Fall 2022 (111-1)

控制系統
Control Systems

Unit 1B
Introduction - Feedback and Control

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NTU-EE

Sep 2022 – Dec 2022

Mobile Robots, Autonomous Driving Vehicles

http://hompage.ntu.edu.tw/~fengli/Research

- Google Self-Driving Cars in 2014

Source: https://youtu.be/TsaES--OTzM Time: 1:03 – 8:37

Mobile Robots, Autonomous Driving Vehicles

- 2020年的交通與生活 Toyota e-Palette

Source: https://www.youtube.com/watch?v=XmoPQuMlOYE
https://www.servicejdc.com/product/blog/item/60-20181015.html

Unmanned Arial Vehicles (UAV)

- Olympic Winter Games by Intel
- 2,000 Drones in Shanghai to Welcome New Year
- 2020 義大世界跨年夜《400台無人機視覺超震撼》
- 2020 台灣燈會無人機展演

https://youtu.be/eIk6j6dprnA

https://youtu.be/v05uHuJj7Hs

https://youtu.be/XS--SQMUeUY

https://youtu.be/XTUS3cfKUuc

https://news.ltn.com.tw/news/life/breakingnews/3077228

Three Layers of Control Tasks

- Top Layer:
  - For Multiple Agents (Group of Vehicles, Cars, Drones)

https://images.app.goo.gl/Zvqbjf3nsAFoLBFK8

https://images.app.goo.gl/FjoqLo13CQ8o4v83A

https://images.app.goo.gl/A9yhHUUEsoJKWPLj9

https://images.app.goo.gl/ErUGddRBXwdwr2b17

- Action:
  - 方向盤
  - 油門煞車
- Goal:
  - 位置/車道
  - 速度/方向

Three Layers of Control Tasks

Middle Layer:

- For Single Agent (Single Vehicle, Car, Drone)

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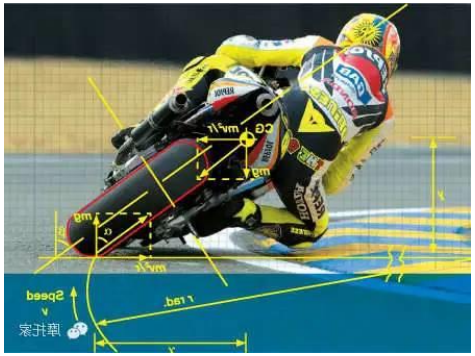


https://images.app.goo.gl/5p7G4g19ZayMYkb28

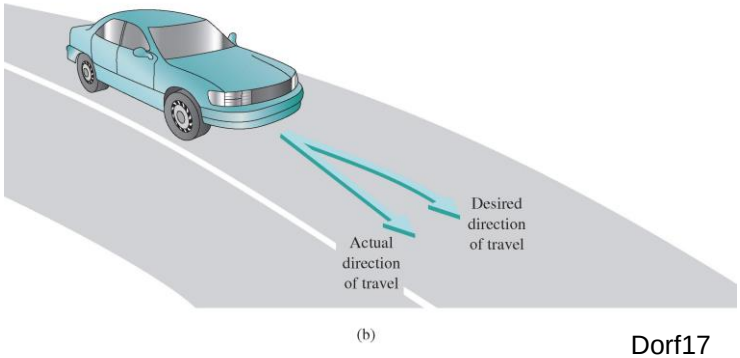
https://images.app.goo.gl/GzScsbcFTDPsaApJ8

- Action:
  - 統整四個輪子
  - 統整四個螺旋槳
- Goal:
  - 方向
  - 加減速

Three Layers of Control Tasks

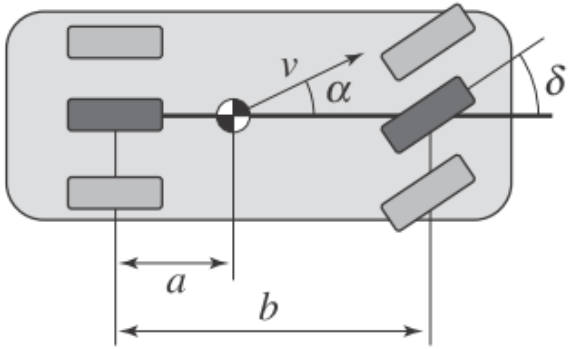
Middle Layer:

- For Single Agent (Single Vehicle, Car, Drone)

