Analysis & Design of Physiological Control systems

BIEN 403

Course Description

Definition of Control Systems

Classification of Control Systems

Course Description

Prerequisites

Concept

Text Books

Course Policies

Grading

Attendance Regulations

Office Hours

Definition

A System

- When a number of elements or components are connected in a sequence to perform a specific function, the group formed is called a **system.**

A control system????????

- In the system, when the output quantity is controlled by varying the input quantity, then the system is called a control system.

Brief History

Feedback control is an engineering discipline. As such, its progress is closely tied to the practical problems that have evolved during history.

The key developments in the history of mankind that affected the progress of feedback control were:

1. The preoccupation of the Greeks and Arabs with keeping accurate track of time.
2. The Industrial Revolution in Europe.
3. The beginning of mass communication and the First and Second World Wars.
4. The beginning of the space/computer age in 1957

Applications

- It evolved as an engineering discipline and due to the universality of the principles involved, it has been extended to various fields like economics, sociology, biology, medicine etc.
- It has played a vital role in the advancement of engineering and science.
- It has become an integral part of the modern manufacturing and industrial processes.

Brief History of Physiological Control

The concept of physiological regulation dates back to ancient Greece (around 500BC) where the human body was considered a small replica of the Universe.

Regulatory systems were defined in more precise terms by French Physiologist ***Claude Bernard*** (19th Century)

Harvard Physiologist ***Walter Cannon*** coined the word ***Homeostasis*** to describe the maintenance of relatively constant physiological conditions

Wiener, in 1940s explored the notion of feedback to a greater level of detail, mindful that most of the physiological systems are nonlinear, he laid a foundation for modeling the non linear dynamics. He coined the word **Cybernetics.**

