

Fall 2022 (111-1)

控制系統  
Control Systems

Unit 1F

Emergent Example of Feedback and Control

Feng-Li Lian

NTU-EE

Sep 2022 – Dec 2022

- 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**



Centers for Disease  
**Control** and **Prevention**

- CoViD – 19（新型冠狀病毒肺炎）
- 口罩自動化生產系統



網曝醫療口罩製造秘辛：2禮拜開60生產線要跪哭了

新頭殼 12k 人追蹤 追蹤  
新頭殼 newtalk 洪翠驊 綜合報導  
2020年2月15日 下午5:14



行政院長蘇貞昌（左）14日視察口罩生產工廠，表示最快月底，口罩產能將可達每日產千萬片。圖：新頭殼資料照/林鈞真攝

[新頭殼newtalk] 中國武漢肺炎疫情發燒，全球口罩需求供不應求，行政院長蘇貞昌視察口罩工廠時指出，2月底或3月初，產能可拉高到每日千萬片，台灣將成為全球第2大口罩生產國。對此，有網友加碼爆料，指製造低價低利醫用口罩的產業，早在20多年前就外移，經濟部此次2個禮拜就開出60條生產線，台灣人員的要跪下來哭了，謝謝再謝謝！

網友「Ann Chang」在臉書曝光「怎麼生產醫療用口罩？」，指出3層厚的醫療用口罩最重要的是不織布那一層，利用不織布防水的特性阻隔飛沫傳遞，而製作時必須採用超音波震動，將布料的四邊熱熔密合，才能達到醫療用防止傳染的要求。

- 主要變數（信號）：
  - 所需的口罩數量
  - 生產原料種類與數量
  - 每一片口罩生產所需的時間
  - 單位時間產量的良率
  - 整體的產能等等等

- 系統：
  - 備料
  - 分批
  - 組裝
  - 包裝
  
  - 傳送
  - 旋轉
  - 擠壓

- CoViD – 19 ( 新型冠狀病毒肺炎 )
- 即時口罩地圖 <https://mask.goodideas-studio.com/>



## ■ 主要變數 (信號) :

- 販賣處的位置 (距離)
- 販賣時間 (絕對時間點, 持續時間)
- 口罩存量 (與時間的關係式)
- 口罩種類

## ■ 系統 :

- 排隊
- 分包
- 交通時間
- 運送時間

udn / 僑壇家 / 新社會

看見我科技實力！唐鳳：多國對台灣口罩地圖有興趣  
2020/02/18 張文馨

行政院政務委員唐鳳受華府普選邀請訪問美國，他14日在駐美代表處分享此行訪問經驗；被問到新冠肺炎 ( COVID-19 ) 在台灣造成口罩短缺，唐鳳說，台灣藉此機會實作開放政策，把原本碼放在網路上的成立口罩地圖，引起美國等國家的興趣，他們都可以直接在網路上看到這次實作過程。



行政院政務委員唐鳳。圖 / 黃仲裕攝影

唐鳳指出，此行也有和美國國會與行政機關官員互動，和美國國會眾議院物聯網連線的主席、金融服務小組委員會、人工智慧任務小組主席，以及行政機關的數位任務小組成員聊到欲罷不能，聽聽眾議院政府、唐鳳稱，與行政官員深入交換意見，並探討可以如何合作，唐鳳指出，台灣在防疫方面上創造實作的精華



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

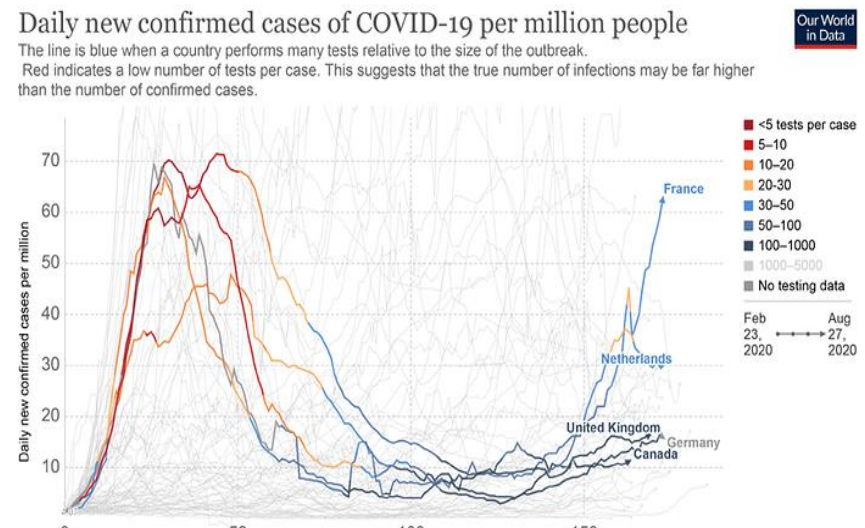
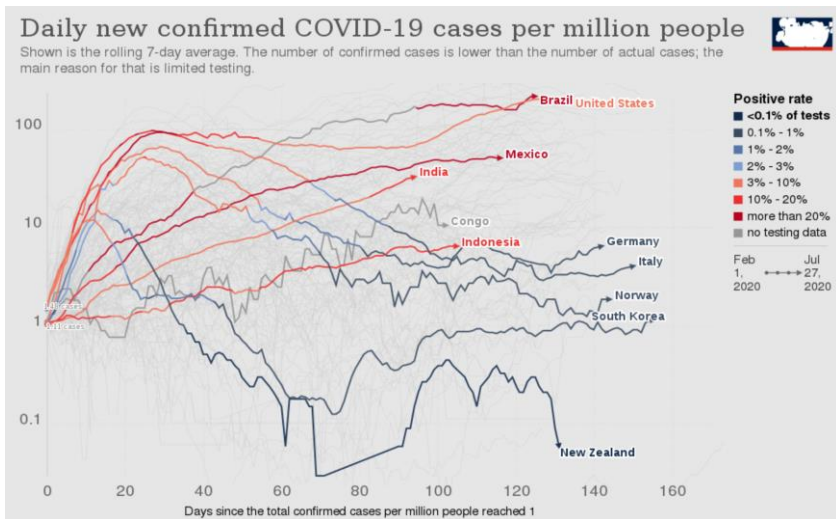
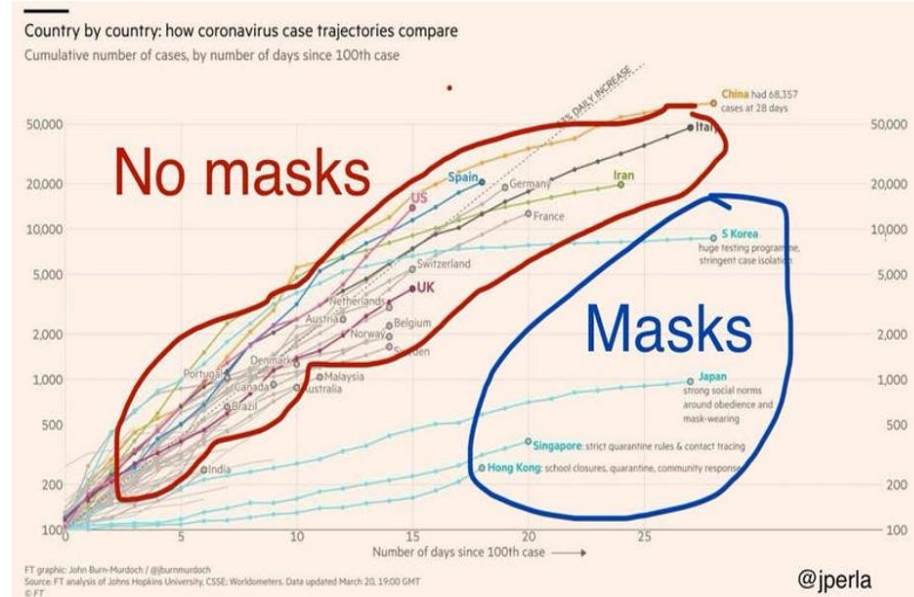
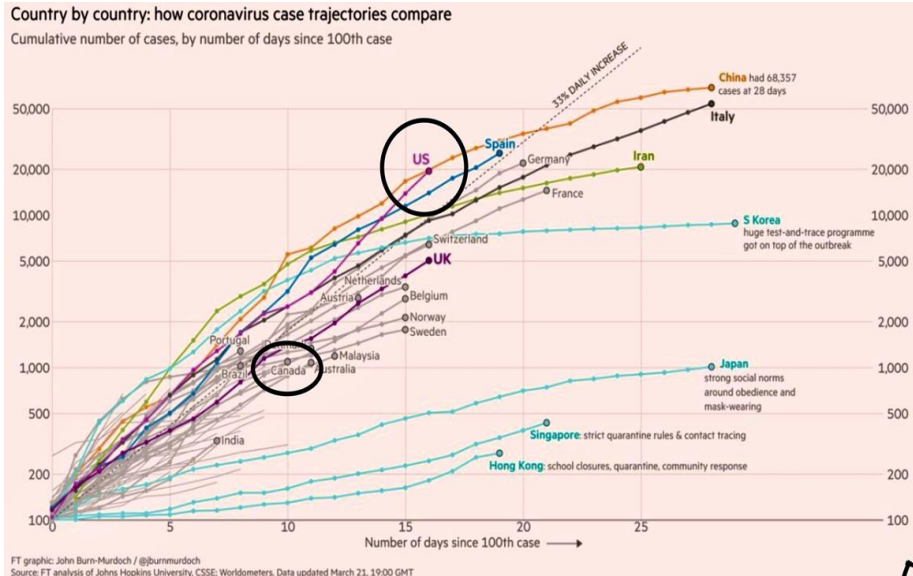


