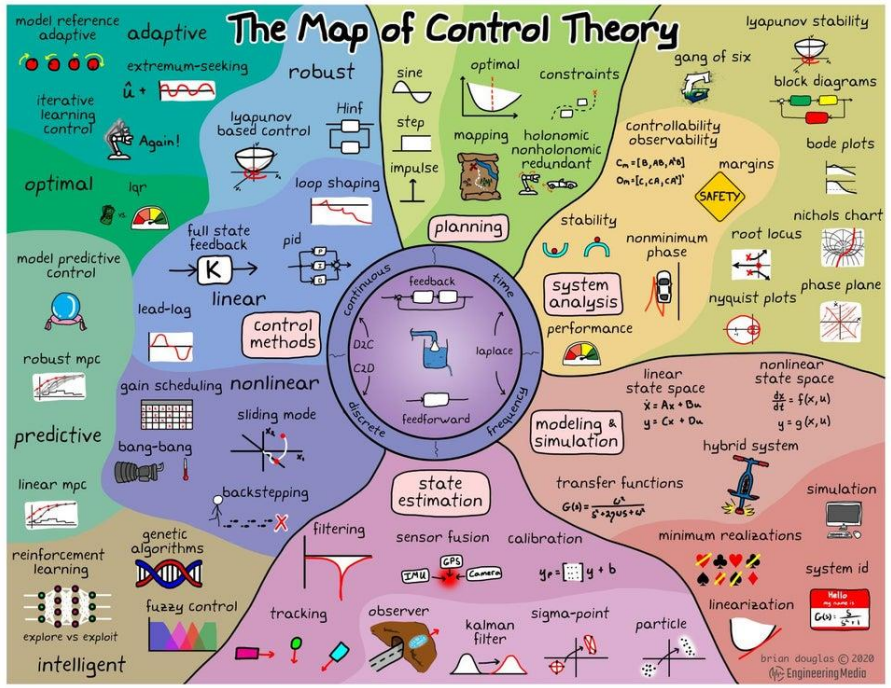
$$m\ddot{x} = u - kx$$



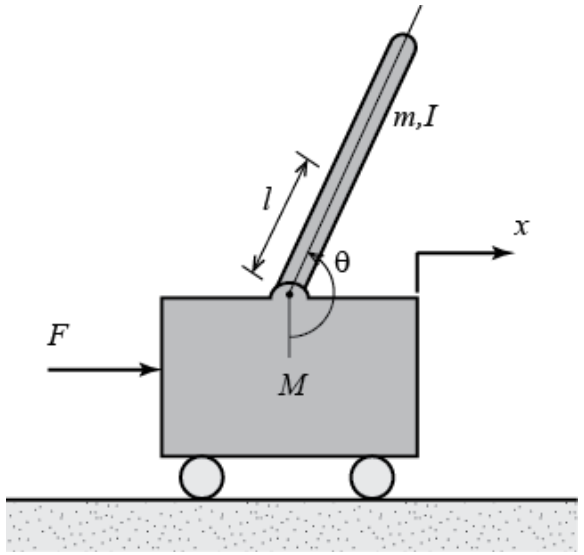
$$m\ddot{x} = u - b\dot{x} - kx$$

What is Control?

- The field of control theory

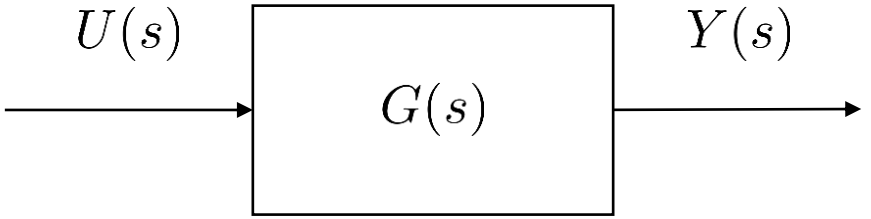


System Modeling



- Transfer Function
  - SISO
  - Frequency domain
- State Space Equation
  - MIMO
  - Time domain