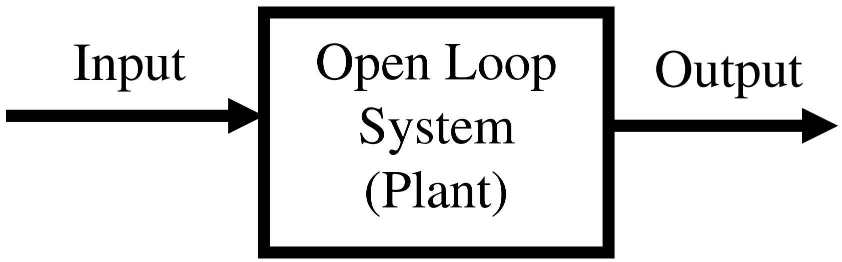
Classification of Control systems

The control systems can be classified as

- Open Loop system and
- Closed loop system

Open Loop Control Systems

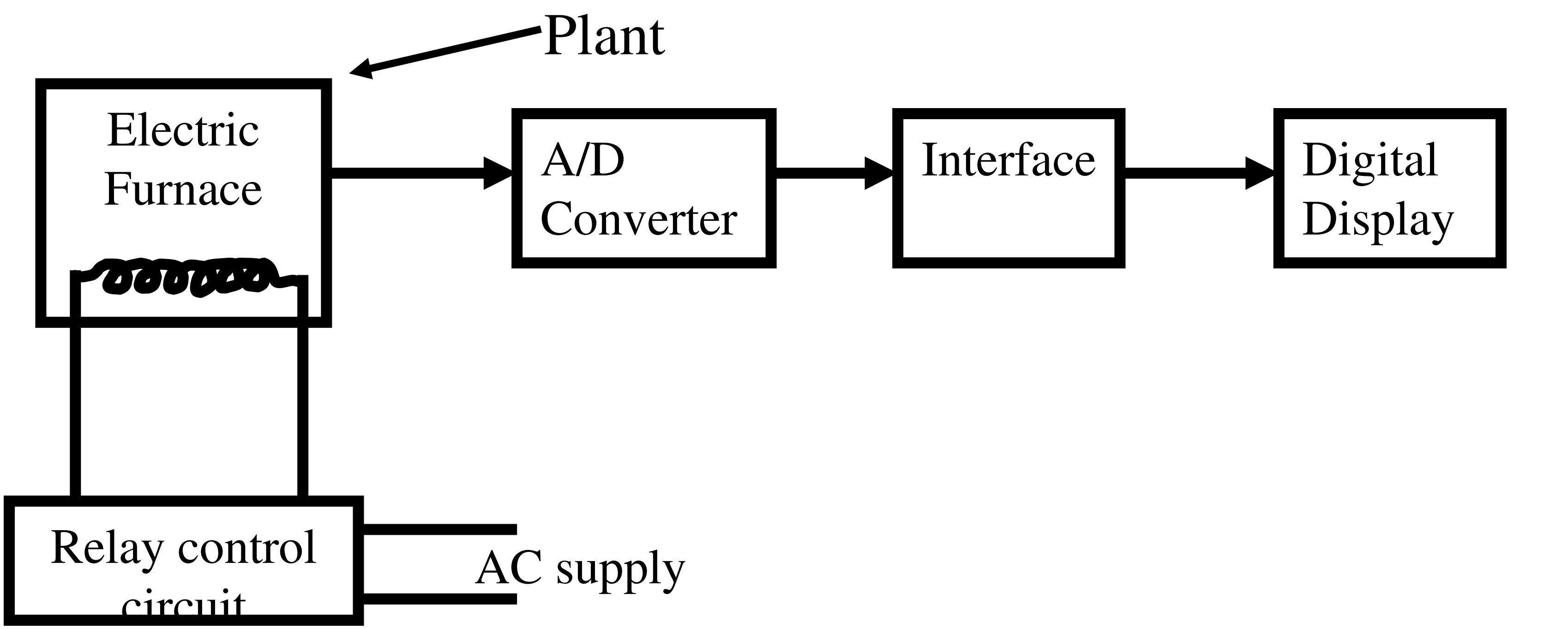
- Any physical system which does not automatically correct the variation in its output is called an open loop control system



- In other words a system in which the variation in the output does not have any effect on the input quantity is called an open loop control system.
- In an open loop system the changes in the output are corrected by changing the input manually

