# Types of Control System

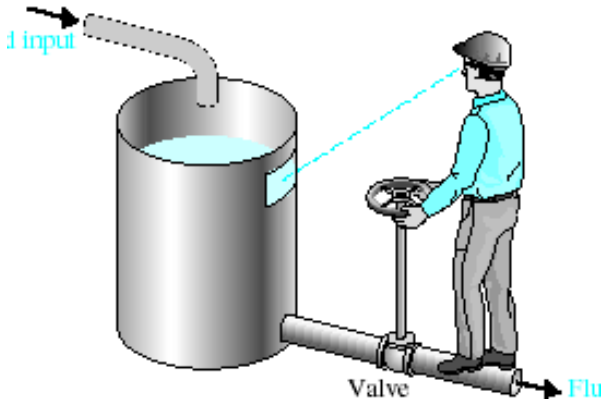
Lec#02

# Types of Control System

- Natural Control System
  - Universe
  - Human Body
- Manmade Control System
  - Vehicles
  - Aeroplanes

# Types of Control System

- Manual Control Systems
  - Room Temperature regulation Via Electric Fan
  - Water Level Control

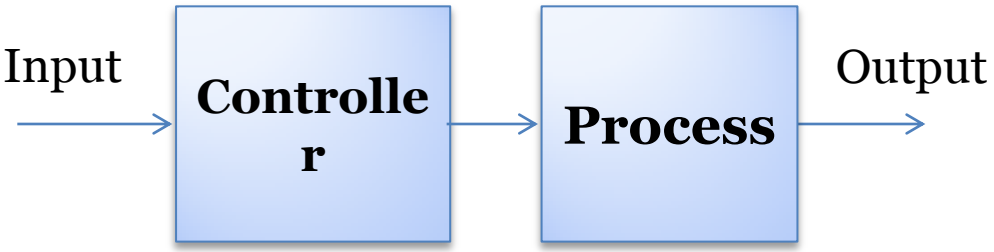



- Automatic Control System
  - Room Temperature regulation Via A.C
  - Human Body Temperature Control

# Types of Control System

**Open-Loop Control Systems** utilize a controller or control actuator to obtain the desired response.

- Output has no effect on the control action. No feedback – no correction of disturbances
- In other words output is neither measured nor fed back.




Open-loop control system (without feedback).

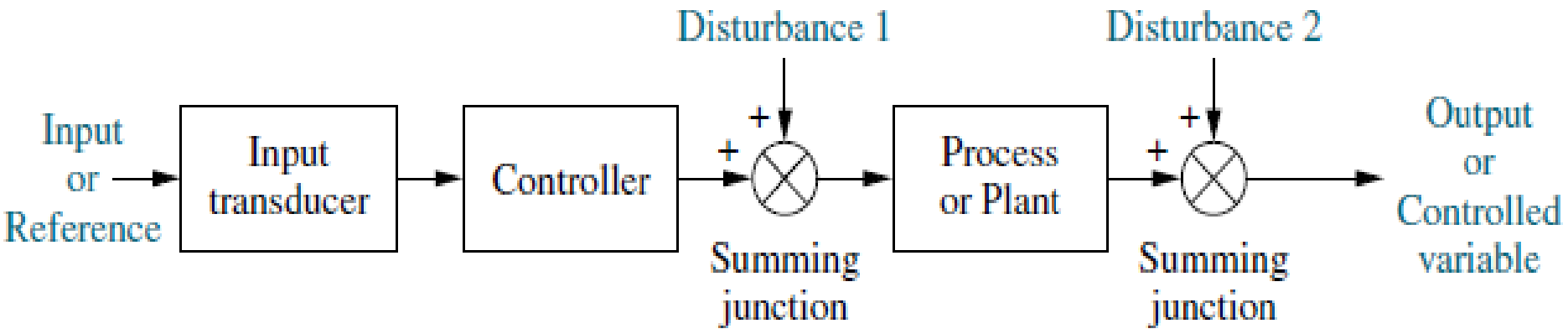
**Examples:- Washing Machine, Toaster, Electric Fan**

# Types of Control System

- Since in open loop control systems reference input is not compared with measured output, for each reference input there is fixed operating condition.
- Therefore, the accuracy of the system depends on calibration.
- The performance of open loop system is severely affected by the presence of disturbances, or variation in operating/ environmental conditions.

# Open-Loop Systems

- A generic open-loop system is shown in Figure.
- It starts with a subsystem called an input transducer, which converts the form of the input to that used by the controller.
- The controller drives a process or a plant.
- The input is sometimes called the reference, while the output can be called the controlled variable.



# Example: Open-loop system

An electric fire used to heat a room

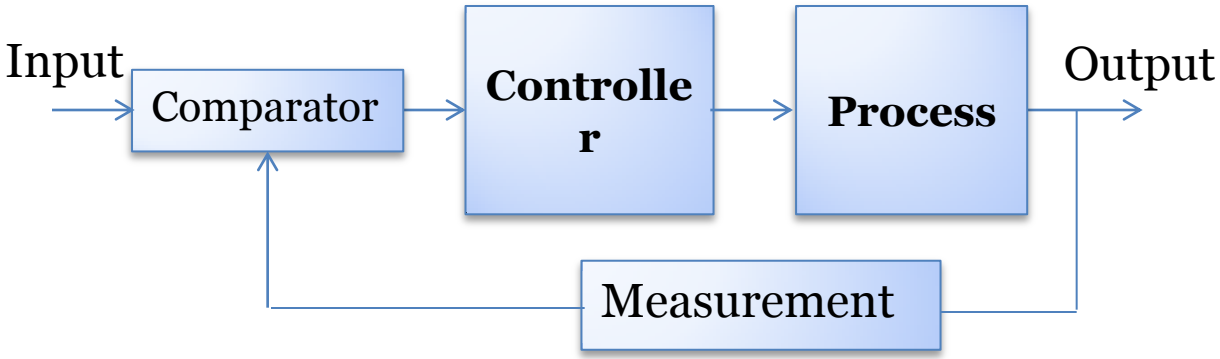
- Controlled variable:  room temperature
- Control element:  the operator
- input:  the switch
- Process:  the room

- Other signals, such as **disturbances** shown are added to the controller and process outputs via summing junctions, which yield the algebraic sum of their input signals using associated signs.

