ECE317 : Feedback and Control

Lecture 1
Introduction

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Outline

- Introduction of the course
  - Automatic control
  - Open-loop system and closed-loop system
  - Goal of the course

What is “Control”?

- Make some object behave as we desire.
- In control engineering, the controlled object is called ***system, or plant, or process***.
- Imagine “control” around you!
  - Room temperature control
  - Car driving, bicycle riding
  - Voice volume control
  - Balance of bank account
  - “Control” (move) the position of the pointer
  - etc.

What is “Automatic Control”?

- Not manual!
- Why do we need automatic control?
  - Convenient (room temperature control, laundry machine)
  - Dangerous (hot/cold places, space, bomb removal)
  - Impossible for human (nanometer scale precision positioning, work inside the small space that human cannot enter, huge antennas control, elevator)
  - It exists in nature. (human body temperature control)
  - High efficiency (engine fuel-injection control)
- Many examples of automatic control around us

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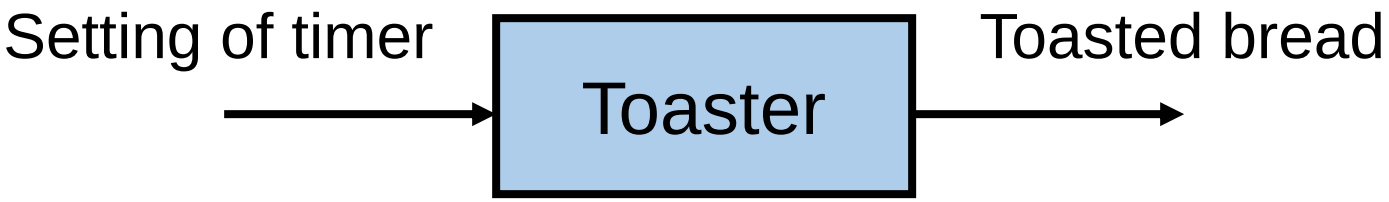
Example: Toaster

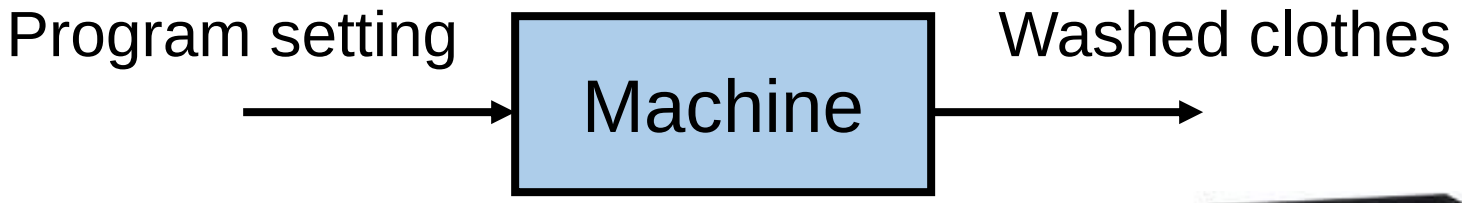
- A toaster toasts bread, by setting timer.



- A toaster does not measure the color of bread during the toasting process.
- What happens if your setting is wrong....
- However, a toaster would be more expensive with:
  - Sensors to measure the color, and
  - Actuators to adjust the timer based on the measured color.