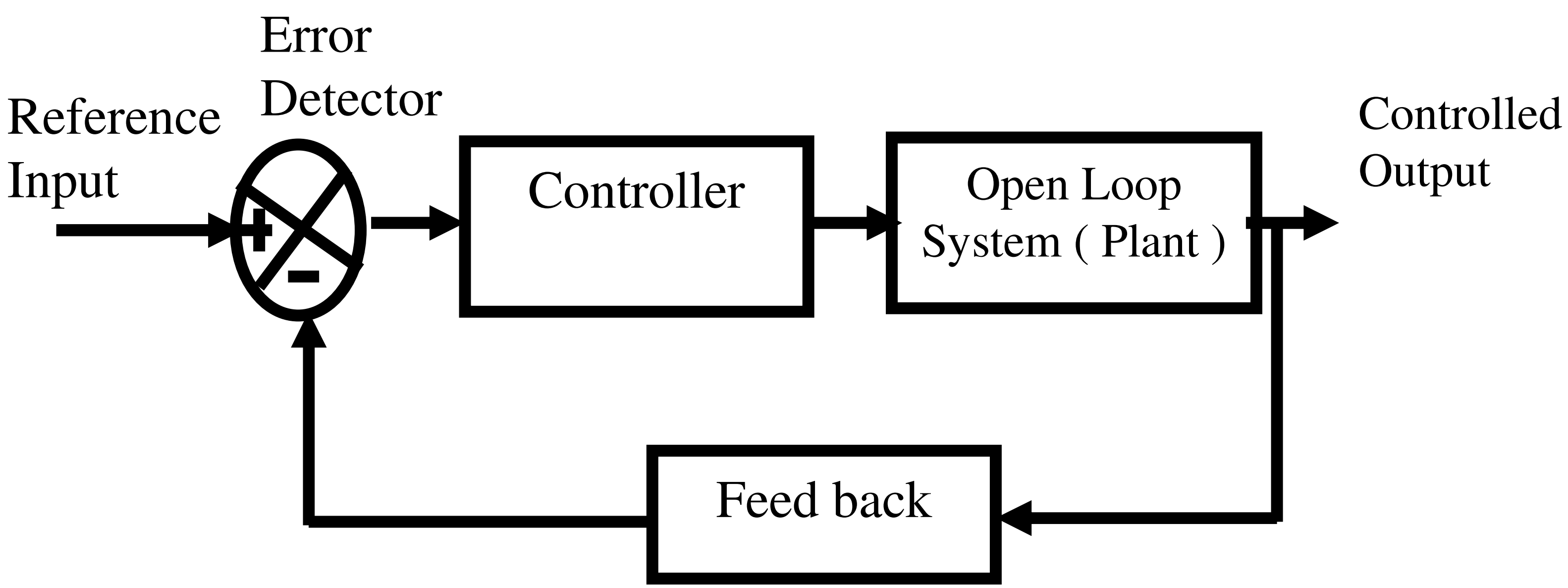
Example of a Open Loop system

- Temperature Control system

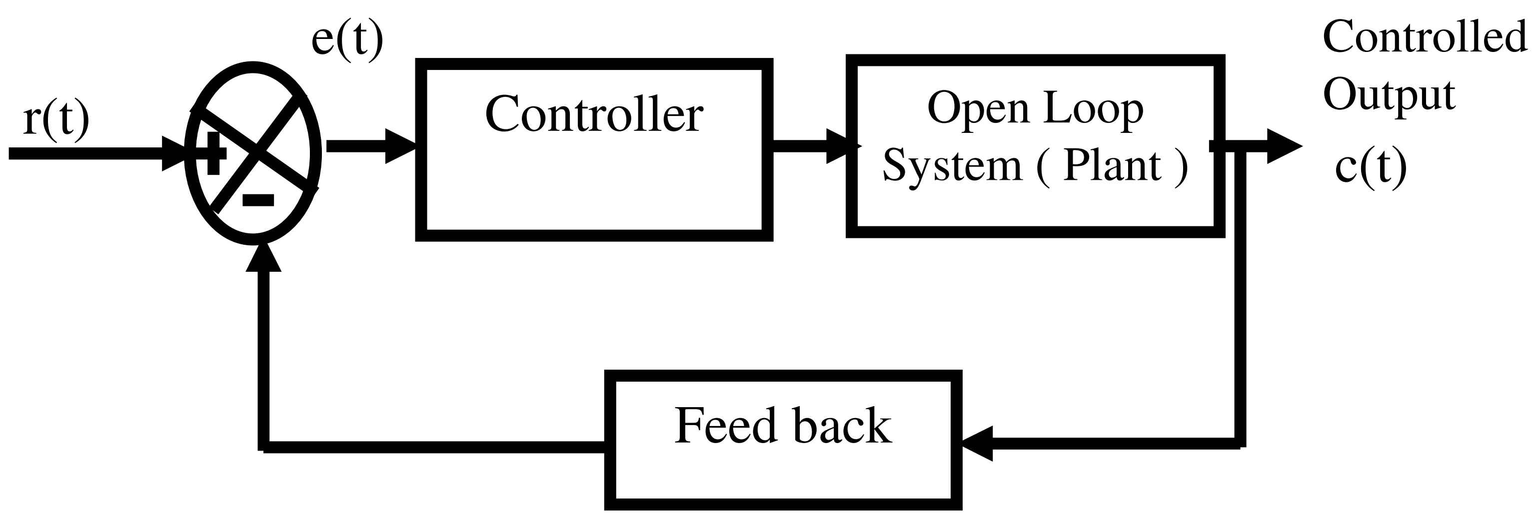


Closed Loop Control Systems

- Control systems in which the output has an effect on the input quantity in such a manner as to maintain the desired output value are called closed loop control systems