- 主要變數（信號）：
  - 確診人數 VS 不同時間點
  - 死亡人數 VS 不同時間點
  - 產生抗體人數 VS 不同時間點
  - 醫療數量，位置，品質，效能

- 系統：
  - 感染機制
  - 治療機制
  - 隔離機制

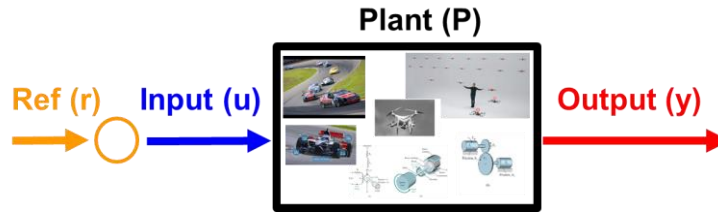


- CoViD – 19 ( 新型冠狀病毒肺炎 )
- 2019年新型冠狀病毒肺炎大流行

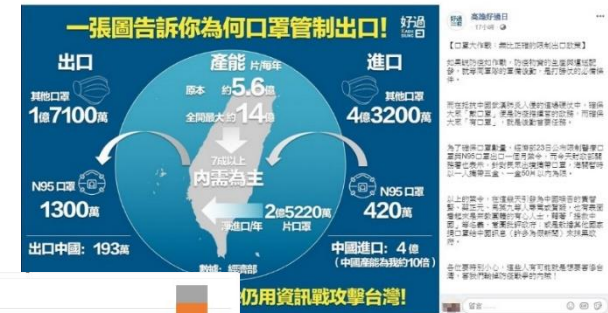
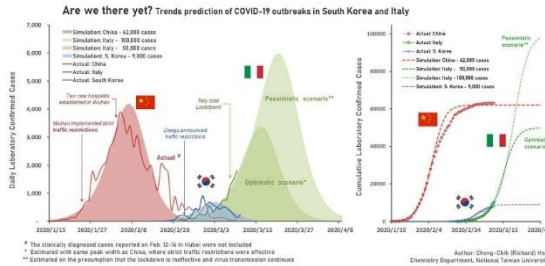


- 預防：
  - 預期口罩需求量
  - 預期購買時間
- 治療：
  - 預期感染人數
  - 預期死亡人數

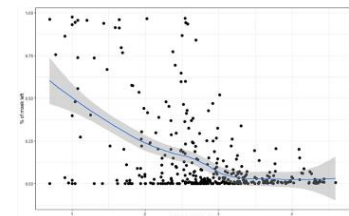
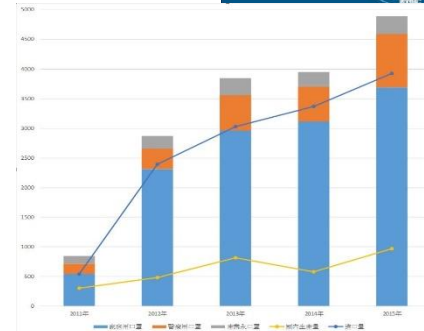
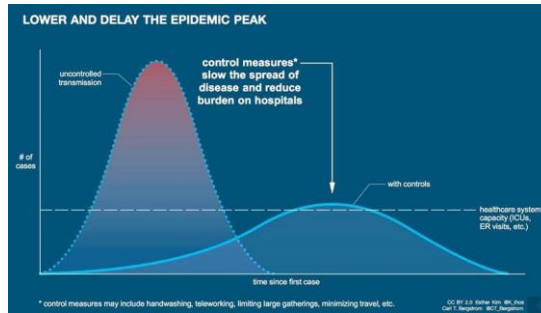
- 生活圈：
  - 人：人民，醫生，工程師等
  - 物：口罩，藥物等
  - 地：隔離區，醫院，住家



- 預防：
  - 口罩使用量
  - 購買等待時間
- 治療：
  - 感染人數
  - 死亡人數

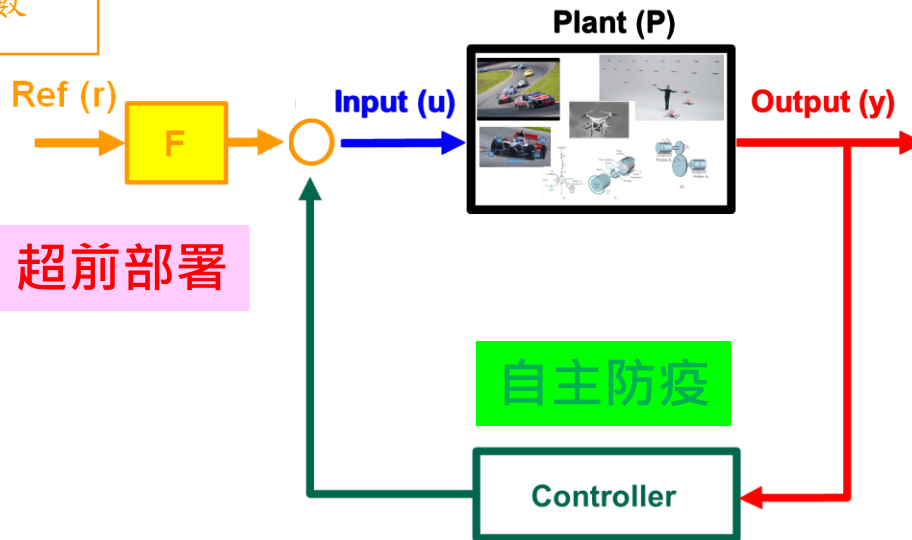


- 人民
- 口罩
- 試劑



- 預防：
  - 預期口罩需求量
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- 治療：
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- 預防：
  - 口罩使用量
  - 購買等待時間
- 治療：
  - 感染人數
  - 死亡人數

- 人民
- 口罩
- 試劑

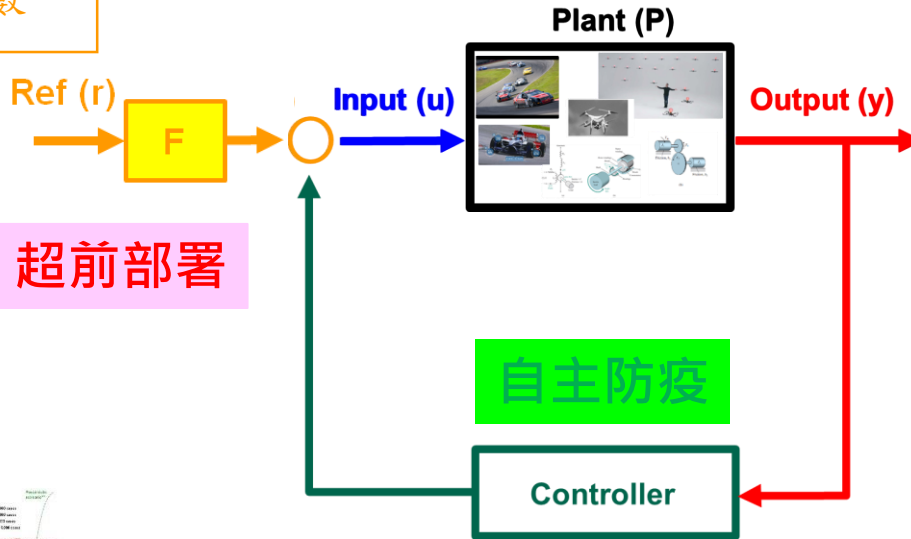
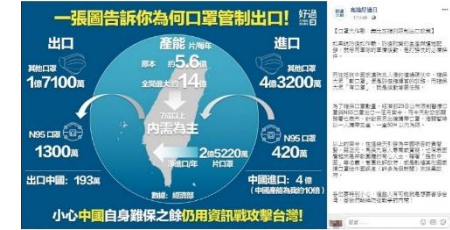
- 預防：
  - 生產機器產能與效率
  - 即時口罩地圖
- 治療：
  - 隔離
  - 藥物
  - 疫苗



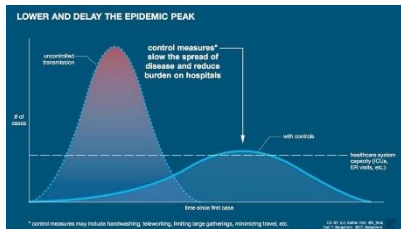
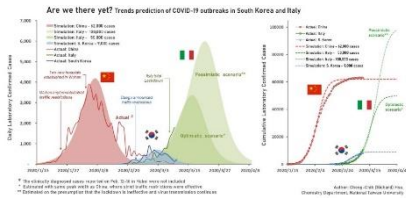
# Open-Loop Control vs Closed-Loop Control