- For example, the plant can be a furnace or air conditioning system, where the output variable is temperature. The controller in a heating system consists of fuel valves and the electrical system that operates the valves.

# Types of Control System

**Closed-Loop Control Systems** utilizes feedback to compare the actual output to the desired output response.

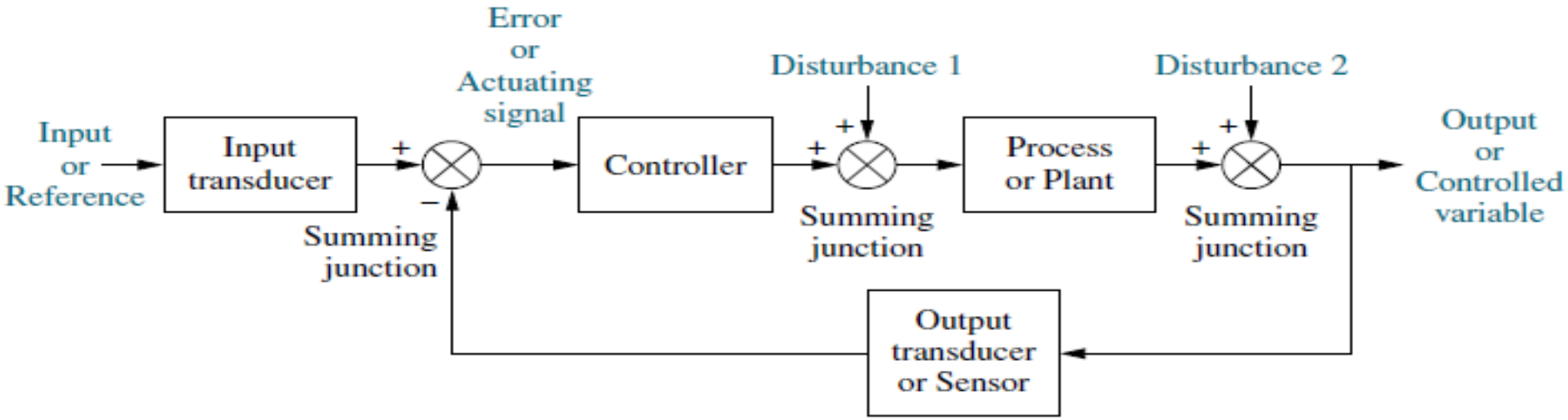



Closed-loop feedback control system (with feedback).

**Examples:- Refrigerator, Iron**

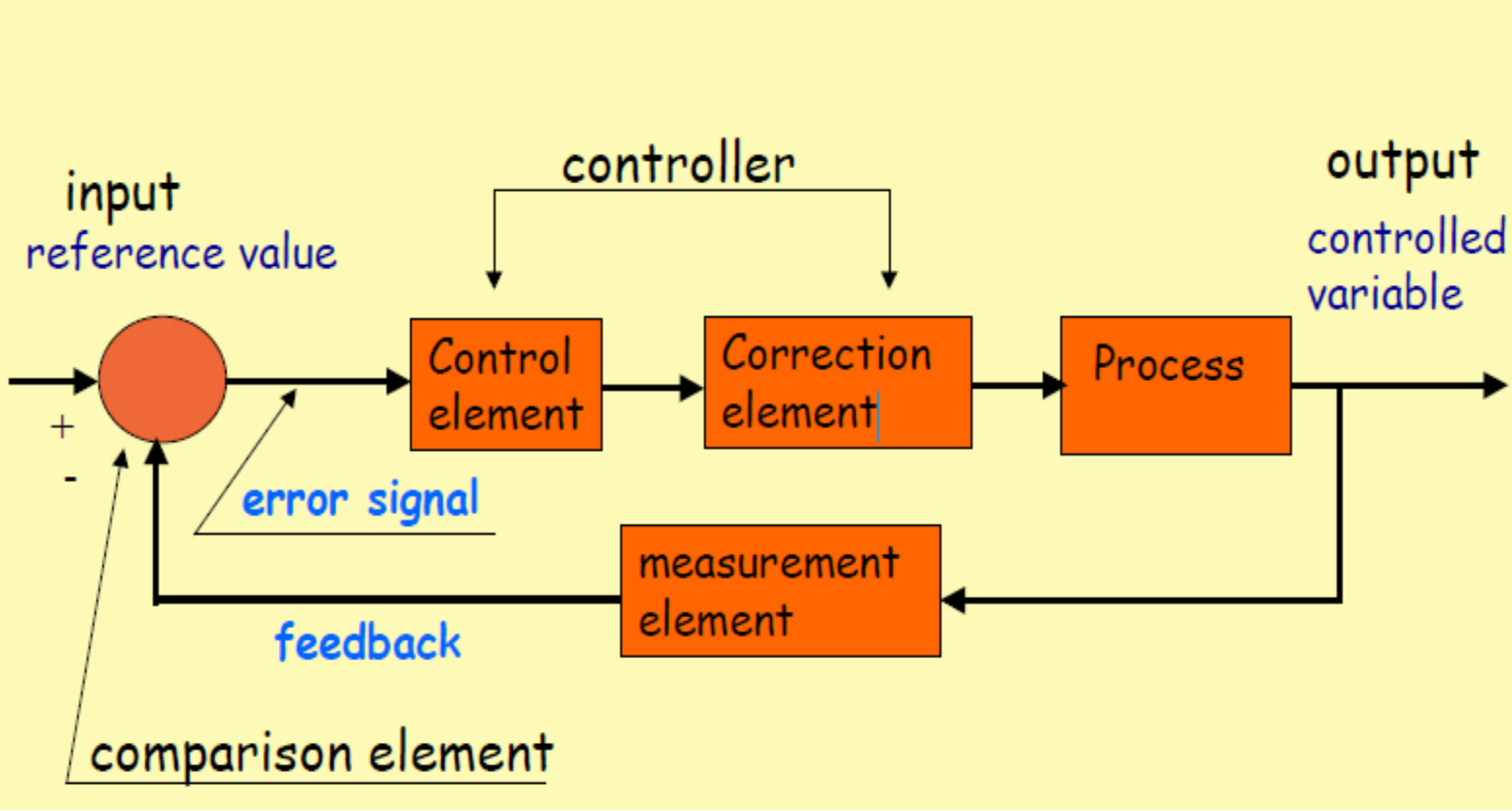
# Closed-Loop (Feedback Control) Systems