General Representation of an Automatic control system

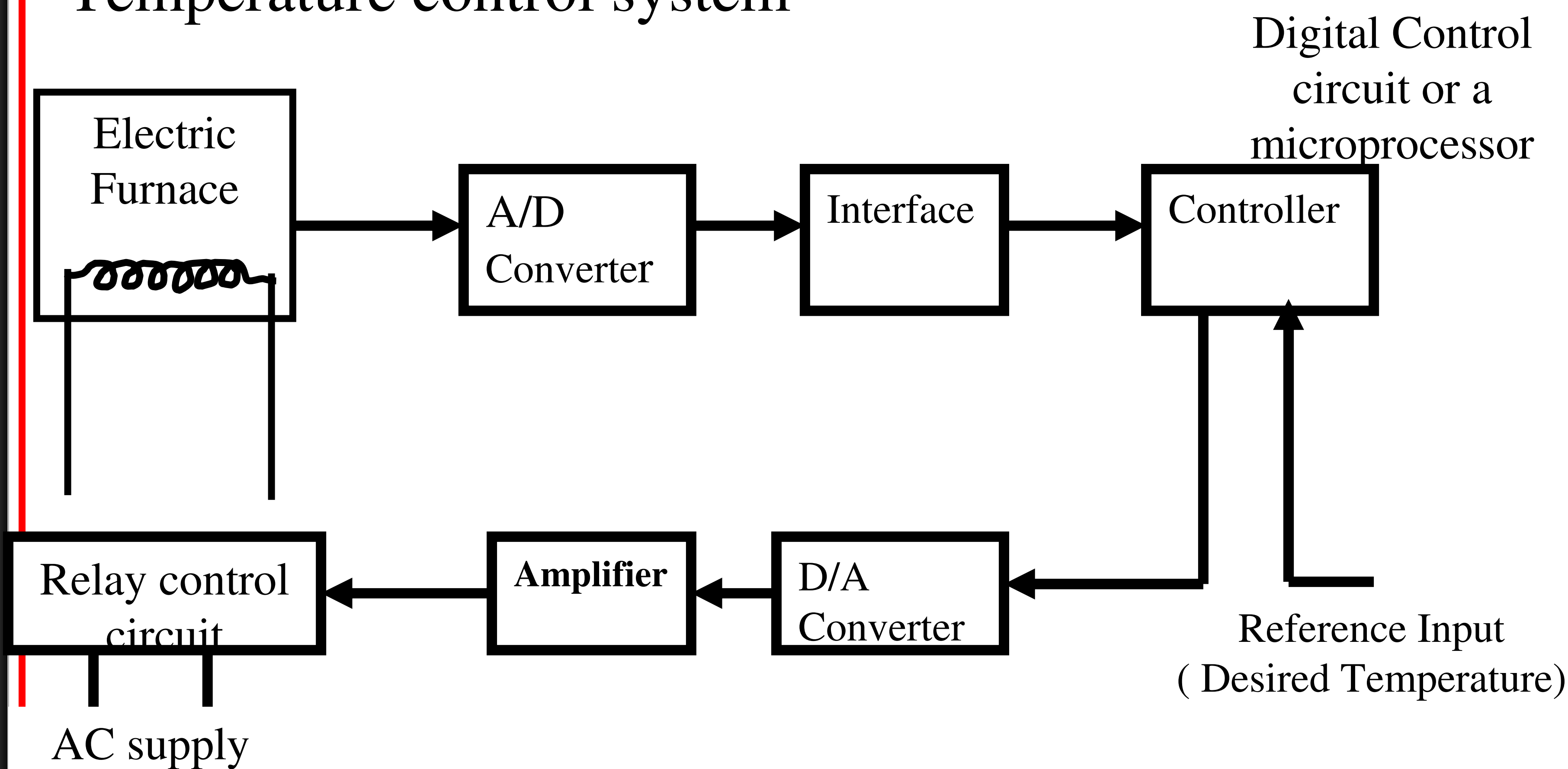


r(t) Reference Input
c(t)Controlled Output

e(t) Error signal

Example of a Closed loop control system

Temperature control system



Simple Physiological Examples Of Open Loop & Closed Loop

- Thermo regulatory control in *Poikilothermic* animals.
- Cold Blooded Animals thermo control is an open loop control while it is a closed loop control in the warm blooded animals (homeothermic)
- Homeostasis i.e, Maintenance of the relatively constant physiological conditions

Pros & Cons of the Open Loop control systems

Pros

- Simple & Economical
- Easier to construct
- On or Off

Cons

- Inaccurate
- unreliable
- The changes in the output due to the external disturbances are not corrected automatically

Pro & Cons of the Automatic control systems

Pros

- Accurate even in the presence of the non-linearity and the external disturbances

Cons

- Complex and costlier
  - may become unstable due to the feedback involved
- The feedback (mostly uses negative feedback) may reduce the overall gain of the system.