Example: Laundry machine

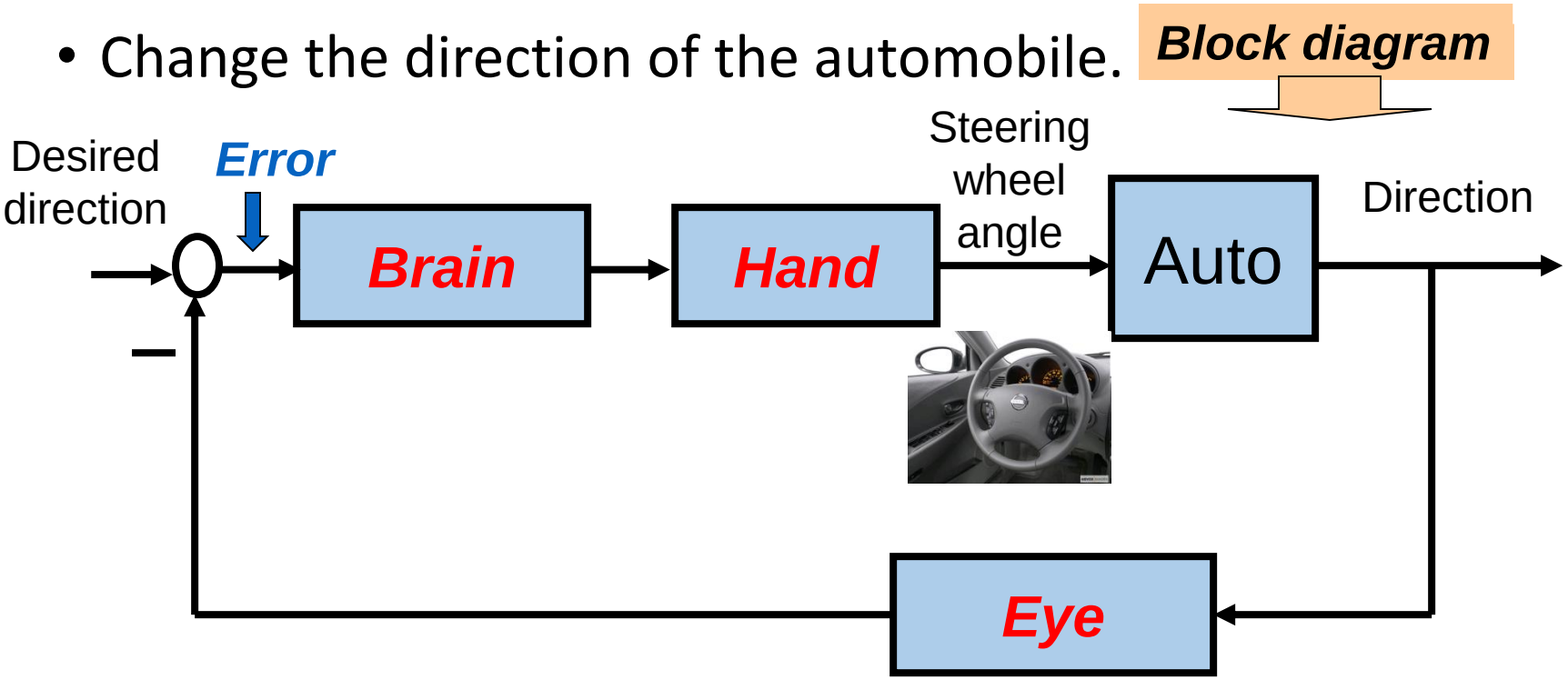
- A laundry machine washes clothes, by setting a program.



- A laundry machine does not measure how clean the clothes become.
- Control without measuring devices (sensors) is called ***open-loop control***.

Ex: Automobile direction control

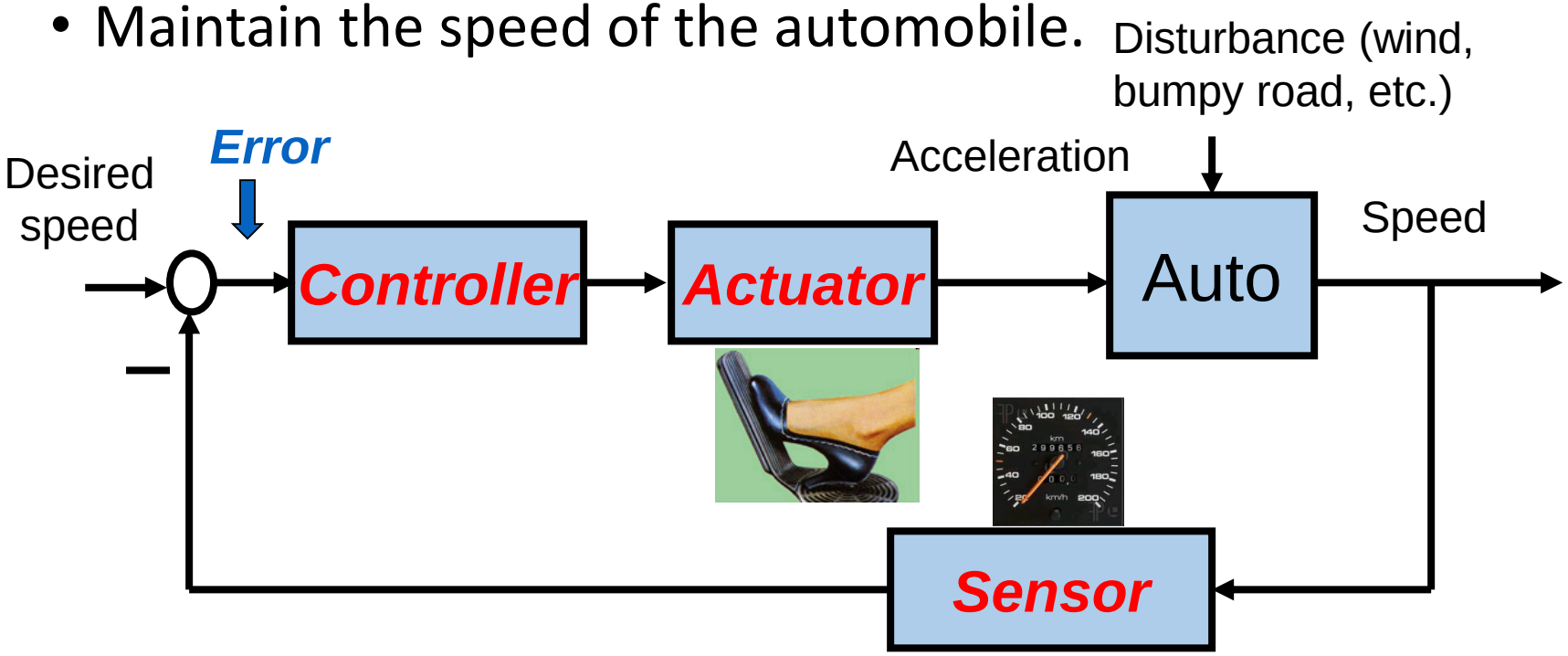
- Change the direction of the automobile.