- 預防：
  - 預期口罩需求量
  - 預期購買時間
- 治療：
  - 預期感染人數
  - 預期死亡人數

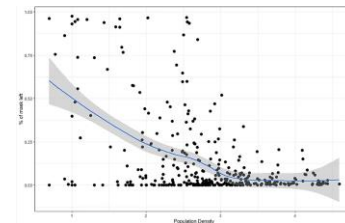
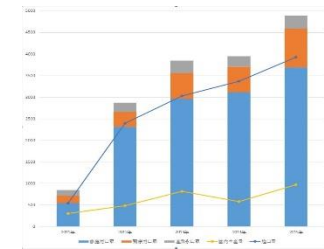
- 生活圈：
  - 人：人民，醫生，工程師等
  - 物：口罩，藥物等
  - 地：隔離區，醫院，住家



- 預防：
  - 口罩使用量
  - 購買等待時間
- 治療：
  - 感染人數
  - 死亡人數



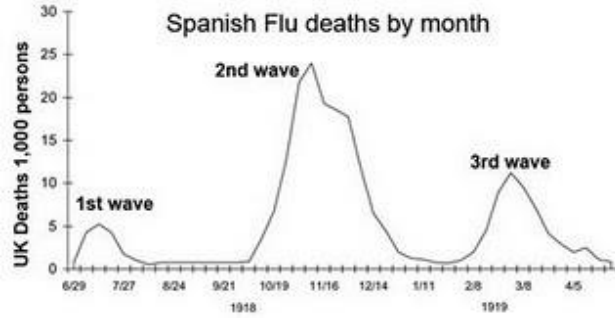
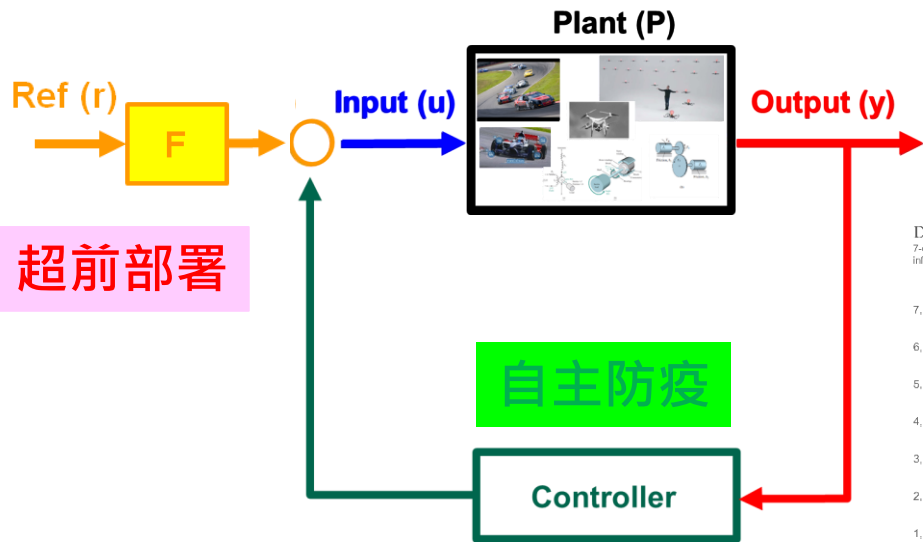
- 預防：
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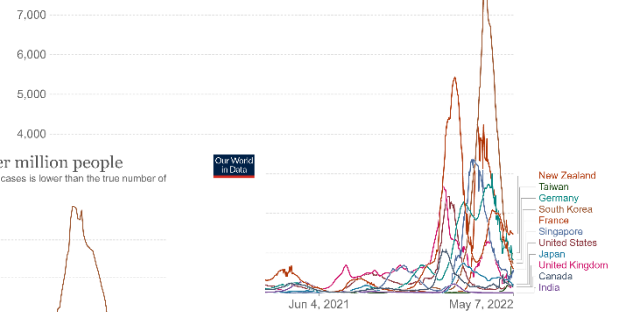


衛生福利部疾病管制署

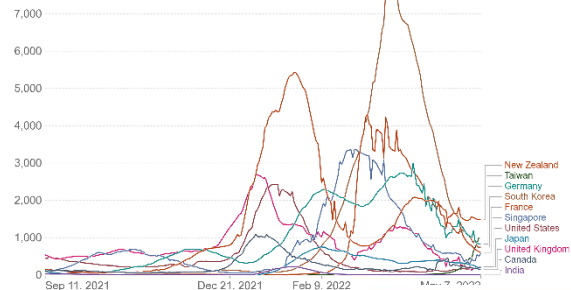
Taiwan Centers for Disease Control



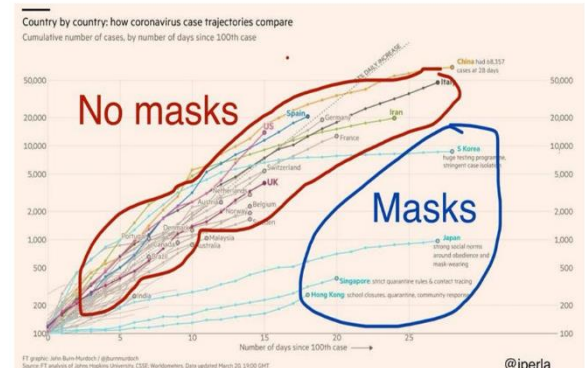
Daily new confirmed COVID-19 cases per million people  
7-day rolling average. Due to limited testing, the number of confirmed cases is lower than the true number of infections.



Daily new confirmed COVID-19 cases per million people  
7-day rolling average. Due to limited testing, the number of confirmed cases is lower than the true number of infections.



Source: Johns Hopkins University CSSE COVID-19 Data



Centers for Disease Control and Prevention

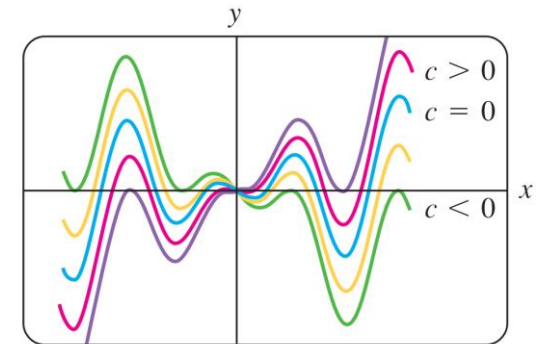
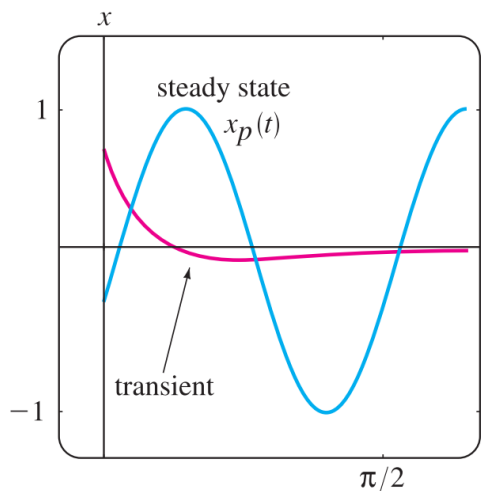
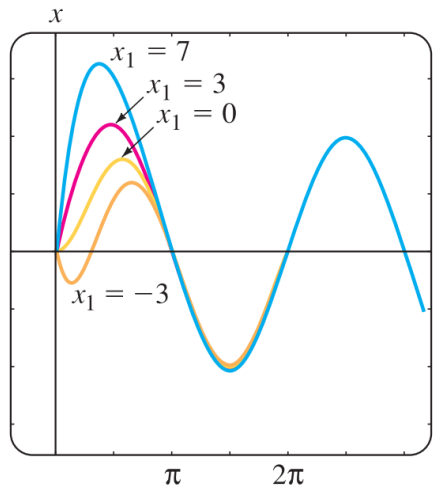
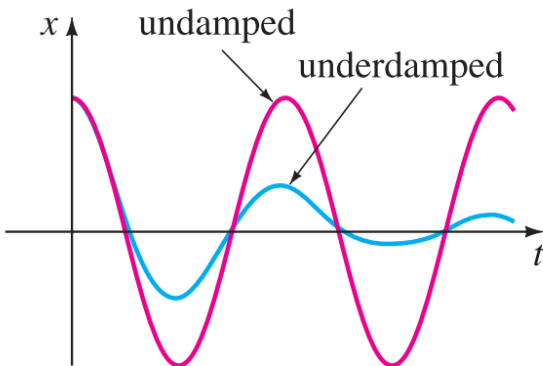
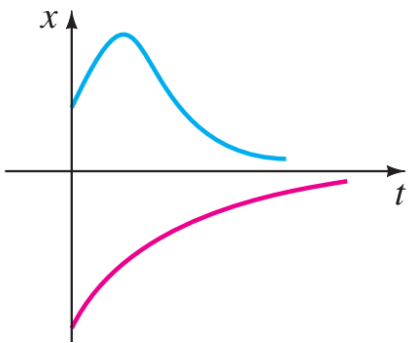
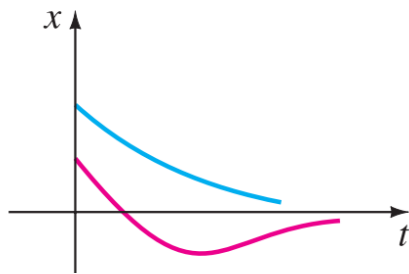
# Understand the System by Differential Equations