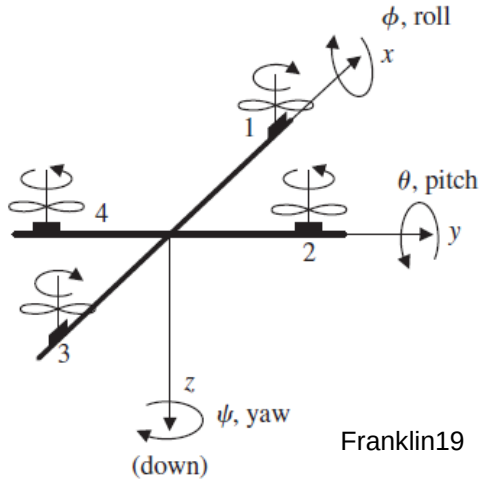


Dorf17

Franklin19



Astrom19

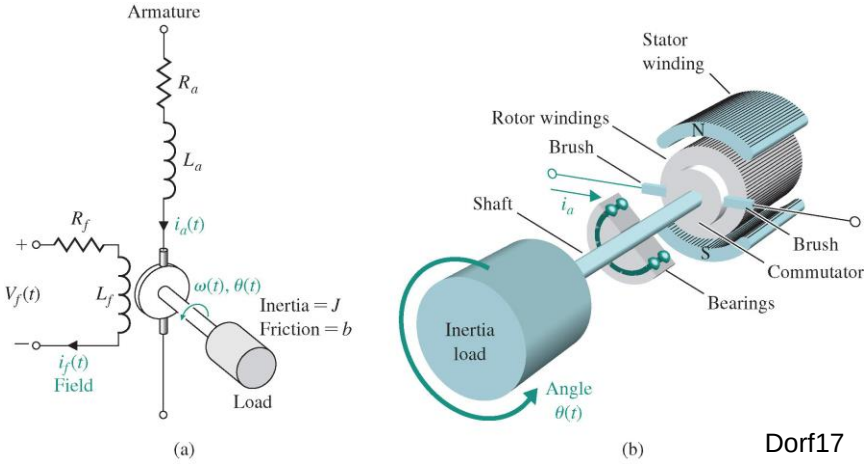


Franklin19

- Action:
  - 統整四個輪子
  - 統整四個螺旋槳
- Goal:
  - 方向
  - 加減速

Three Layers of Control Tasks

- **Bottom Layer:**
  - For Subsystems (Wheel, Motor, Engine, Gear Box, Braking)



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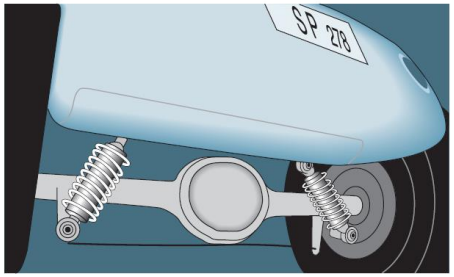

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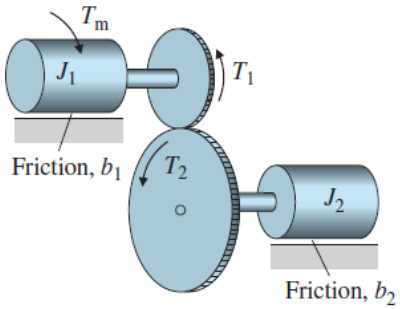

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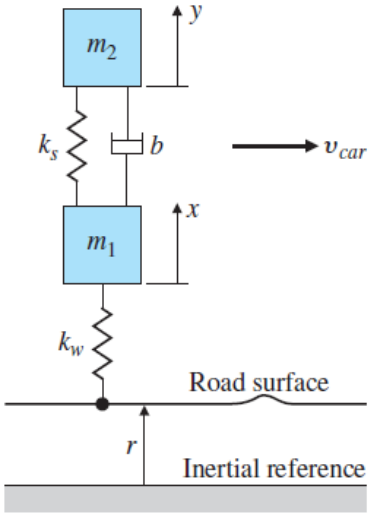


Franklin19

- **Action:**
  - 控制驅動電流/電壓
- **Goal:**
  - 每一個輪子/螺旋槳的轉速/轉角

Three Layers of Control Tasks

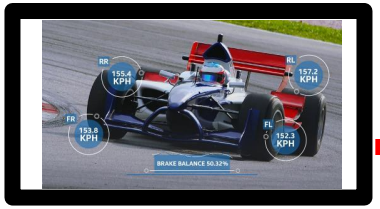
- **Top Layer:**
  - For Multiple Agents (Group of Vehicles, Cars, Drones)

➢ 方向盤
➢ 油門煞車

➢ 位置/車道
➢ 速度/方向

- **Middle Layer:**
  - For Single Agent (Single Vehicle, Car, Drone)

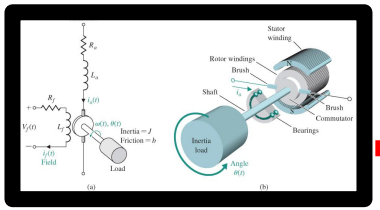
➢ 統整四個輪子
➢ 統整四個螺旋槳



➢ 方向
➢ 加減速

- **Bottom Layer:**
  - For Subsystems (Wheel, Motor, Engine, Gear Box, Braking)