- The disadvantages of open-loop systems, namely sensitivity to disturbances and inability to correct for these disturbances, may be overcome in closed-loop systems. The generic architecture of a closed-loop system is shown in Figure.
- The input transducer converts the form of the input to the form used by the controller.



- An output transducer, or sensor, measures the output response and converts it into the form used by the controller.
- For example, if the controller uses electrical signals to operate the valves of a temperature control system, the input position and the output temperature are converted to electrical signals. The input position can be converted to a voltage by a potentiometer, a variable resistor, and the output temperature can be converted to a voltage by a thermistor, a device whose electrical resistance changes with temperature.

# Basic elements of a closed-loop system



**Comparison Element/Actuator**: Compares the reference value with the measured value and produces an error signal.

Error = reference – measured value

**Control element/Controller**: This element decides what action to take when it receives an error signal.

**Process element:** The process or plant is the system of which a variable is being controlled.

**Output transducer/ Measurement element:** This produces a signal related to the variable being controlled and provides the signal fed back to the comparison element to determine if there is an error.

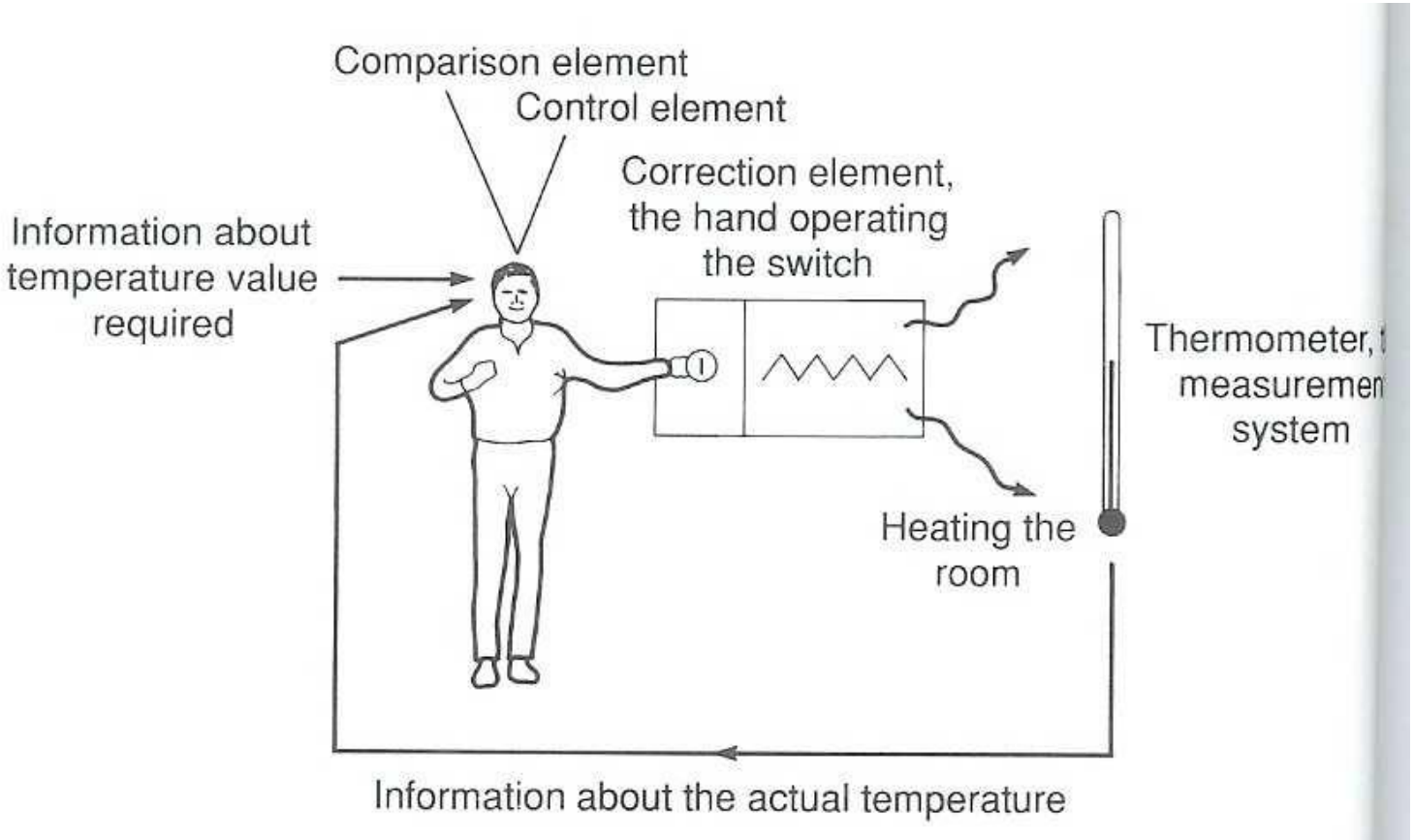
**Feedback**: The feedback can be either positive or negative:

Error signal = reference value + feedback

Error signal = reference value - feedback

# Example of a closed-loop system

- An electric fire used to heat a room with a thermometer indicating the current room temperature



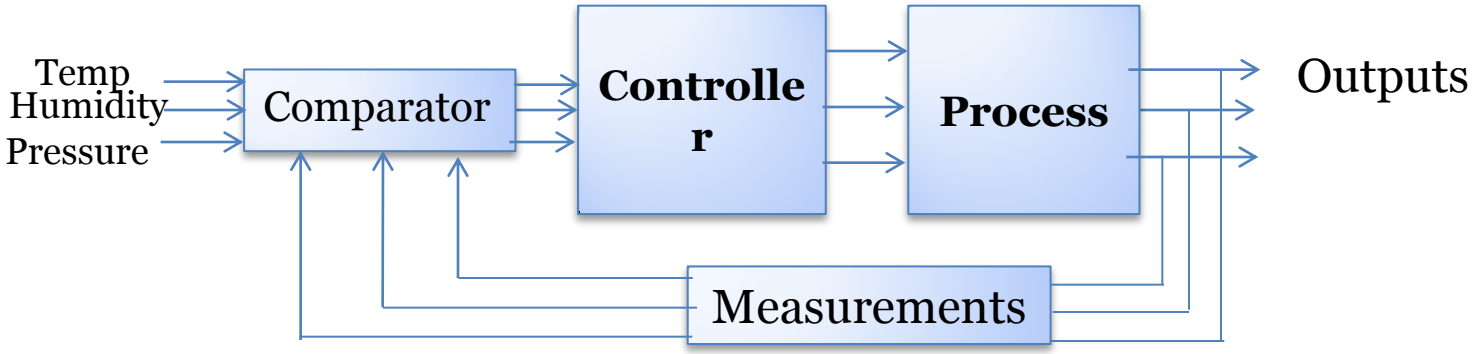
# Identify the following in above example

- Controlled variable:
- Reference value:
- Comparison element:
- Error signal:
- Control element:
- Correction element:
- Process:
- Measuring device:

- Controlled variable: the room temperature
- Reference value: the required room temperature
- Comparison element: the operator
- Error signal: the difference between measured and required temperature
- Control element: the operator
- Correction element: the hand of the operator
- Process:  the room
- Measuring device: the thermometer