Are Physiological Control and the Engineering control the same??????

Partly Yes because the methodology of system analysis can be applied to both the the physiological and engineering control systems.

During the first part of the course we devote much time on the methodology of systems analysis

And No?????? Any differences???????

Differences between the Physiological and Engineering control system

- An engineering control system is designed to accomplish a given task
  - Physiological systems are versatile and capable of serving different functions
- Engineering control has components that are generally known to the designer
  - Physiological control systems usually consists of components that are unknown and difficult to analyze

Differences between the Physiological and Engineering control system

- Physiological systems are adaptive

- Physiological systems have an extensive degree of cross coupling

Classification Of Automatic Control systems

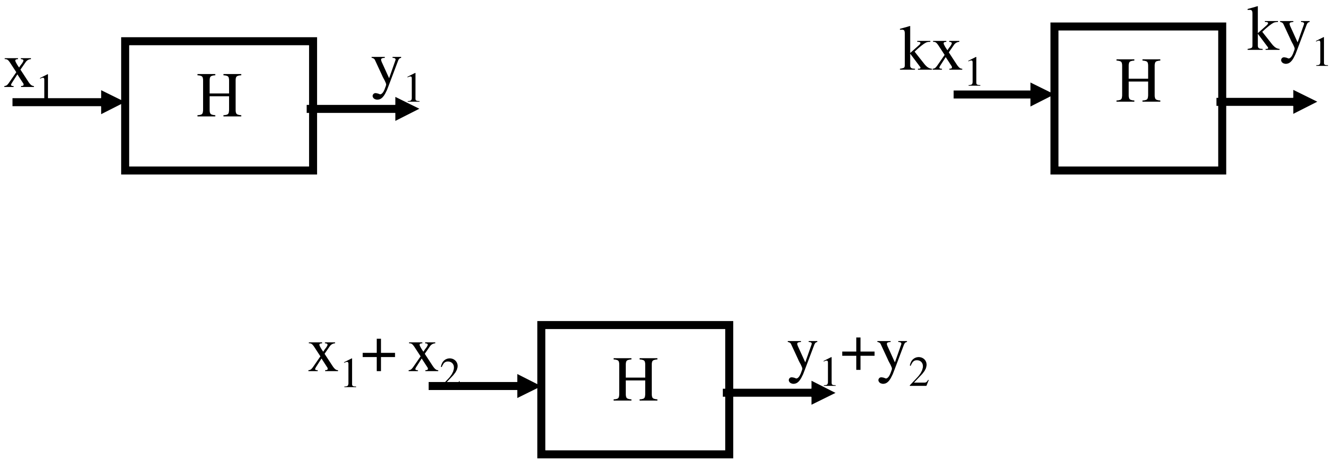
- Can be classified based on
  - Type of the system
  - Type of Control

- The system can be either a Linear, Non Linear, Time variant, Time invariant, Lumped, Distributed

•The type of the control used can be Continuous or Analog control, Discrete event control or Digital control