➢ 控制驅動電流/電壓



➢ 每一個輪子/螺旋槳的轉速/轉角

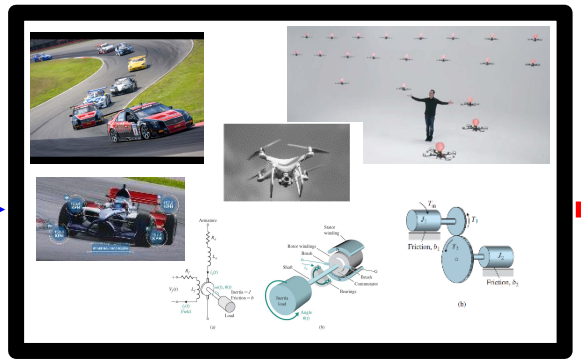
Plant, Input, Output, Action, Goal

Signals & Systems

Control Systems

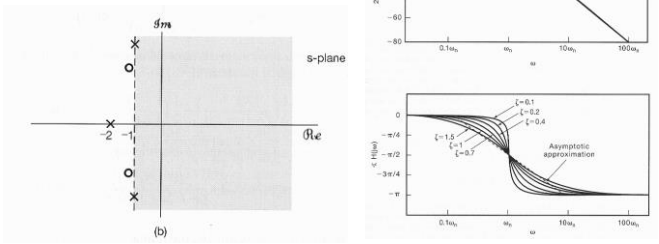
1. Model
2. Response
3. Analysis
4. Feedback
5. Control

Ref (r) → Input (u) → **Plant (P)** → Output (y)