$$\frac{d^2x}{dt^2} + 2\lambda \frac{dx}{dt} + \omega^2 x = 0,$$

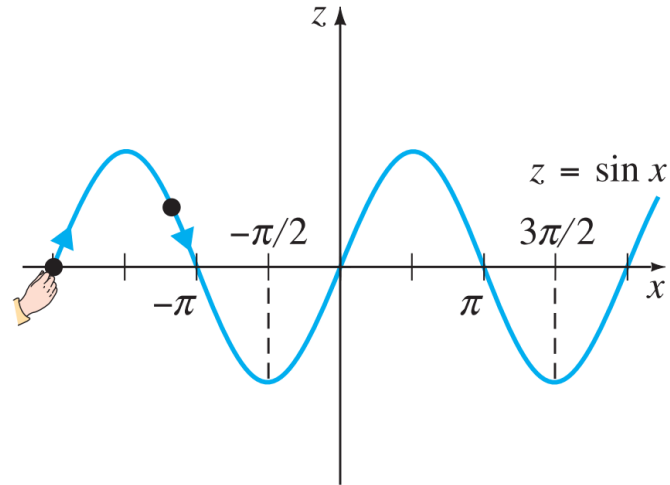
$$\frac{d^2x}{dt^2} + 2\lambda \frac{dx}{dt} + \omega^2 x = F(t),$$

$$xy' - y = x^2 \sin x$$

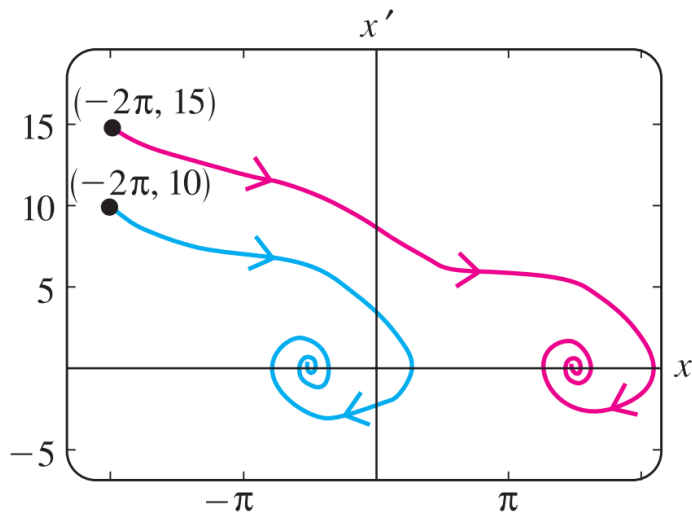
$$y = cx - x \cos x$$



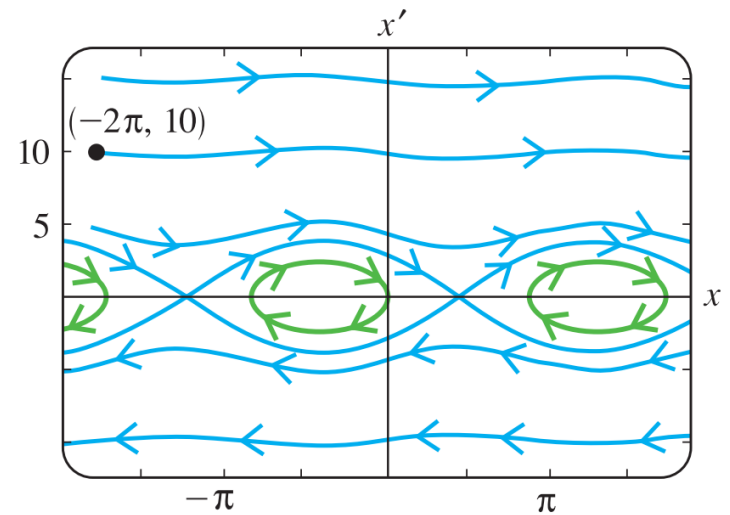
## ■ Bead Sliding Along a Sine Wave



**FIGURE 10.4.4**  $-\pi/2$  and  $3\pi/2$  are stable.



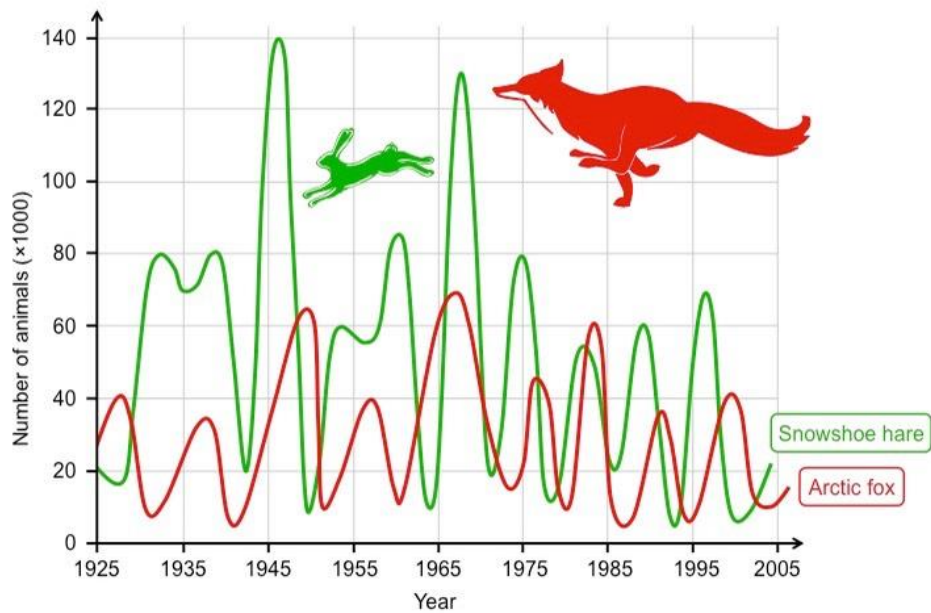
**FIGURE 10.4.5**  $\beta = 0.01$



**FIGURE 10.4.6**  $\beta = 0$

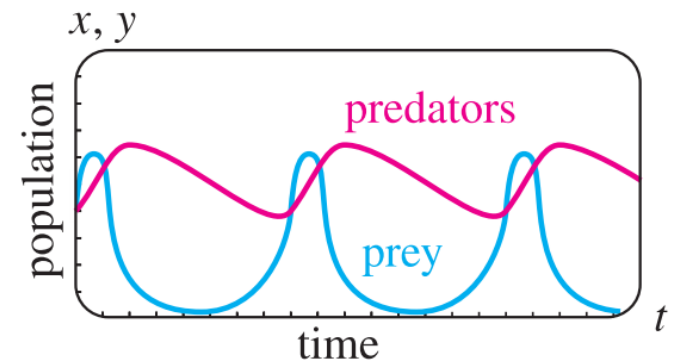


## Lotka-Volterra Predator-Prey Model (兔子與狐狸)

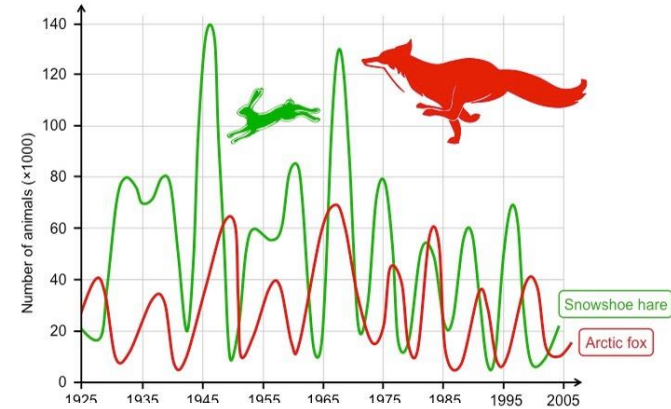


$$\frac{dx}{dt} = -0.16x + 0.08xy$$

$$\frac{dy}{dt} = 4.5y - 0.9xy$$

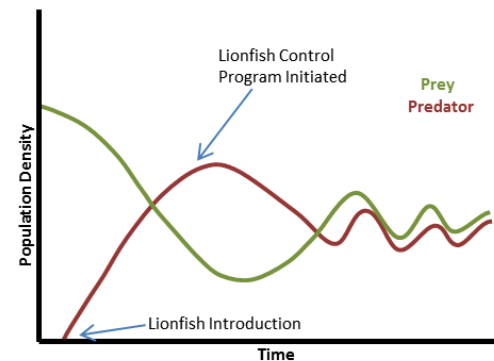
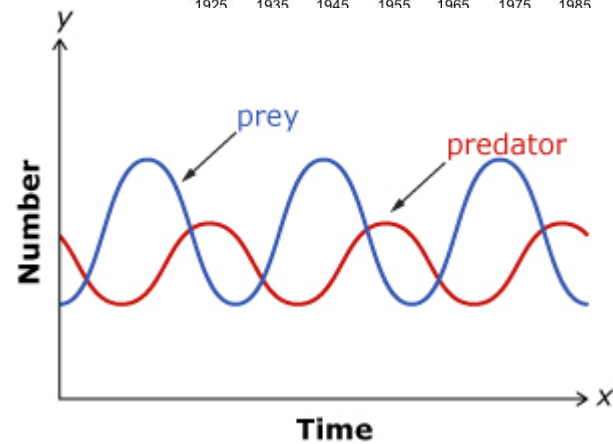
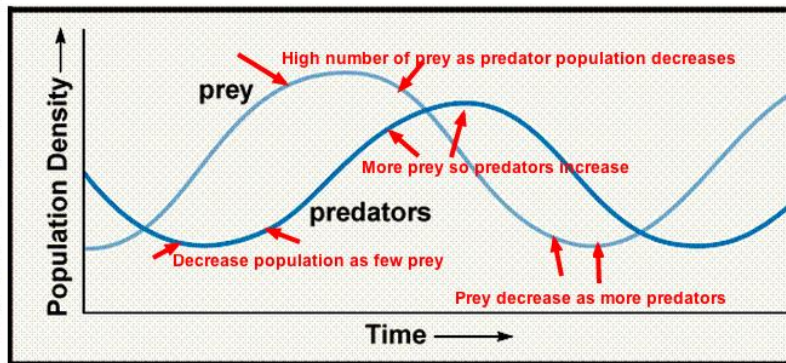


## Lotka-Volterra Predator-Prey Model ( 兔子與狐狸 )



Sylvia S Mader, Biology, 6th edition. © 1998 The McGraw-Hill Companies, Inc. All rights reserved.