- Control with measuring devices (sensors) is called ***closed-loop (feedback) control***.
- Manual (not-automatic) control

Ex: Automobile cruise control

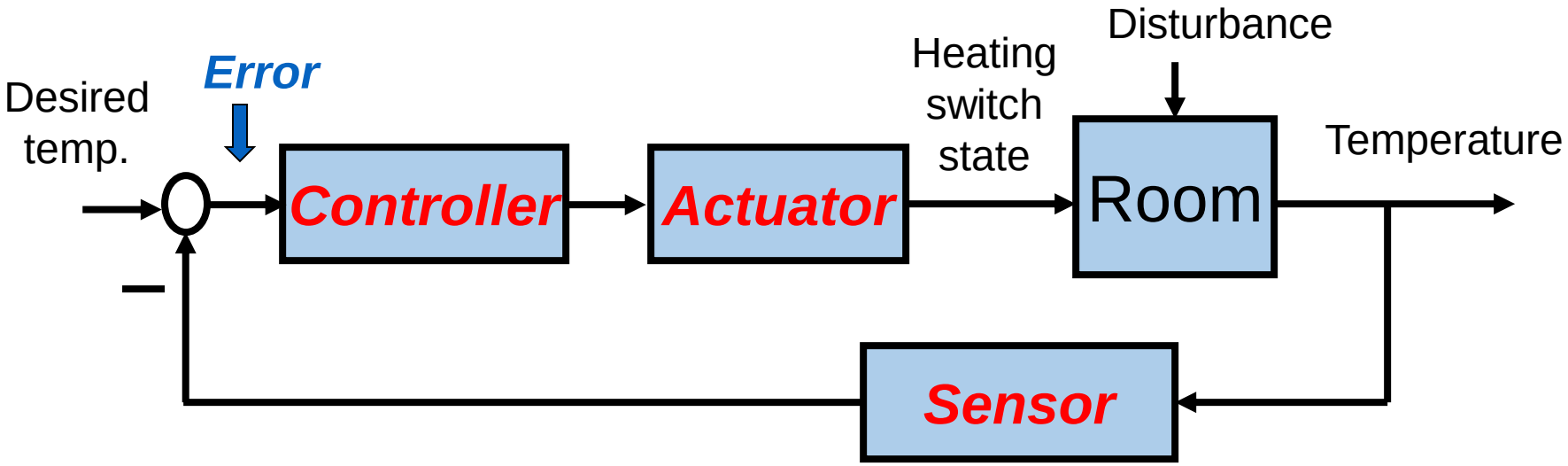
- Maintain the speed of the automobile.



- Cruise control can be both manual and automatic.
- When the controlled system is “Automobile”, ***input*** and ***output*** depend on ***control objectives,*** and not unique!