# Types of Control System

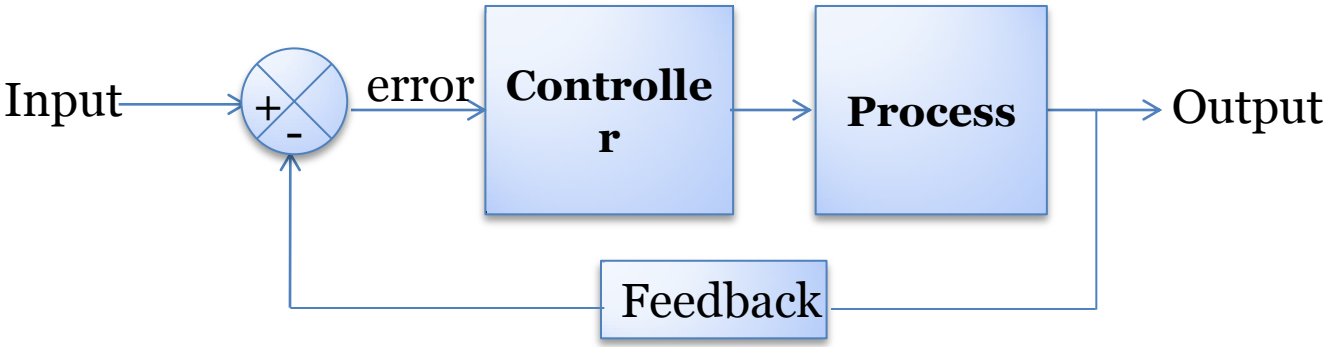
**Multivariable Control System**



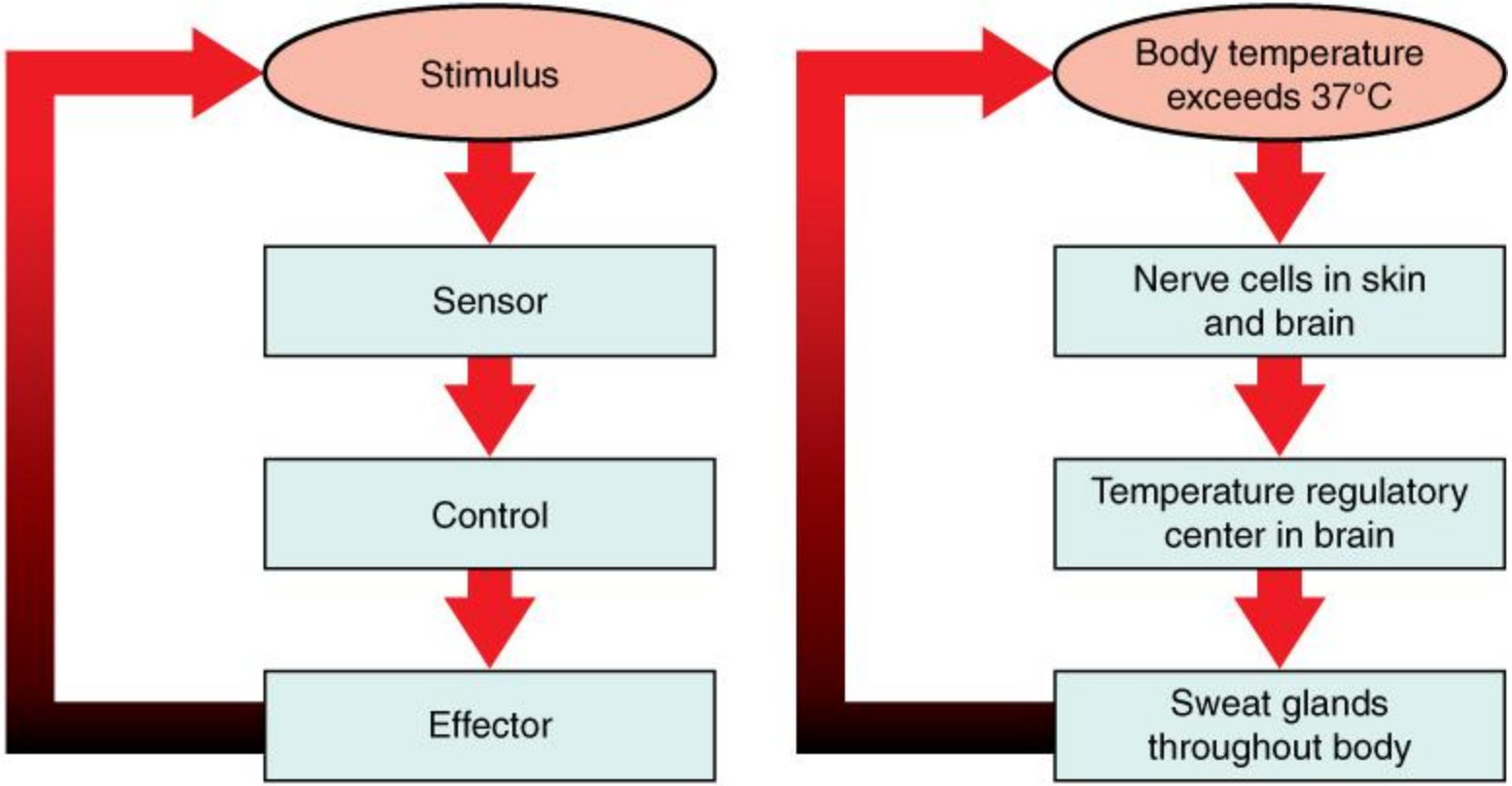
# Types of Control System

**Feedback Control System**

- A system that maintains a prescribed relationship between the output and some reference input by comparing them and using the difference (i.e. error) as a means of control is called a feedback control system.




- Feedback can be positive or negative.



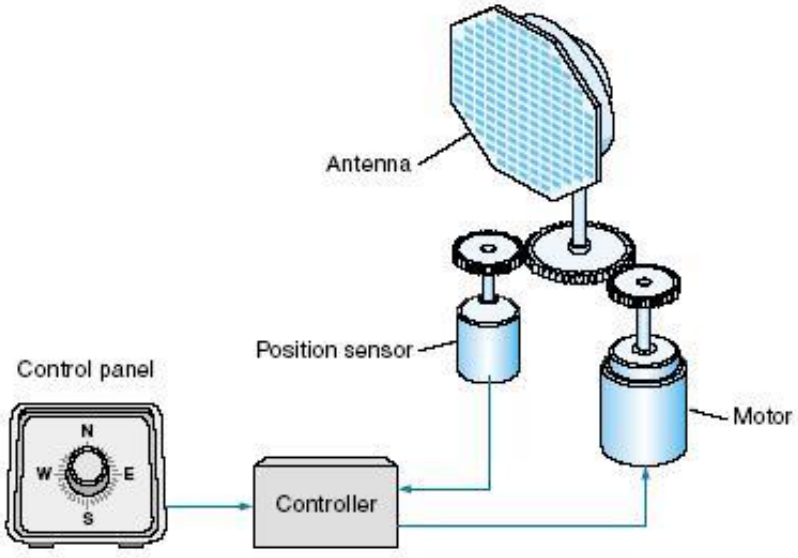

(a) Negative feedback loop

(b) Body temperature regulation

# Types of Control System

**Servo System**

- A Servo System (or servomechanism) is a feedback control system in which the output is some mechanical position, velocity or acceleration.