### Comparison of Prey and Predators' Populations



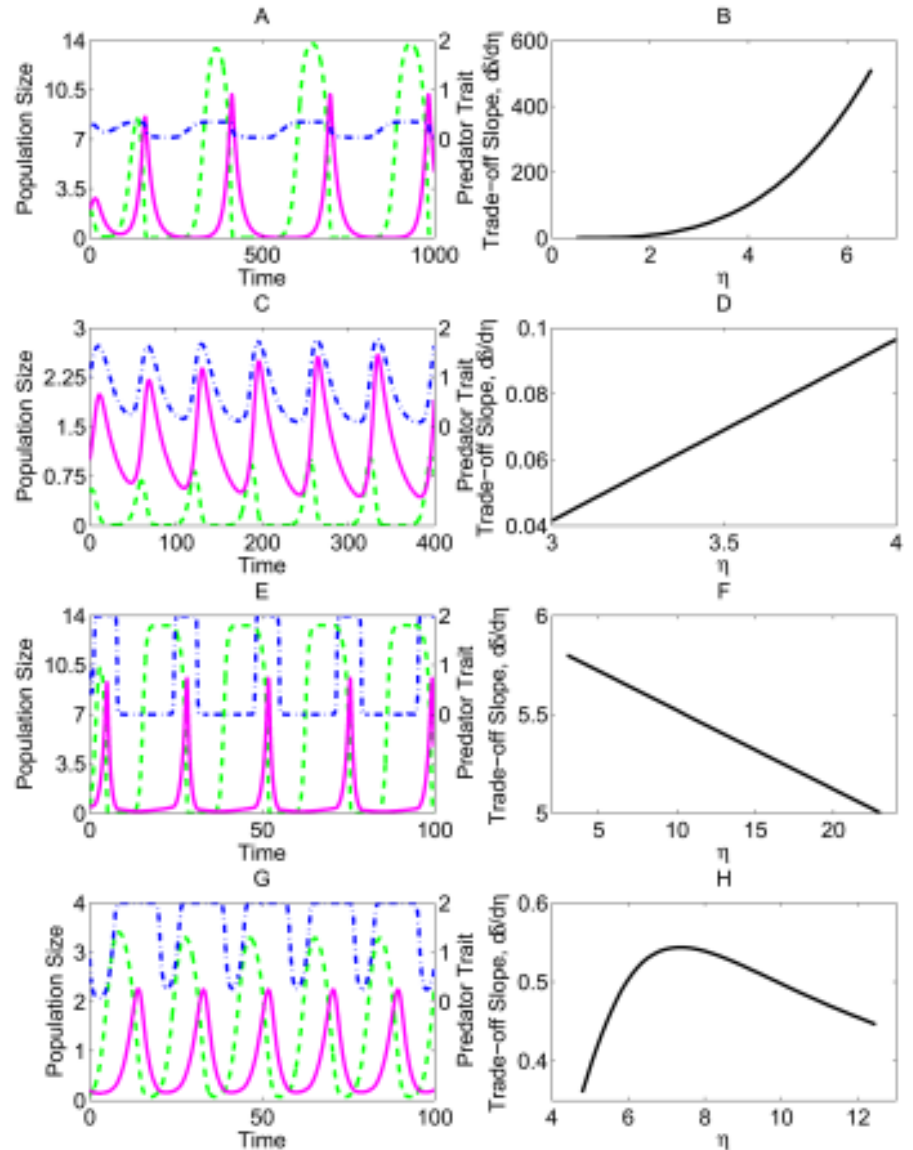
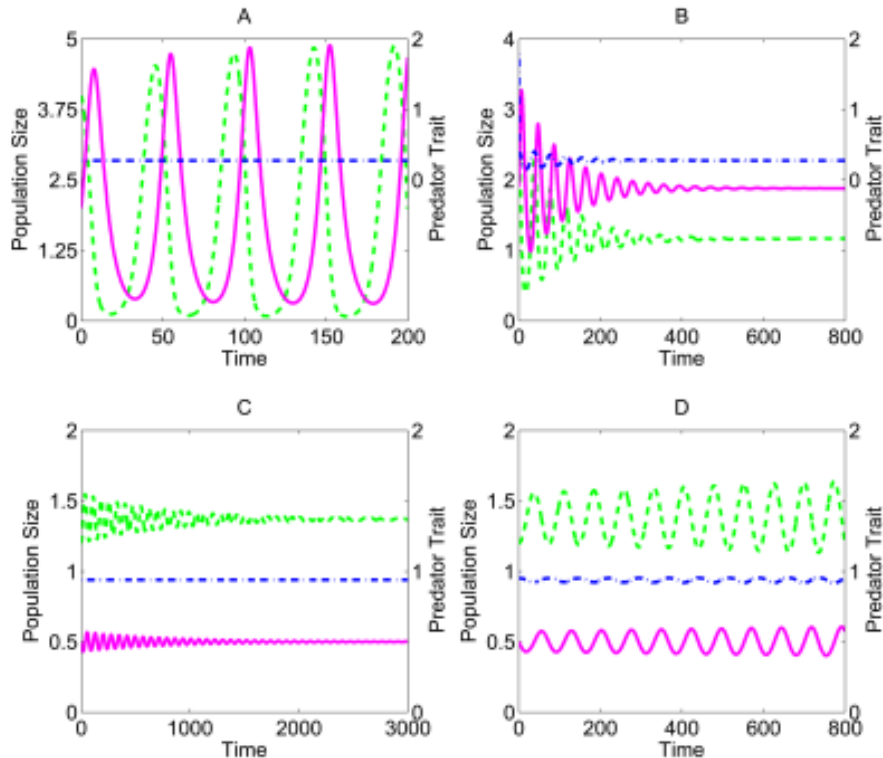
## Lotka-Volterra Predator-Prey Model (兔子與狐狸)