Ex: Room temperature control

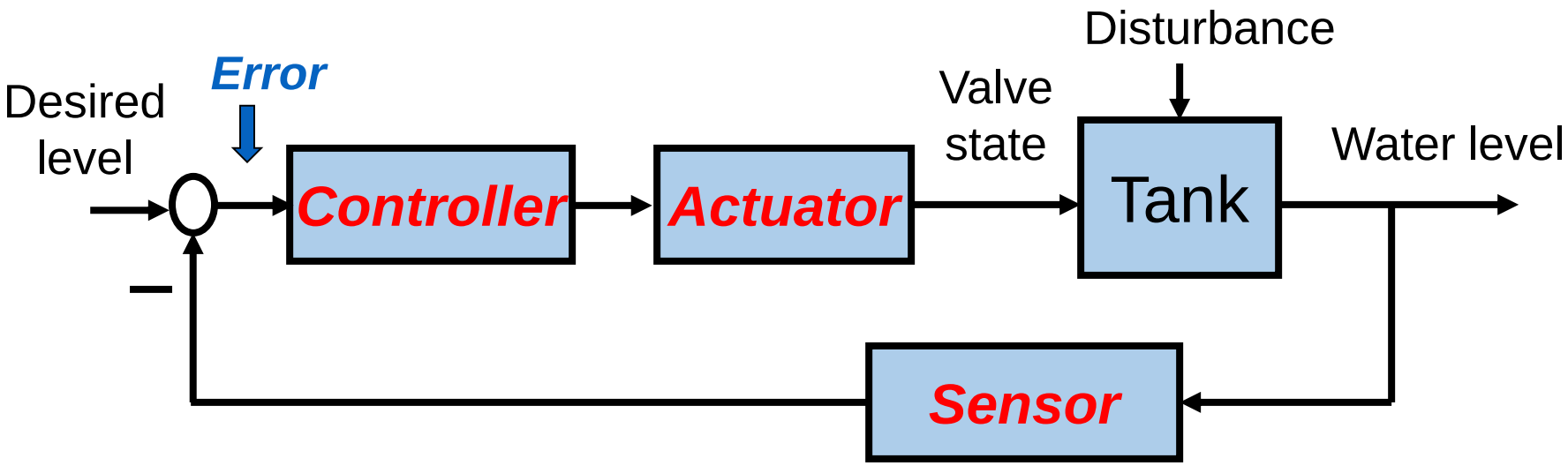
- Maintain the temperature in a room.



- Temperature control can be automatic.
- Note the similarity of the diagram above to the diagram in the previous slides!