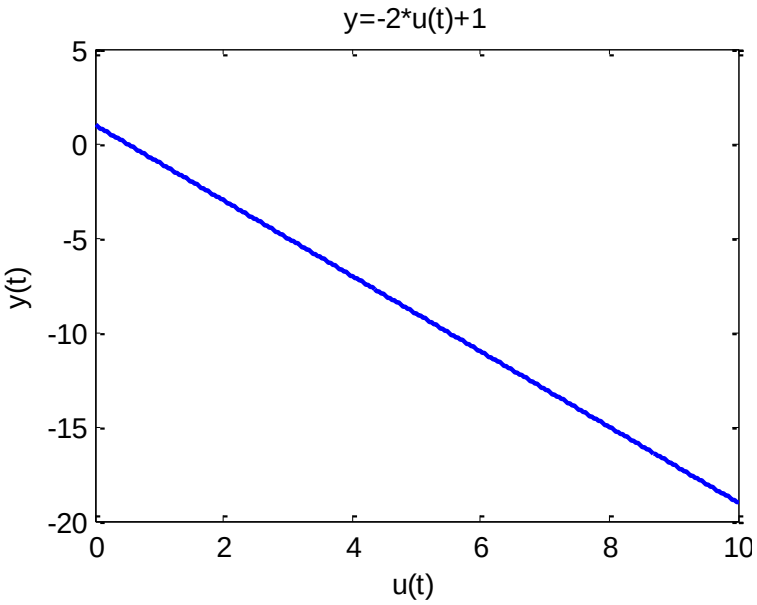

Antenna Positioning System

# Types of Control System

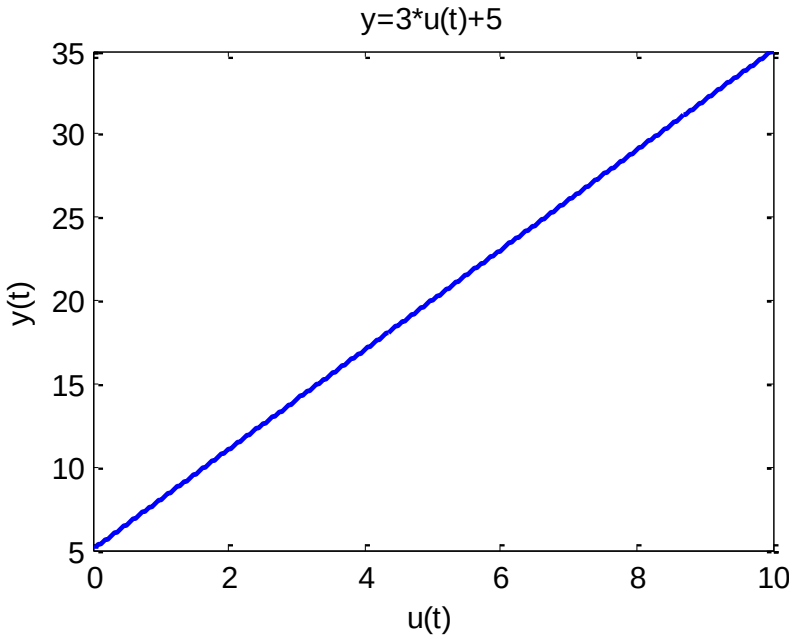
**Linear vs. Nonlinear Control System**

- A Control System in which output varies linearly with the input is called a linear control system.


$$y(t) = -2u(t) + 1$$



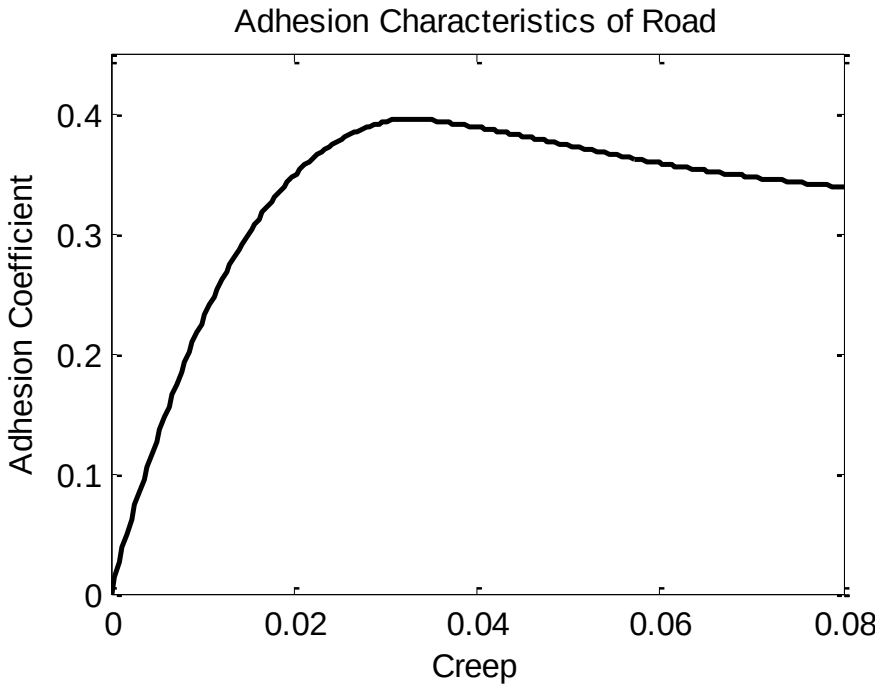

$$y(t) = 3u(t) + 5$$



# Types of Control System

**Linear vs. Nonlinear Control System**

- When the input and output has nonlinear relationship the system is said to be nonlinear.



# Types of Control System

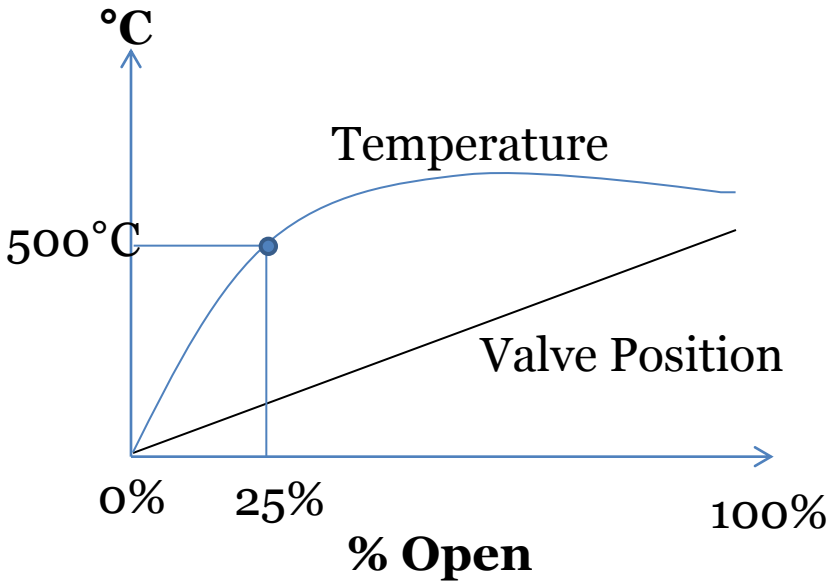
**Linear vs. Nonlinear Control System**

- Linear control System Does not exist in practice.
- Linear control systems are idealized models fabricated by the analyst purely for the simplicity of analysis and design.
- When the magnitude of signals in a control system are limited to range in which system components exhibit linear characteristics the system is essentially linear.