VOL. 176, NO. 5 THE AMERICAN NATURALIST NOVEMBER 2010

E-ARTICLE

### Understanding Rapid Evolution in Predator-Prey Interactions Using the Theory of Fast-Slow Dynamical Systems

Michael H. Cortez<sup>1,\*</sup> and Stephen P. Ellner<sup>1,2</sup>

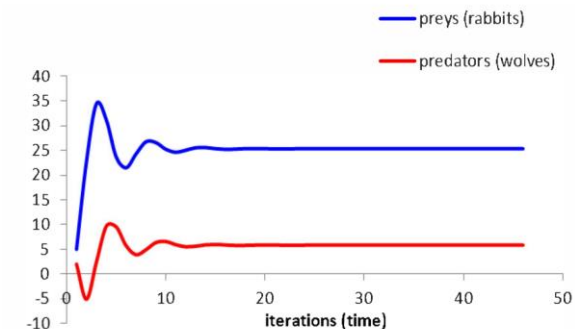
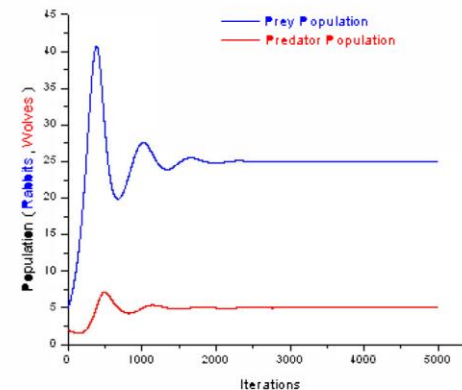
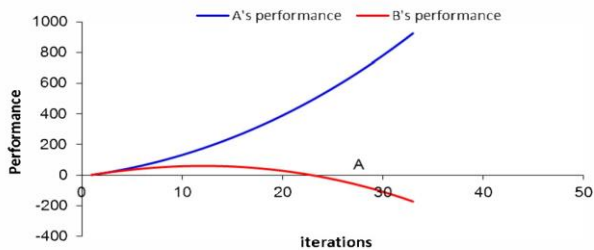
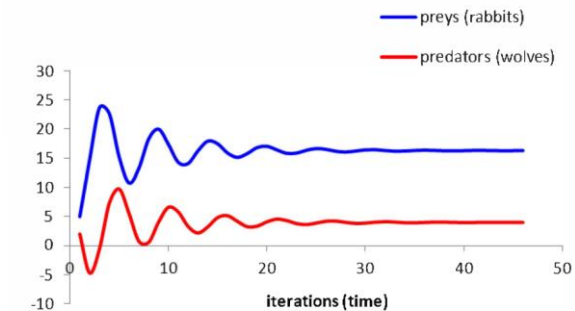
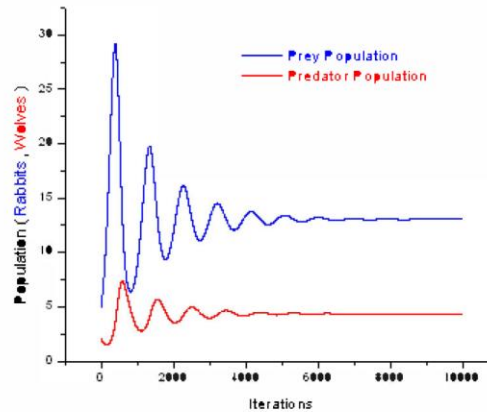
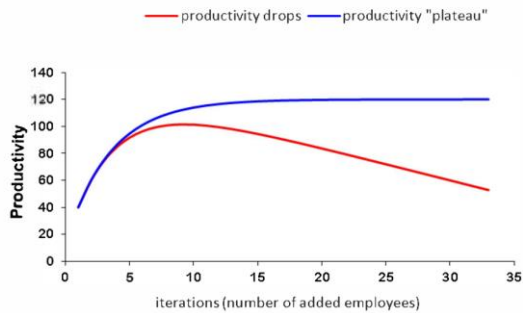
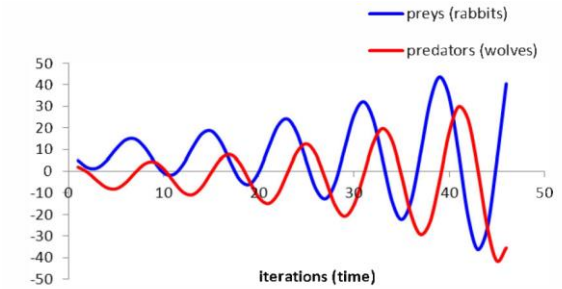
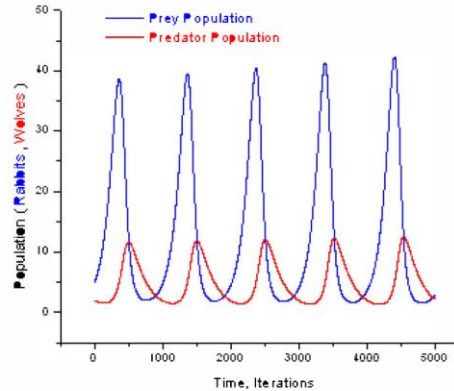


## Lotka-Volterra Predator-Prey Model (兔子與狐狸)

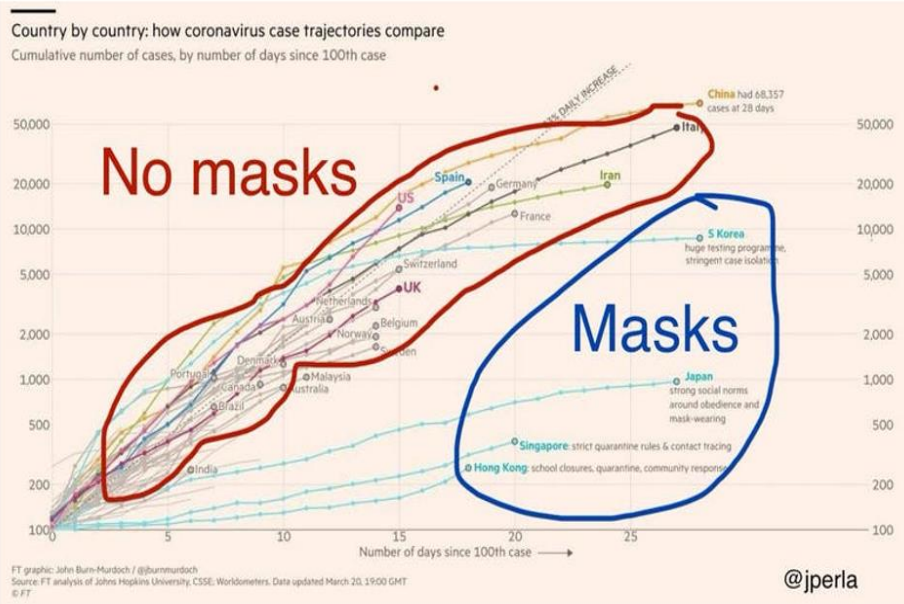
### Resilience Modeling by Means of a Set of Recursive Functions.

Maria Teresa Signes Pont, Juan Manuel García Chamizo, Higinio Mora Mora, Jerónimo Mora Pascual  
Departamento de Tecnología Informática y Computación  
Universidad de Alicante  
03690 San Vicente del Raspeig - Alicante, España  
[\[teresa\\_juanma\\_hmora\\_jeronimo\]@dtic.ua.es](mailto:{teresa_juanma_hmora_jeronimo}@dtic.ua.es)

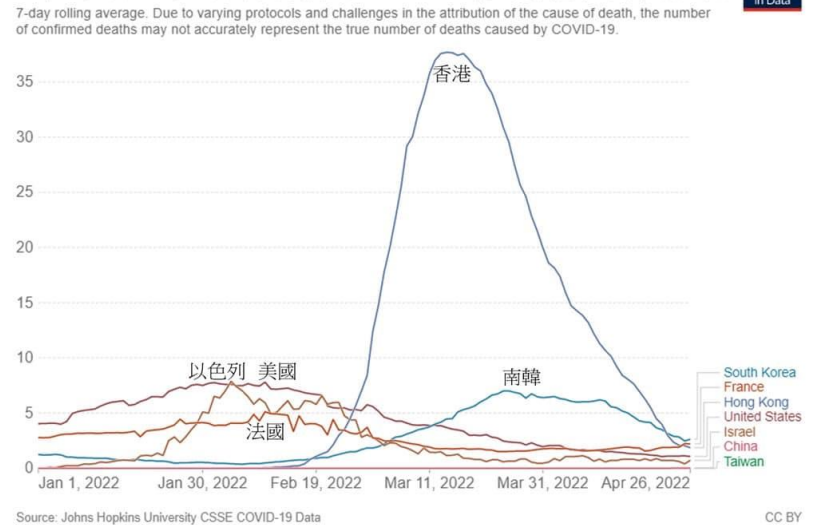
978-1-4799-0181-4/13/\$31.00 ©2013 IEEE







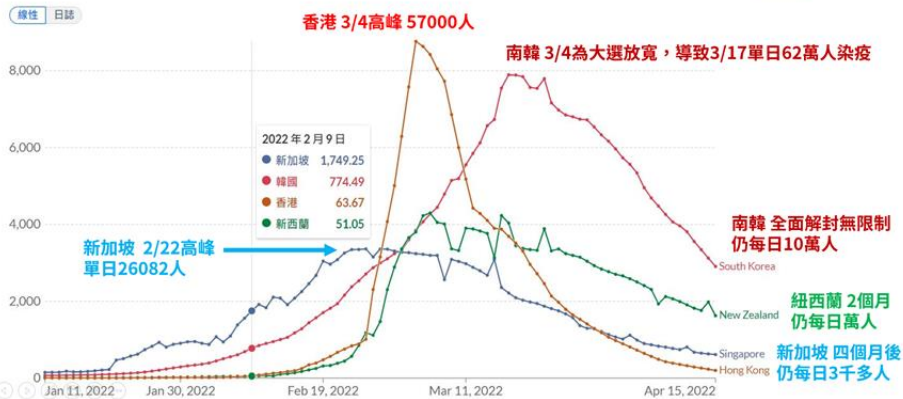
圖二：2022年1月1日至4月26日6國每百萬人口COVID-19的7日滾動平均確診死亡數