$$\frac{d^2y(t)}{dt^2} + 2\frac{dy(t)}{dt} - 3\,y(t) = 5\,u(t)$$

$$P(s) = \frac{Y(s)}{U(s)} = \frac{5}{s^2 + 2s - 3}$$

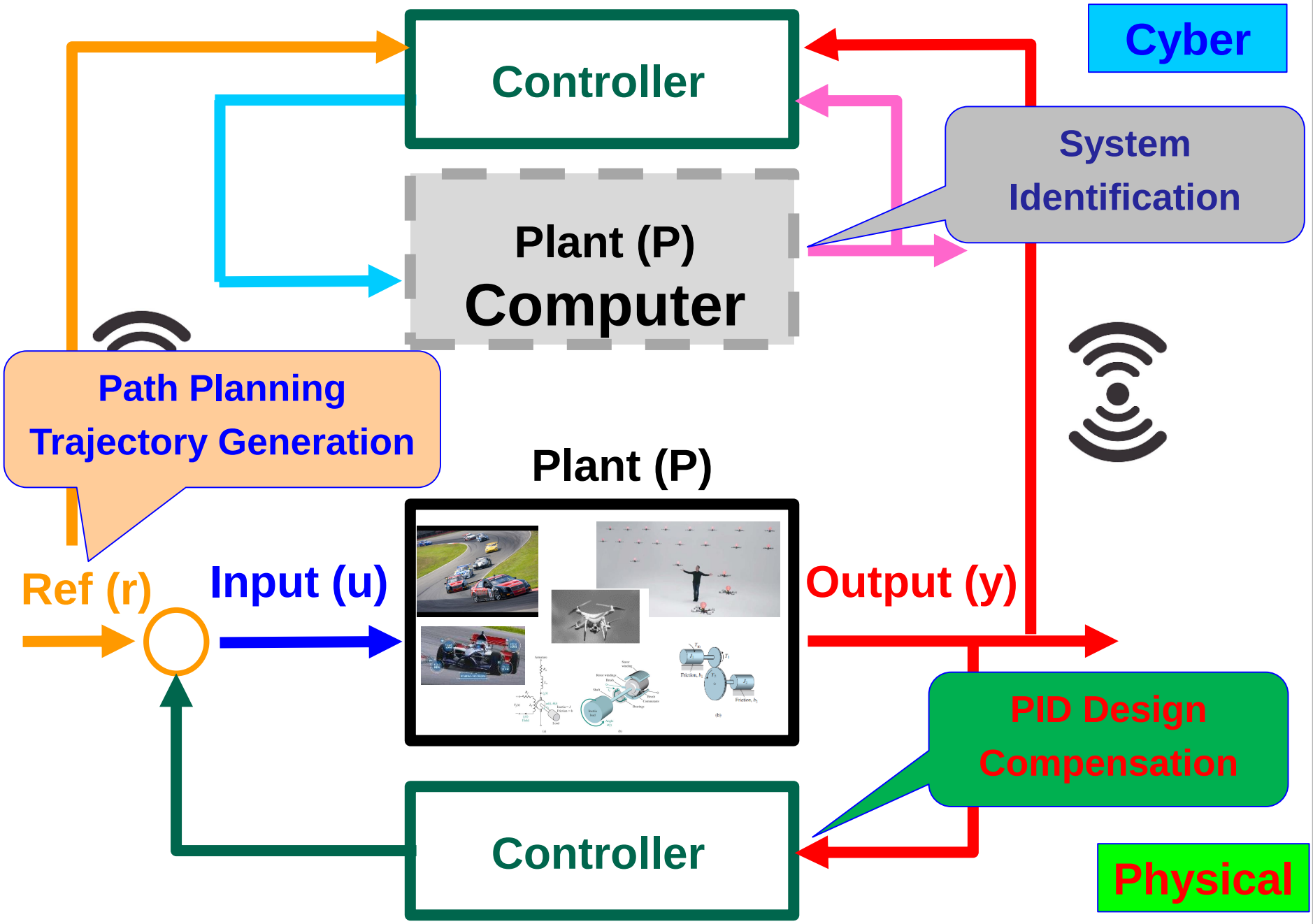


Controller

$$\frac{d^2y(t)}{dt^2} + 4\frac{dy(t)}{dt} + 3\,y(t) = 3\,r(t)$$

$$G(s) = \frac{Y(s)}{R(s)} = \frac{3}{s^2 + 4s + 3}$$

Plant, Input, Output, Action, Goal



Feedback and Control in Teaching and Learning

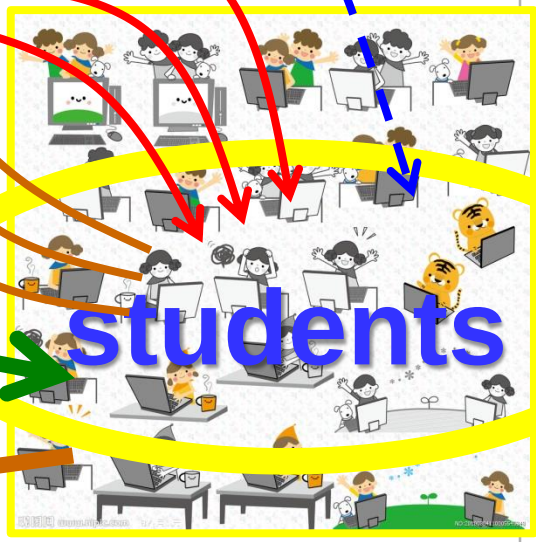
Teacher

Students

Information System

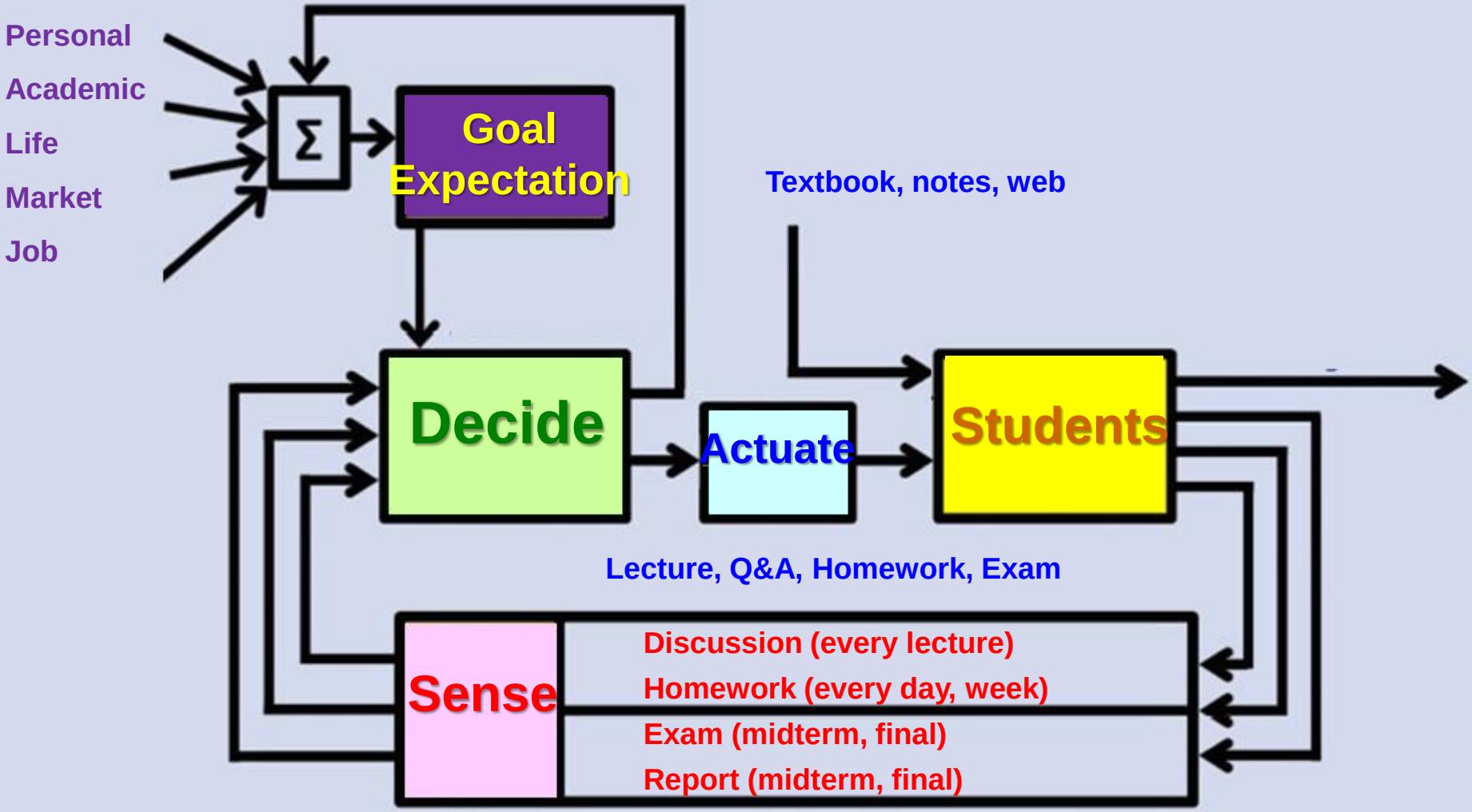
Plantform
(Real-Time-
Interactive-Feedback)