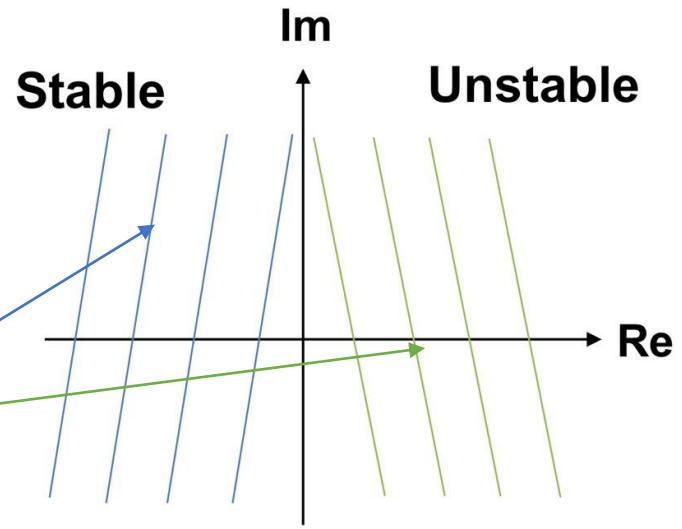
Transfer Function



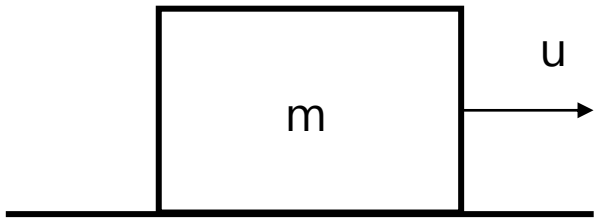
$$G(s) = K\frac{\prod_{i=1}^{m}(s-z_i)}{\prod_{i=1}^{n}(s-p_i)} = \frac{p(s)}{q(s)}$$

$p(s) = 0 \Rightarrow \text{zero}$

$q(s) = 0 \Rightarrow \text{pole}$

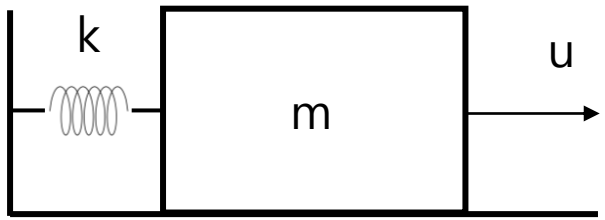


Transfer Function



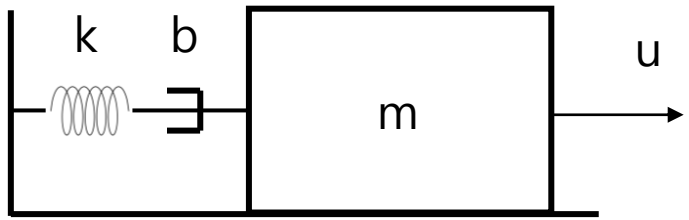
$$m\ddot{x} = u$$

$$G(s) = \frac{Y(s)}{U(s)} = \frac{1}{ms^2}$$



$$m\ddot{x} = u - kx$$

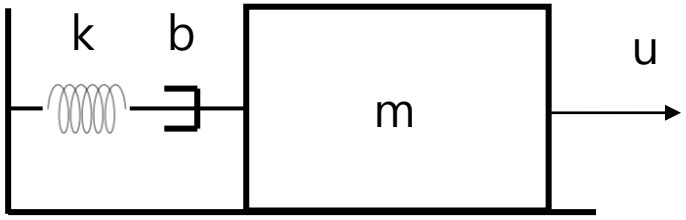
$$G(s) = \frac{Y(s)}{U(s)} = \frac{1}{ms^2 + k}$$