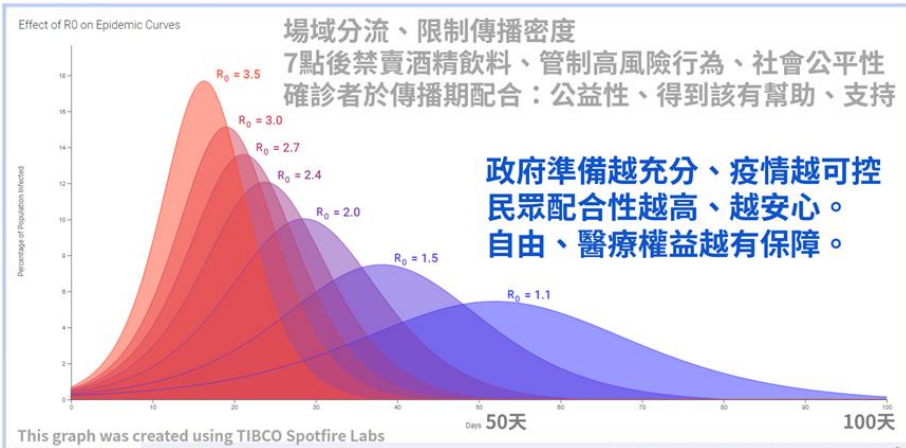
## 準備不充分，政治影響防疫，將造成難以承受患者潮

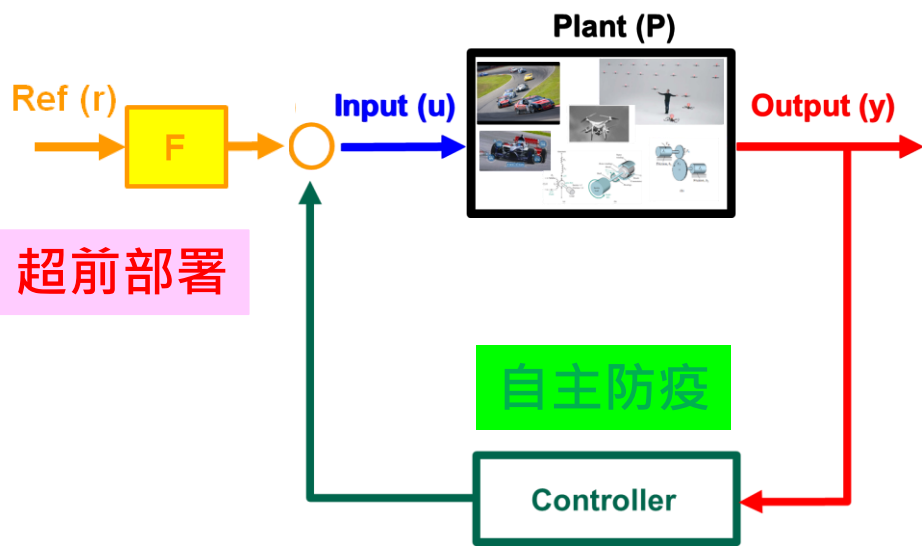
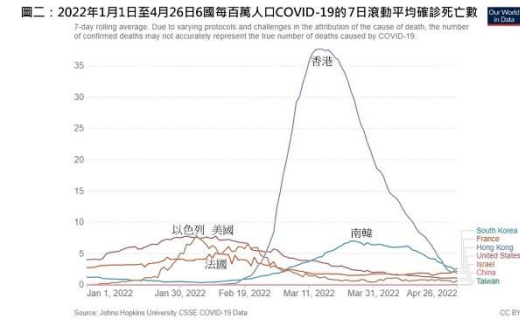
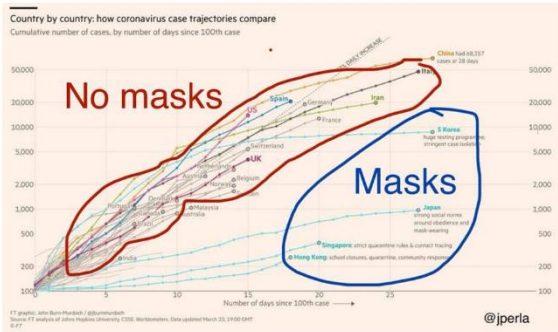
每百萬人中每日新增確診的 COVID-19 病例  
7天滾動平均值，由於檢測有限，確診病例數低於真實感染數。

受限於5倍以上的龐大長者疫苗缺口，  
台灣無法學另三國在疫情下降後解封

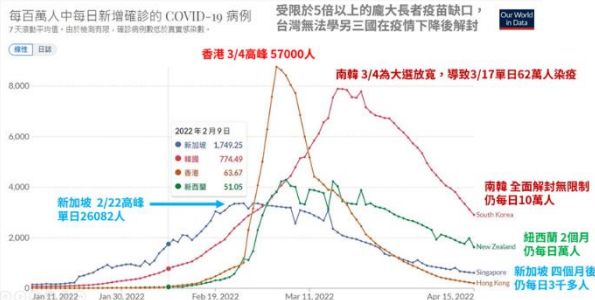


## 隔離確診者目的：避免大量患者，癱瘓社會功能

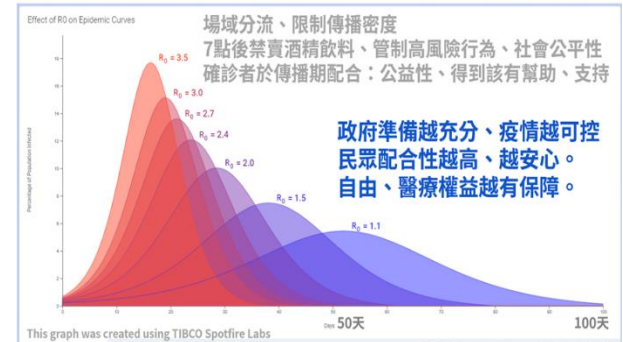




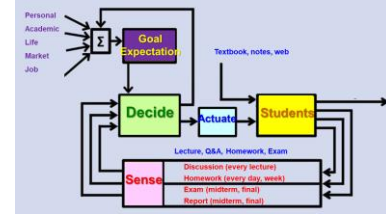
## 準備不充分，政治影響防疫，將造成難以承受患者潮



## 隔離確診者目的：避免大量患者，癱瘓社會功能

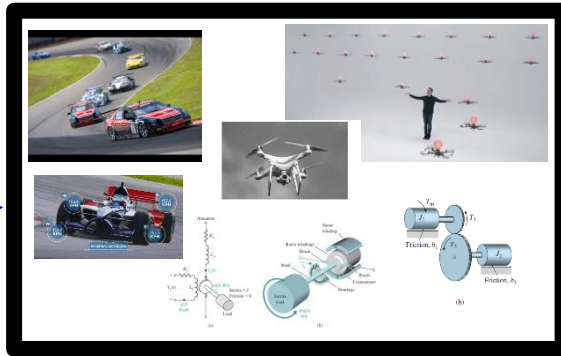


# Plant (P)



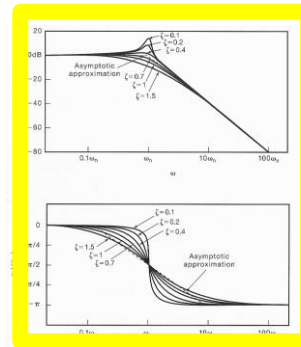
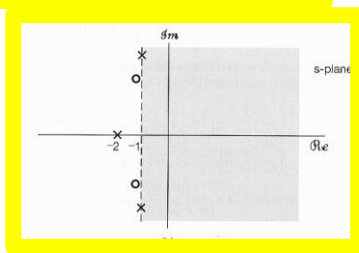
Ref (r)      Input (u)

Output (y)



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

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



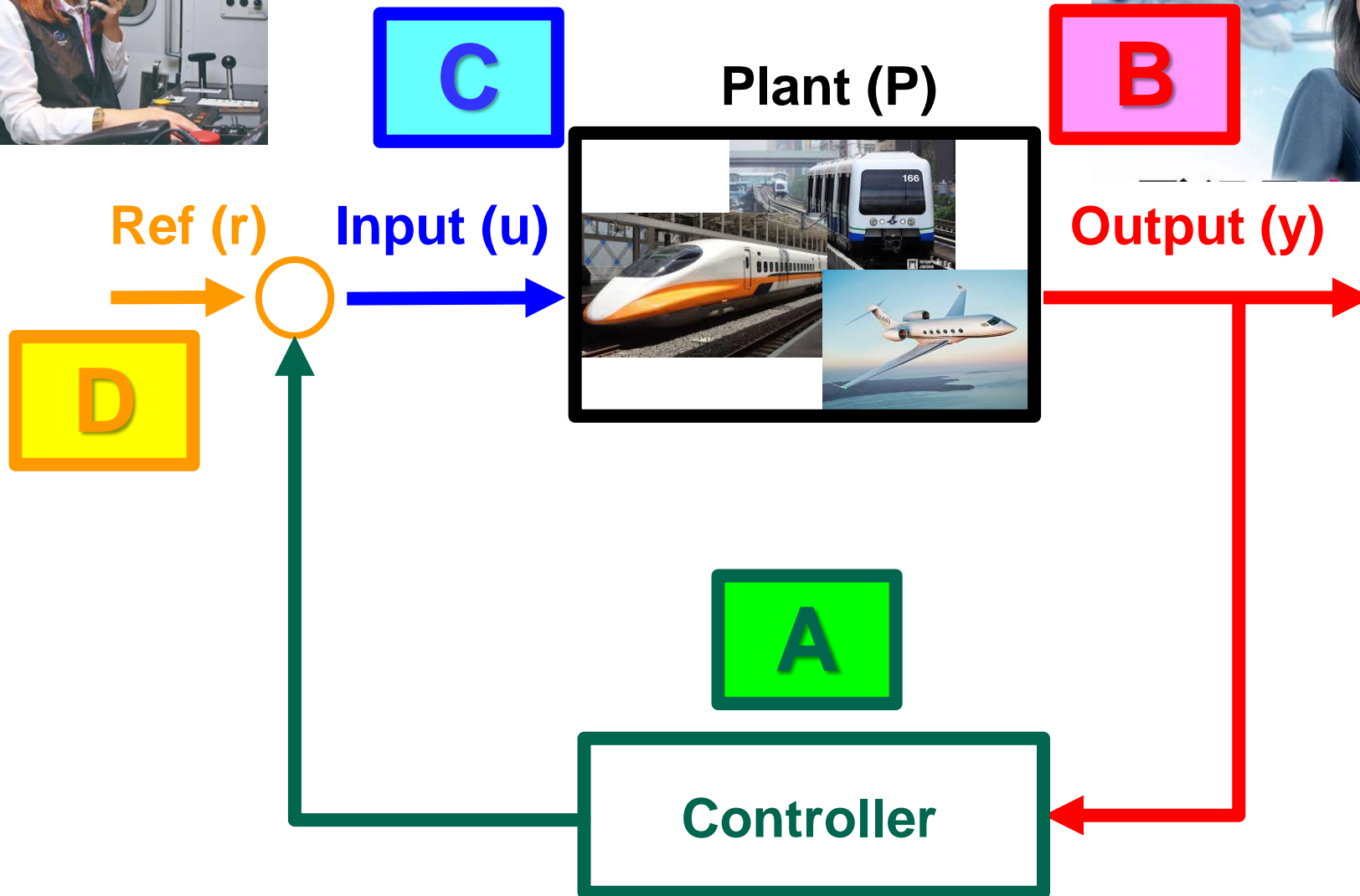
Controller

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

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

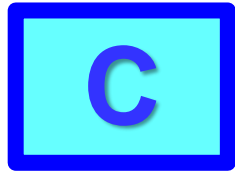
$$G(s) = \frac{Y(s)}{R(s)} = \frac{3}{s^2 + 4s + 3}$$