Teacher



students

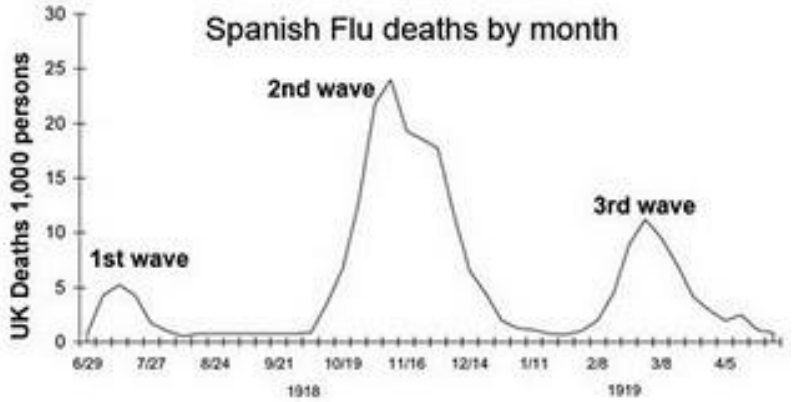
Feedback and Control in Teaching and Learning



Source：IEEE CSM 2013

Control vs Non-Control

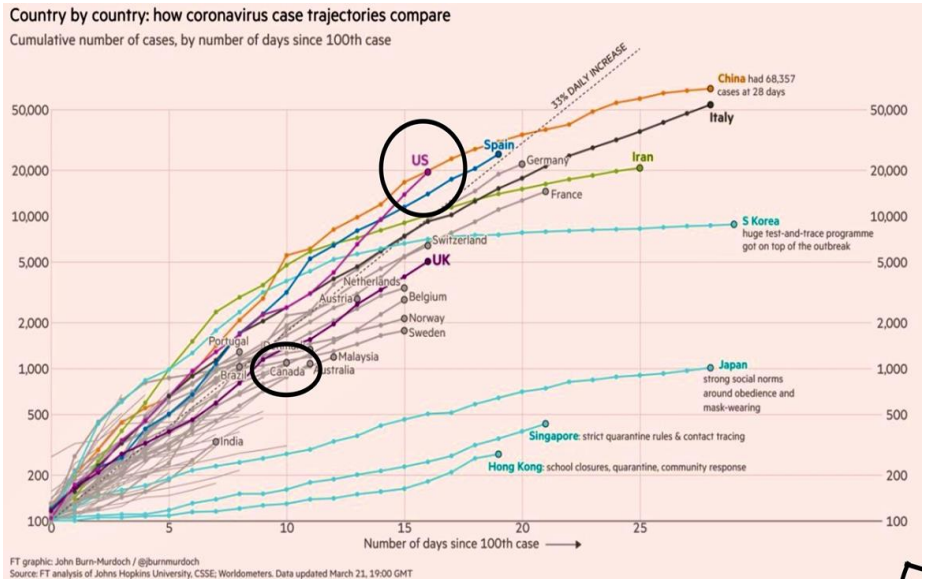
- CoViD – 19（新型冠狀病毒肺炎）
- 1918年西班牙流感大流行

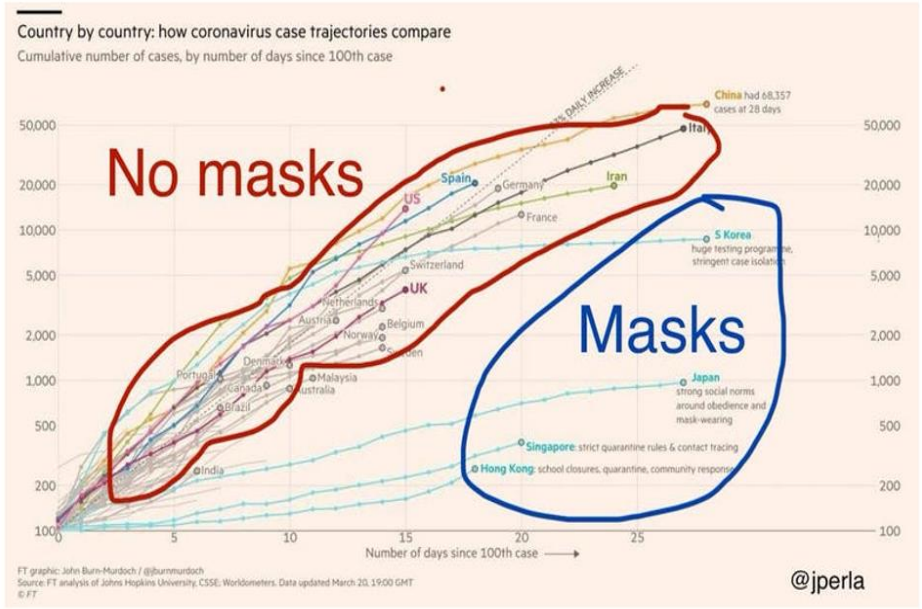


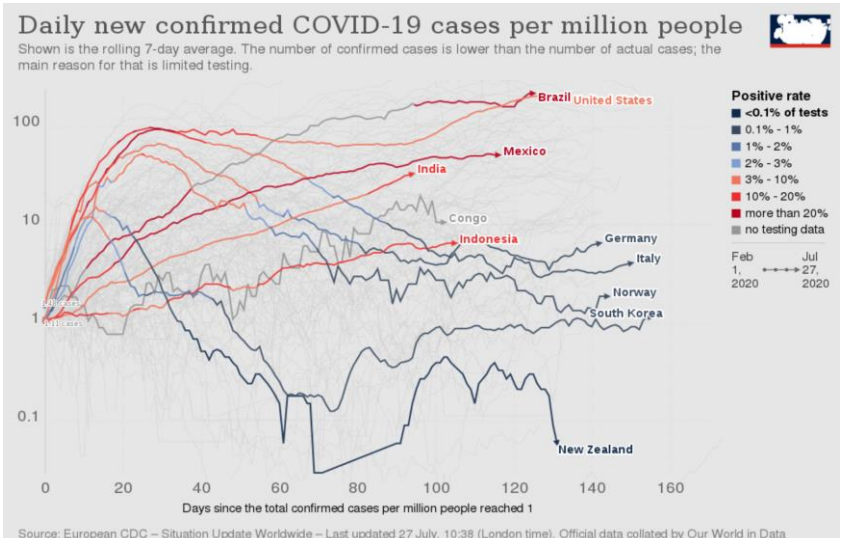
- 主要變數（信號）：
  - 確診人數 vs 不同時間點
  - 死亡人數 vs 不同時間點
  - 產生抗體人數 vs 不同時間點
  - 醫療數量，位置，品質，效能
- 系統：
  - 感染機制
  - 治療機制
  - 隔離機制