$$m\ddot{x} = u - b\dot{x} - kx$$

$$G(s) = \frac{Y(s)}{U(s)} = \frac{1}{ms^2 + bs + k}$$

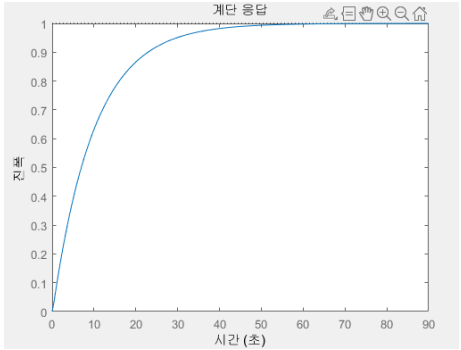
Transfer Function



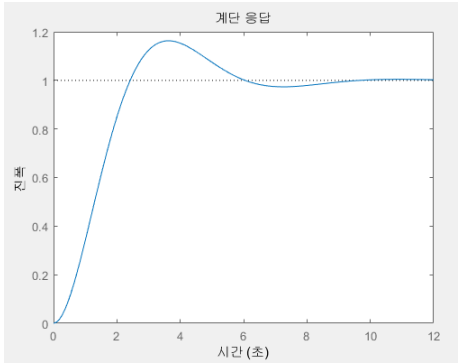
$$m\ddot{x} = u - b\dot{x} - kx$$

$$G(s) = \frac{Y(s)}{U(s)} = \frac{1}{ms^2 + bs + k}$$

$$u(t) = 1(t)$$

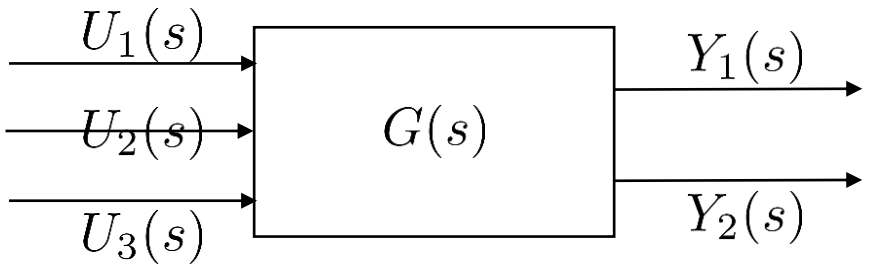


<m=1, b=10, k=1>



<m=1, b=1, k=1>

State Space Equation



the number of input: m

$\times$

the number of output: n

$\Downarrow$

the number of transfer function: $\boxed{\text{m} \times \text{n}}$

State Space Equation

$$\begin{cases} \dot{x} = Ax + Bu \\ y = Cx + Du \end{cases}$$

LTI system

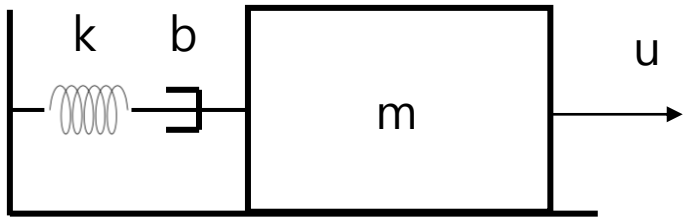
$$\begin{cases} \dot{x} = A(t)x + B(t)u \\ y = C(t)x + D(t)u \end{cases}$$