# Where is the control? Who is the controller?





# Where is the control? Who is the controller?



Plant (P)



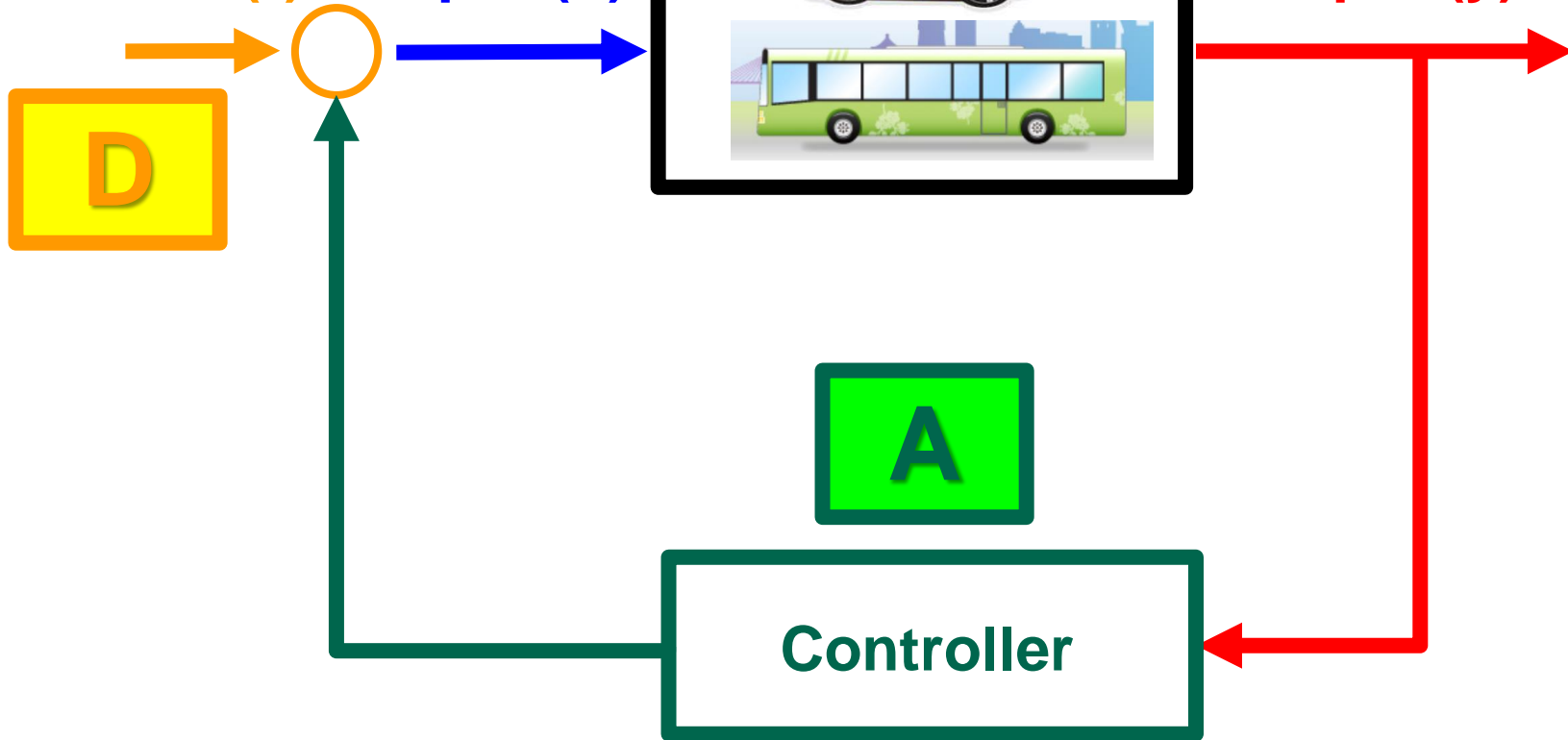
Ref (r)

Input (u)

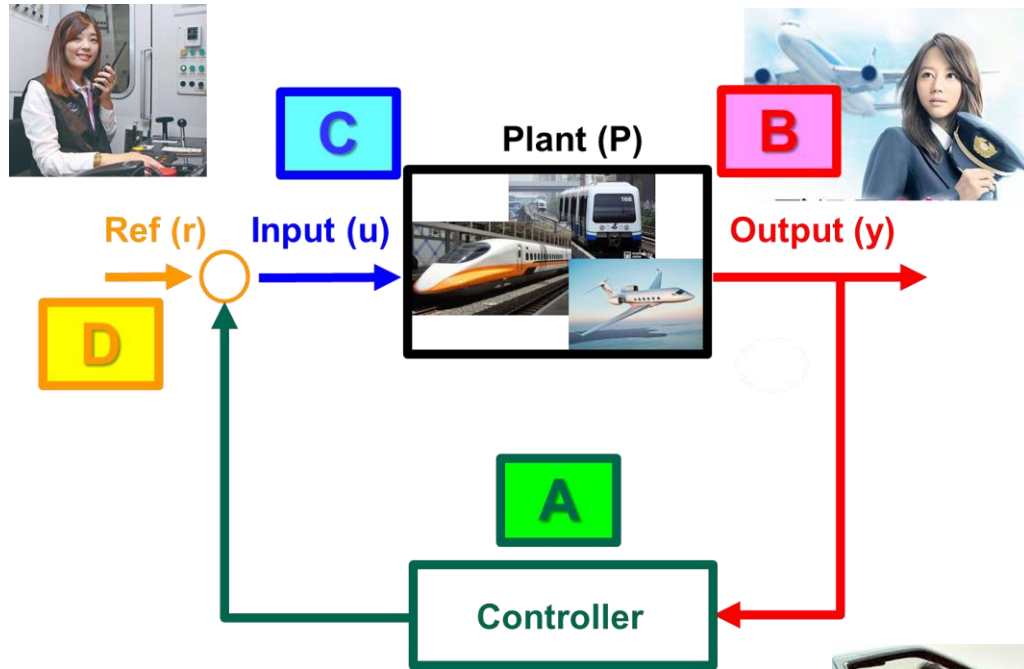
Output (y)



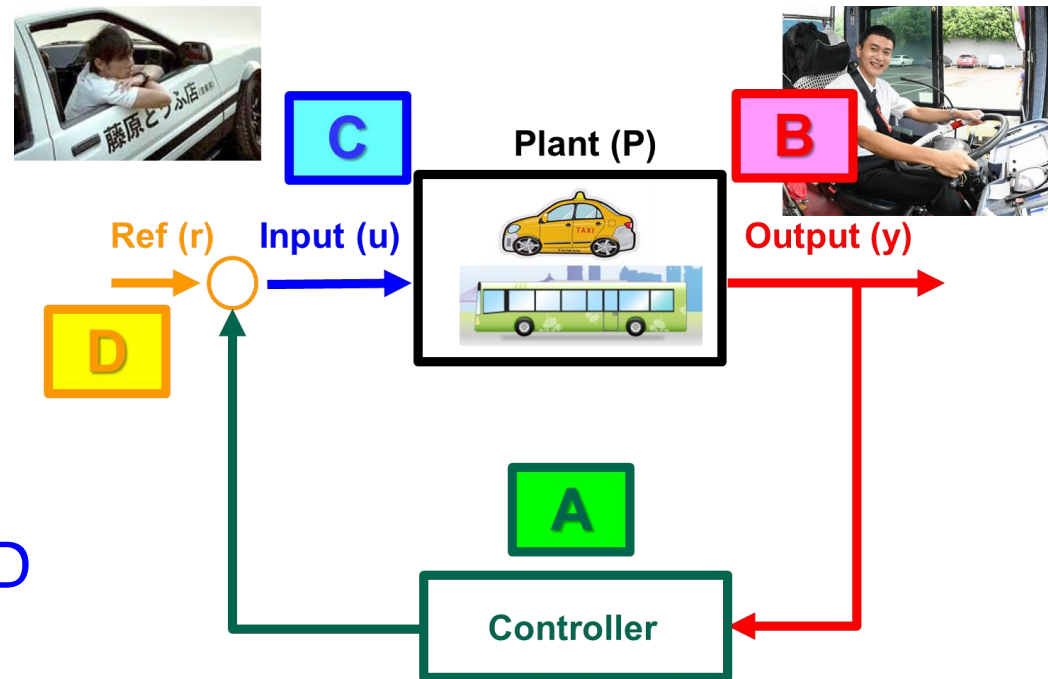
Controller



# Where is the control? Who is the controller?



▪ A, B, C, or D



▪ A, B, C, or D