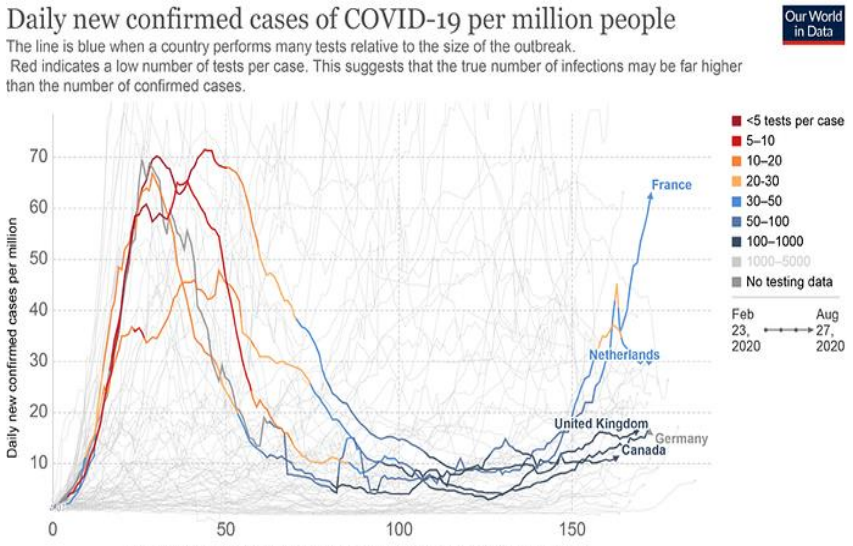
Control vs Non-Control

- CoViD – 19（新型冠狀病毒肺炎）
- 2019年新型冠狀病毒肺炎大流行







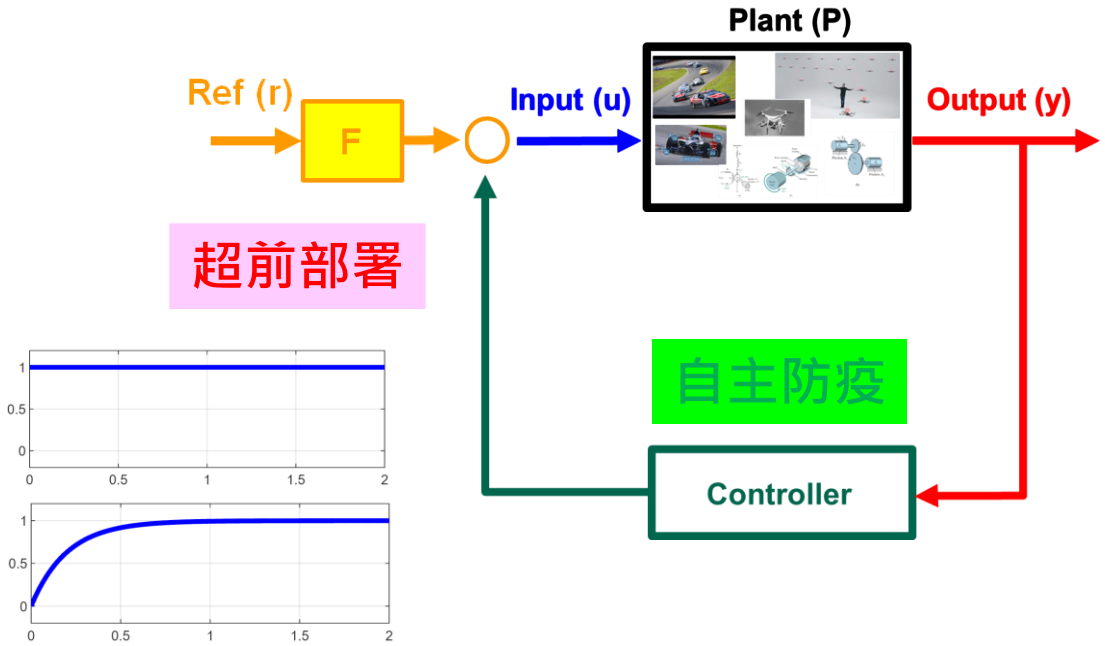


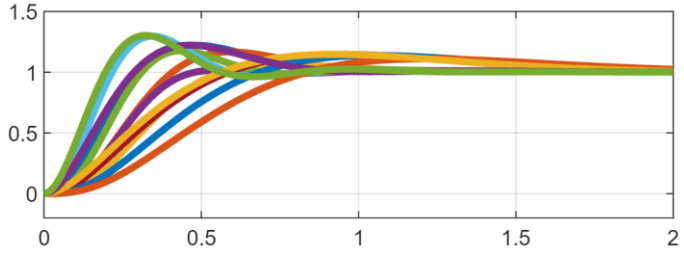
Feedback and Feedforward Controls (超前部署) vs (自主防疫)

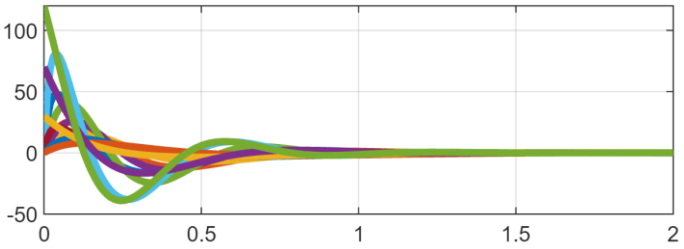
- CoViD – 19 (新型冠狀病毒肺炎)

衛生福利部疾病管制署 Taiwan Centers for Disease Control