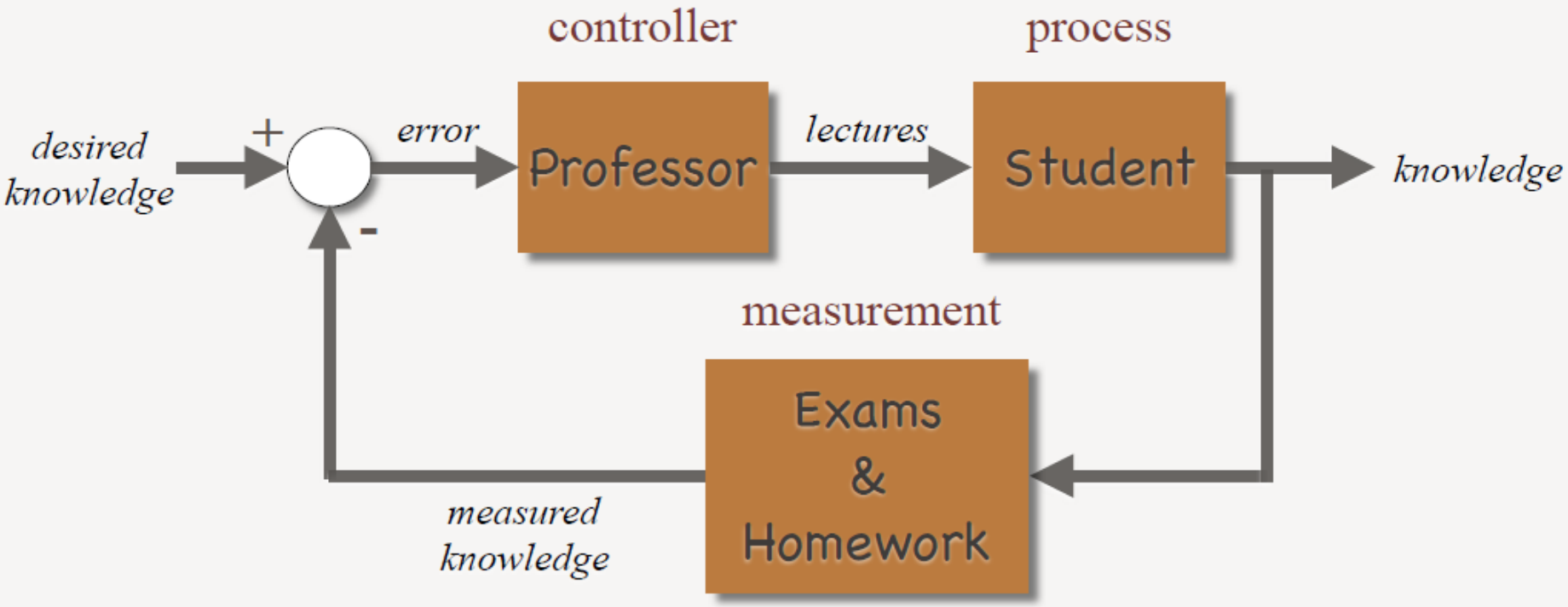
Ex: Water level control

- Maintain the water level in a tank.

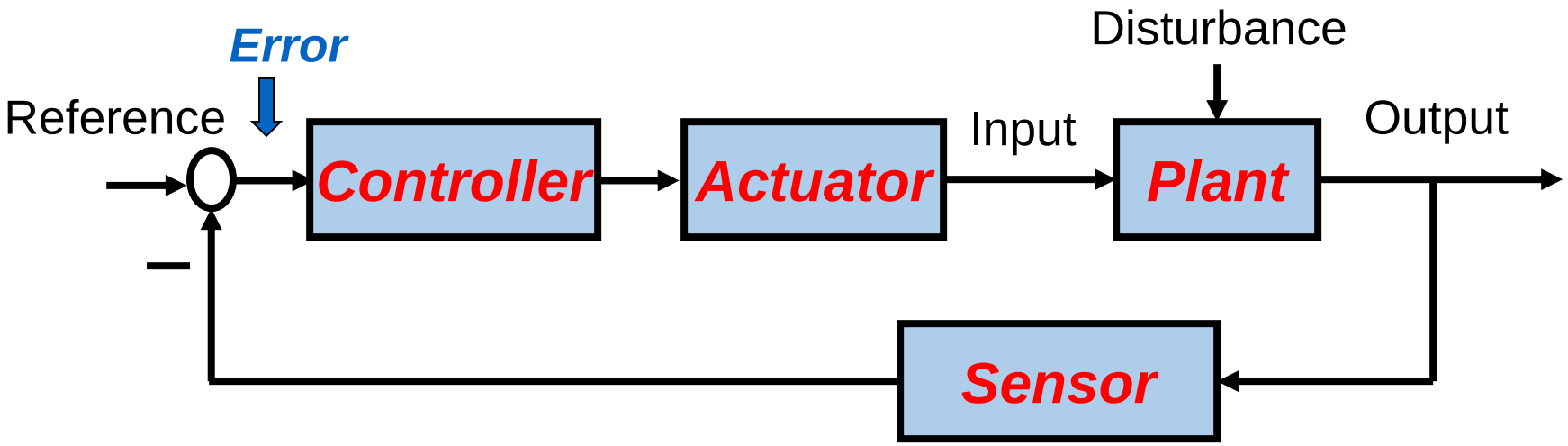


- Water level control can be automatic.
- Other examples : autopilot, catching a ball, etc

THE STUDENT-PROFESSOR LEARNING PROCESS



Automatic feedback control systems: Elements and design objective



- Control system design objective is to design a controller such that the output follows the reference in a "satisfactory" manner even in the face of disturbances.