LTV system

$$\dot{x} = f(t, x) + g(t, x)u$$

Nonlinear system

State Space Equation



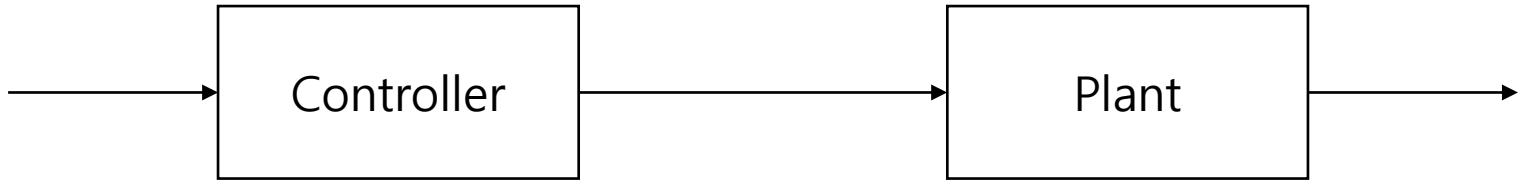
$$m\ddot{x} = u - b\dot{x} - kx$$

$$\ddot{x} = -\frac{k}{m}x - \frac{b}{m}\dot{x} + \frac{1}{m}u$$

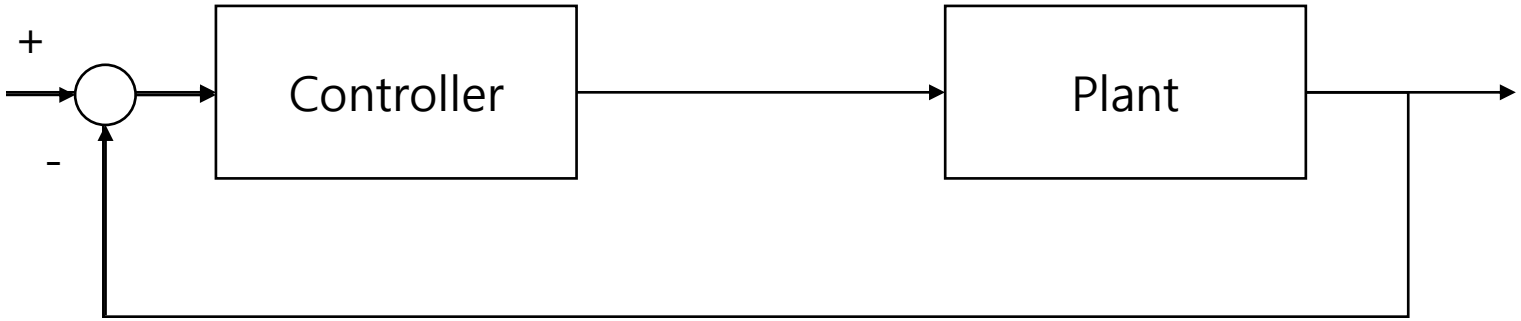
$$\text{let } X = \begin{bmatrix} x \\ \dot{x} \end{bmatrix}$$

$$\dot{X} = \begin{bmatrix} \dot{x} \\ \ddot{x} \end{bmatrix} = \underbrace{\begin{bmatrix} 0 & 1 \\ -\frac{k}{m} & -\frac{b}{m} \end{bmatrix}}_{A} \begin{bmatrix} x \\ \dot{x} \end{bmatrix} + \underbrace{\frac{1}{m}}_{B} u$$

Open Loop/Closed Loop



<Open Loop>



<Closed Loop>

Open Loop/Closed Loop

[Open Loop]

[장점]

시스템의 전력 소비량이 매우 적음

통신량이 거의 없음

[단점]

시스템의 정확도 & 신뢰도가 떨어짐
→ 플랜트에 따라 성능은 천차만별

[Closed Loop]

[장점]

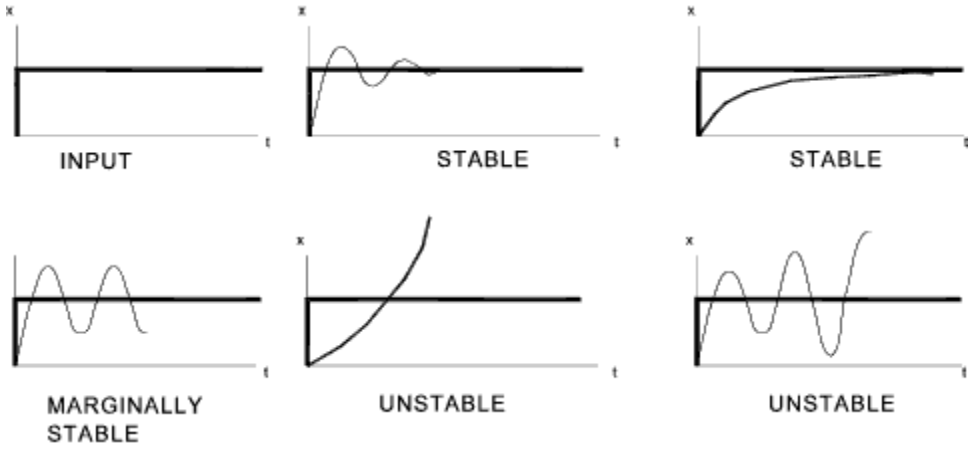
출력에 대한 피드백을 통해 시스템을 최적화 하여 안정적으로 유지할 수 있음
→ 정확도 & 신뢰도가 높음

강인성이 좋음

[단점]

통신량과 전력 소비량이 상대적으로 많음

System Stability



Ex) BIBO, Lyapunov, Routh criteria

Thank You