CDC Centers for Disease Control and Prevention







- 排隊買口罩

- 排隊打疫苗

- 排隊買快篩

Key Terminologies in Feedback and Control

- Manual Control
- Automatic Control

- Open-Loop Control
- Closed-Loop Control or Feedback Control

- Regulation
- Tracking or Servo System

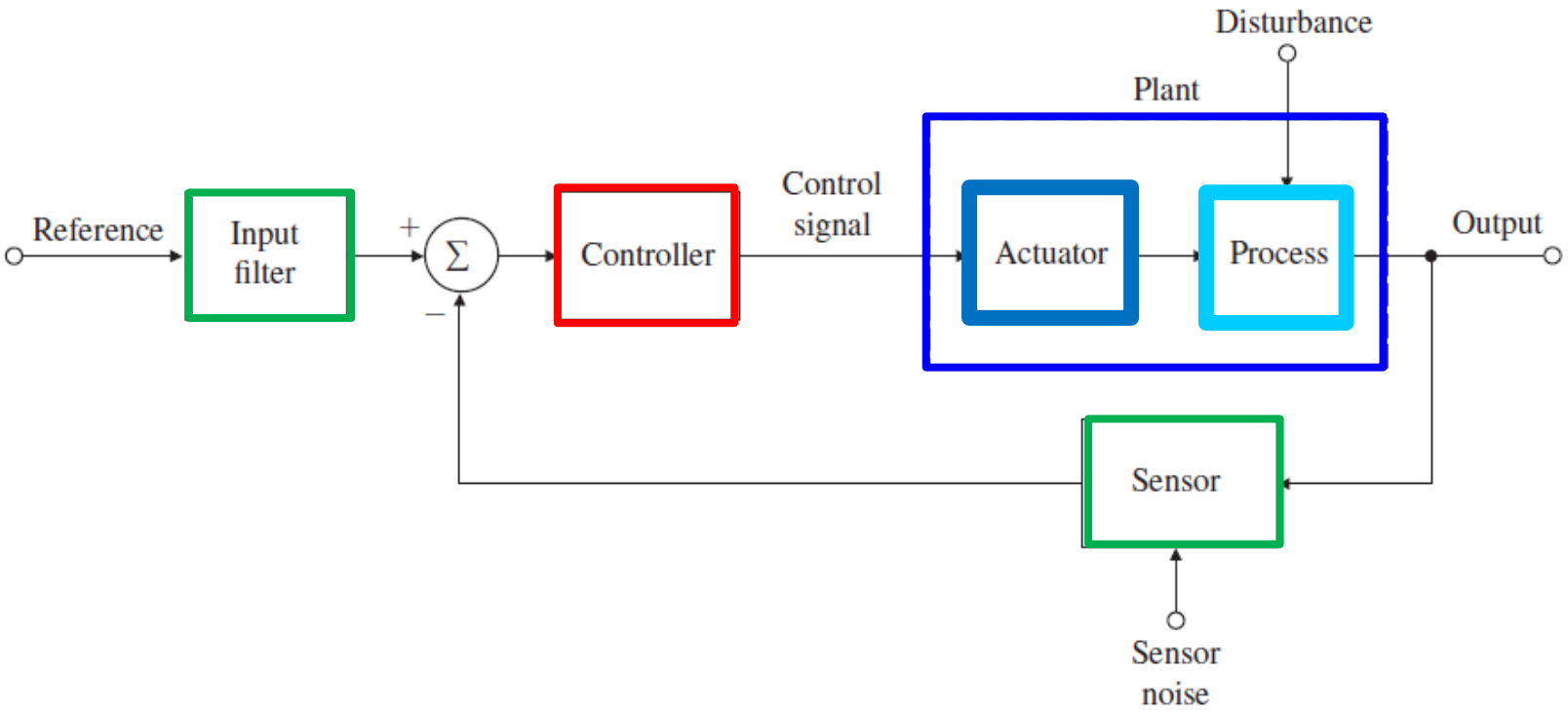
- Feedback
- Feedforward
- Control as a hidden technology