Features of feedback control

- Advantage: Strong, or robust, against
  - uncertainty
  - unpredictable disturbance
  - variation of plant etc.
- Disadvantage:
  - The action is taken after some undesirable event happens.
  - Stability issues

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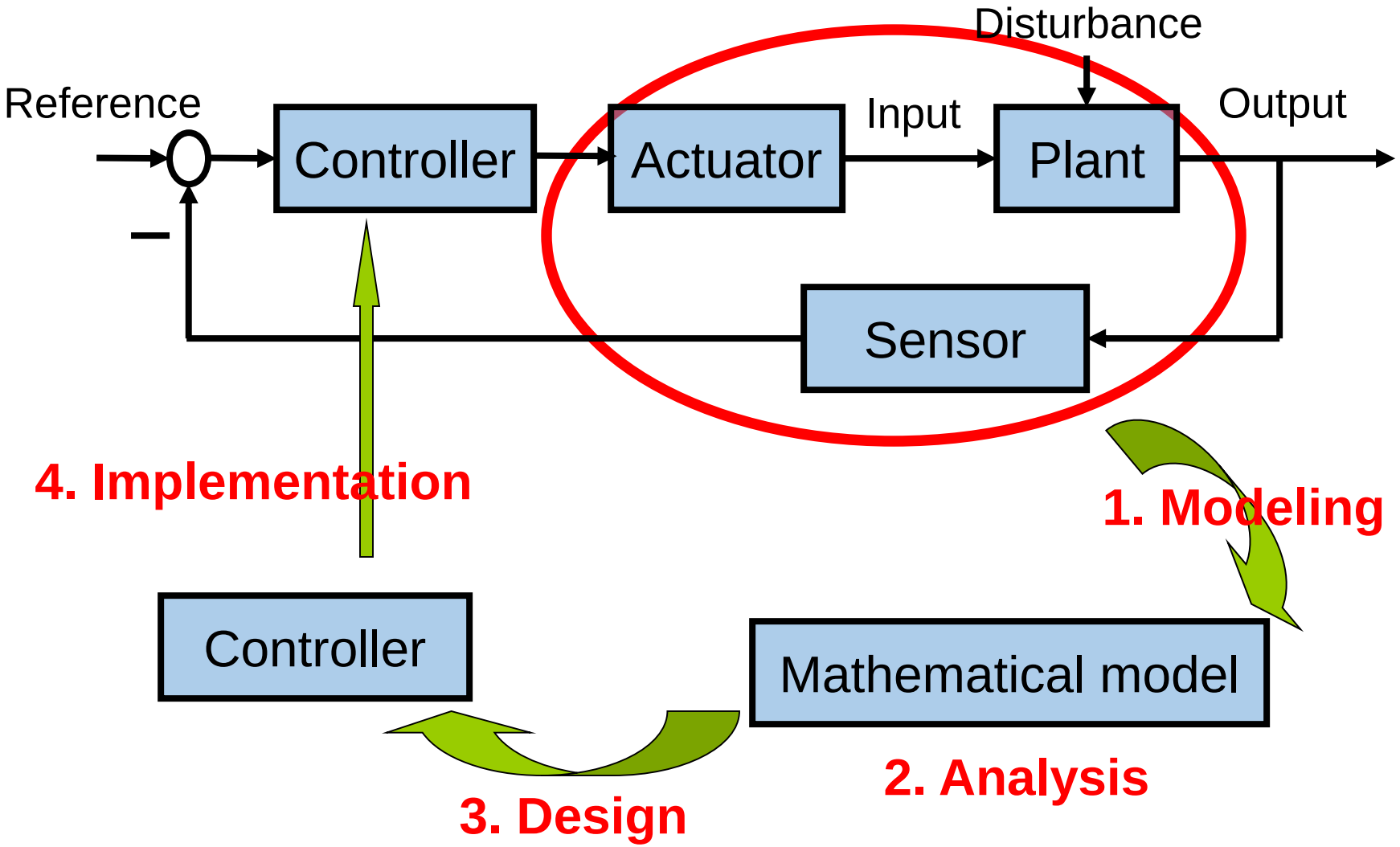
Systematic controller design process



Goal of this course

To learn basics of feedback control systems

- Modeling as a transfer function and a block diagram
  - Laplace transform (Mathematics!)
  - Electrical, mechanical
  - Example system: DC-to-DC switching converter
- Analysis
  - Stability: Pole Locations, Routh-Hurwitz criterion
  - Time response (transient and steady state)
  - Frequency response, Bode diagram
- Design
  - frequency response technique, Bode diagram
  - frequency compensation,

  Theory, simulation with Matlab and PECS, practice in laboratories

Course roadmap

Modeling

Laplace transform

Transfer function

Block Diagram
Linearization

Models for systems
- electrical
- mechanical
- example system

Analysis

Stability
- Pole locations
- Routh-Hurwitz

Time response
- Transient
- Steady state (error)

Frequency response
- Bode plot

Design

Design specs

Frequency domain

Bode plot

Compensation

Design examples

Matlab & PECS simulations & laboratories