# Types of Control System

**Linear vs. Nonlinear Control System**

- Temperature control of petroleum product in a distillation column.



# Types of Control System

**Time invariant vs. Time variant**

- When the characteristics of the system do not depend upon time itself then the system is said to be time invariant control system.

$$y(t) = -2u(t) + 1$$

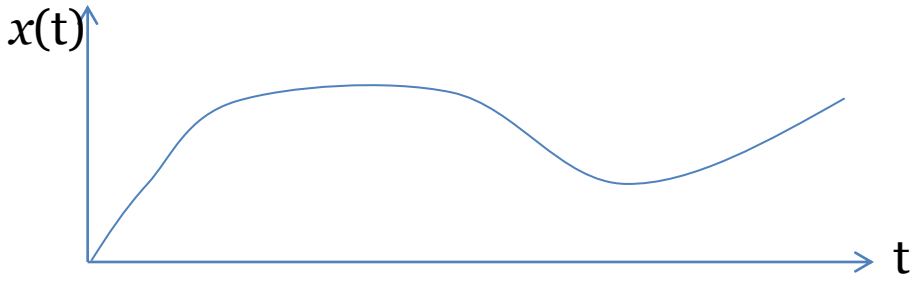
- Time varying control system is a system in which one or more parameters vary with time.

$$y(t) = 2u(t) - 3t$$

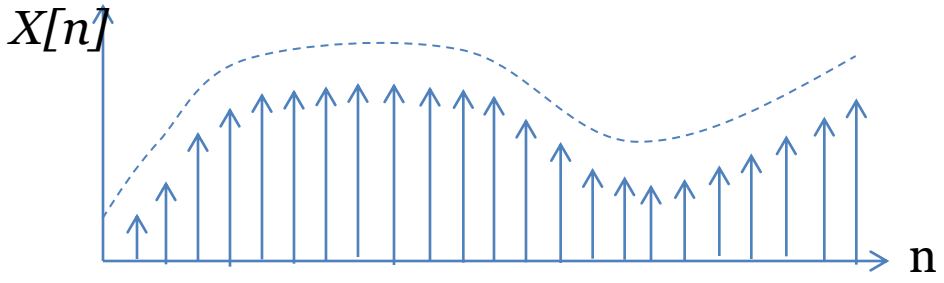
# Types of Control System

**Continuous Data vs. Discrete Data System**

- In continuous data control system all system variables are function of a continuous time t.



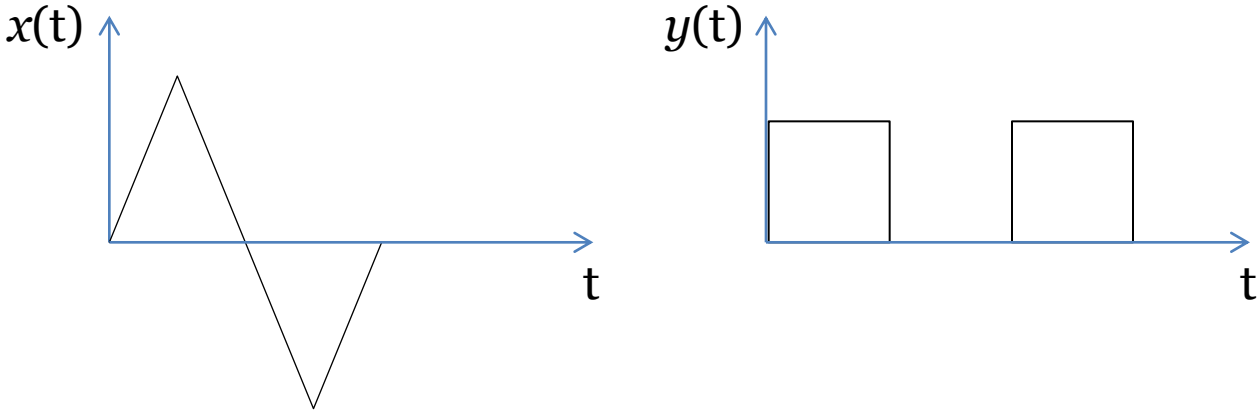

- A discrete time control system involves one or more variables that are known only at discrete time intervals.