Review of Basic terms

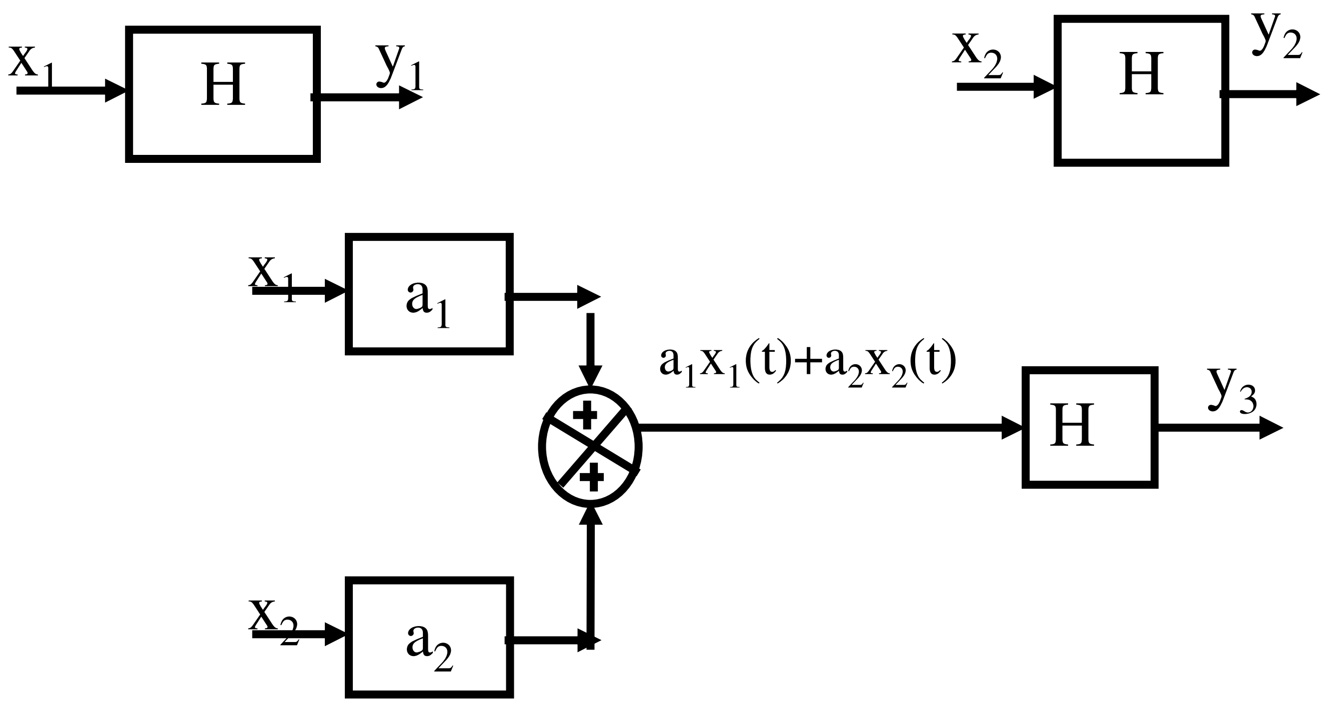
- **Linearity** : A system is said to be linear if it follows the principle of the superposition and homogeneity.



It can be described accurately by linear differential equations

Review of Basic terms

- **Linearity :**



For H to be linear $y_3(t) = a_1y_1(t)+a_2y_2(t)$

Review of Basic terms

- Time Invariant systems : The systems in which the parameters don't change with time, are termed Time invariant systems.

•It can be described by ordinary differential equations

•On the other hand, the time variant systems can only be described by partial differential equations, even though they are linear

Some important points

- Through out the course, we deal mostly with the LTI (Linear Time Invariant)systems as the analysis and design of such systems are well developed.
- No system in the universe is completely Linear or time Invariant.
- They are assumed to be time invariant and linearized about an operating point

Some examples

- Consider the system described by the following equations. Let the inputs to the system be x(t) and the outputs be y(t)

$$\frac{d^2}{dt^2}x(t)+4x^2+2\sin x(t)=2y(t)$$

$$2tx(t)+\sin x(t)+y(t)=0$$

$$\frac{d^5}{dt^5}x(t)+4\frac{d^4}{dt^4}x(t)+\frac{d^2}{dt^2}x(t)+2=y(t)$$

Classification based on the type of the controller

- Analog control : In this type of control system, the control signal is provided continuously and thus can also be called a Continuous signal control

- Discrete Event Control: When the control signal is provided only at discrete events of time

- Digital control : When the controller used is a computer (a digital device), it can be either a continuous control or discrete control

The Design Process

- Building a model for the plant to be controlled
- Writing the mathematical equations describing the system
- Develop a controller to control the system according to the specifications given
- Testing and analysis (both in time domain and frequency domain)

Next class………

Laplace Transforms and the Fundamentals of modeling