- Systems, Subsystems, Signal/Information Flow
- Process, Plant,
  Actuator, Sensor, Filter, Controller, Compensator

Key Terminologies in Feedback and Control

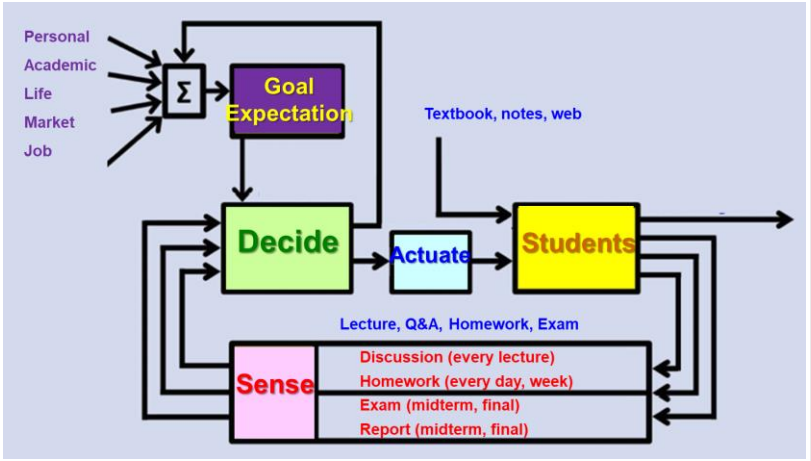
- Goals:
  - Stability
  - Tracking
  - Disturbance Rejection
  - Robustness
- Classic Control
- Modern Control

Key Terminologies in Feedback and Control



- **Modeling**: the plant
- **Analysis**: the plant
- **Design**: the controller

for the plant



Plant, Input, Output, Action, Goal

Signals & Systems

Control Systems

1. Model
2. Response
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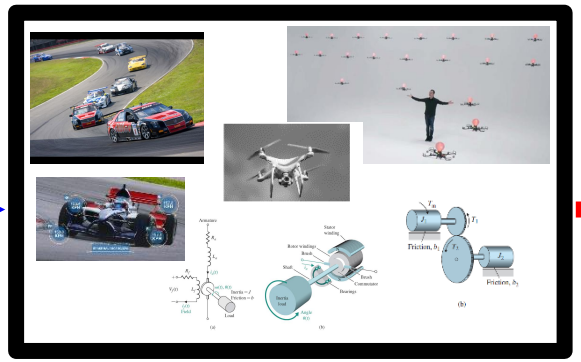
4. Feedback
5. Control

Plant (P)

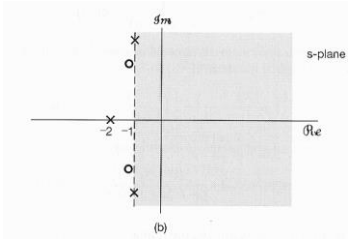


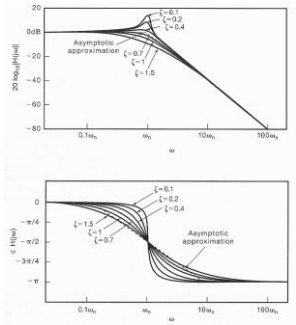
Ref (r) → **Input (u)** → **Output (y)**

Controller

$$\frac{d^2y(t)}{dt^2} + 2\frac{dy(t)}{dt} - 3\,y(t) = 5\,u(t)$$

$$P(s) = \frac{Y(s)}{U(s)} = \frac{5}{s^2 + 2s - 3}$$





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