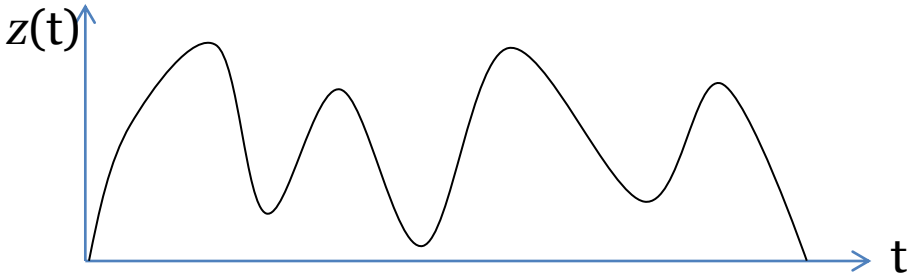
# Types of Control System

**Deterministic vs. Stochastic Control System**

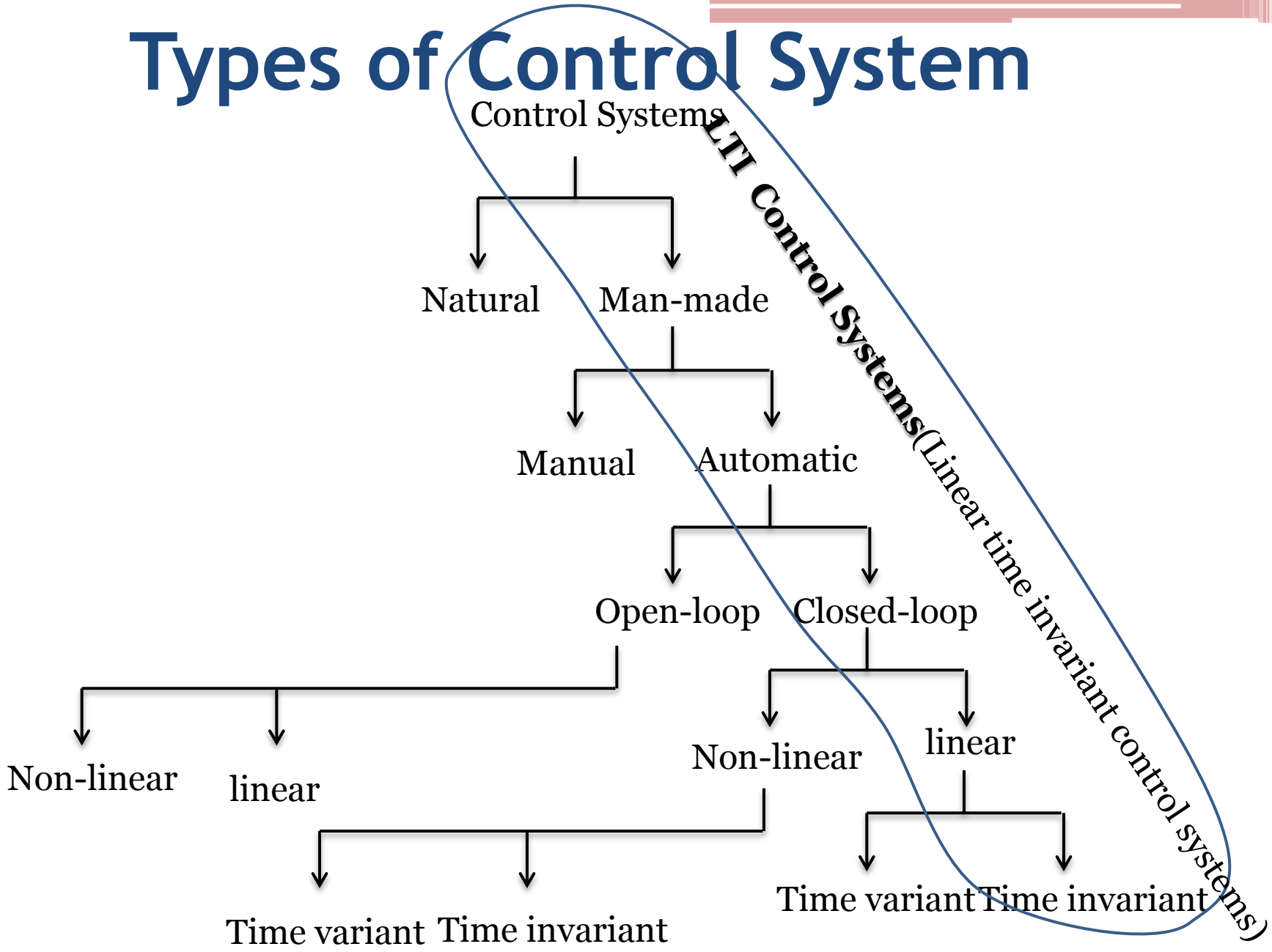
- A control System is deterministic if the response to input is predictable and repeatable.




- If not, the control system is a stochastic control system.



# Types of Control System



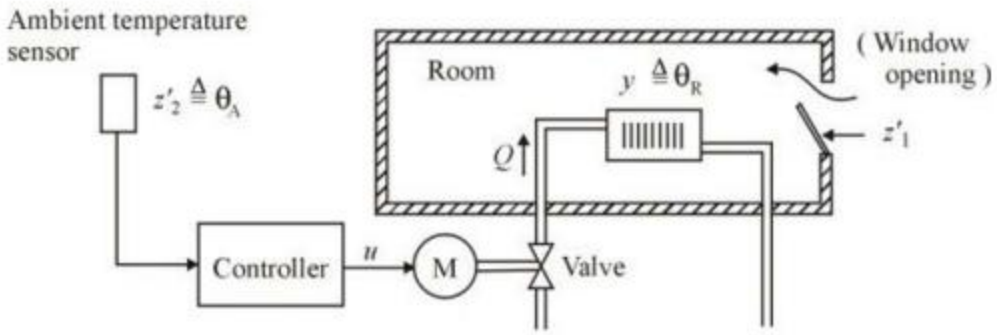



Figure 5. Open-loop room temperature control system

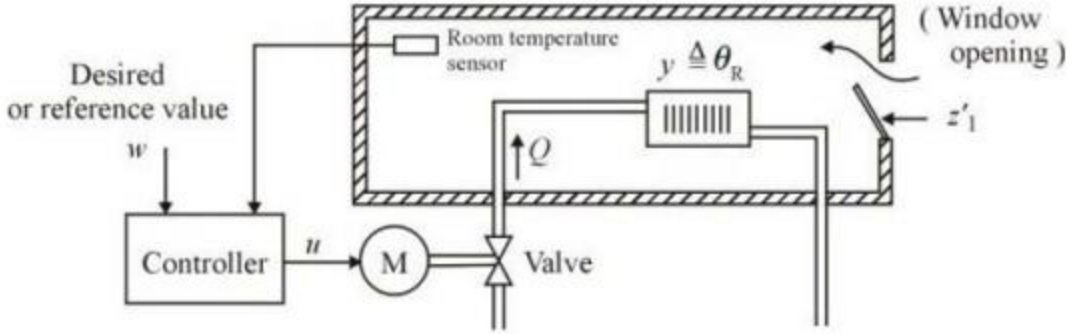



Figure 7. Closed-loop room temperature control system.