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CONTROL SYSTEM

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PREFACE

The course is provides knowledge regarding various concepts of feedback control system and the required mathematical methods. The emphasis of the course is on control action, transfer functions, and Laplace transforms. This course also provides knowledge in analyzing and data interpretation on different types of controller mode.

CONTROL SYSTEM

- INTRODUCTION TO CONTROL SYSTEM
- CONTROLLER PRINCIPLE
- TRANSFER FUNCTION
- STABILITY AND PERFORMANCE

DJM40092 - CONTROL SYSTEM

CHAPTER 1

INTRODUCTION TO CONTROL SYSTEM

TABLE OF CONTENTS

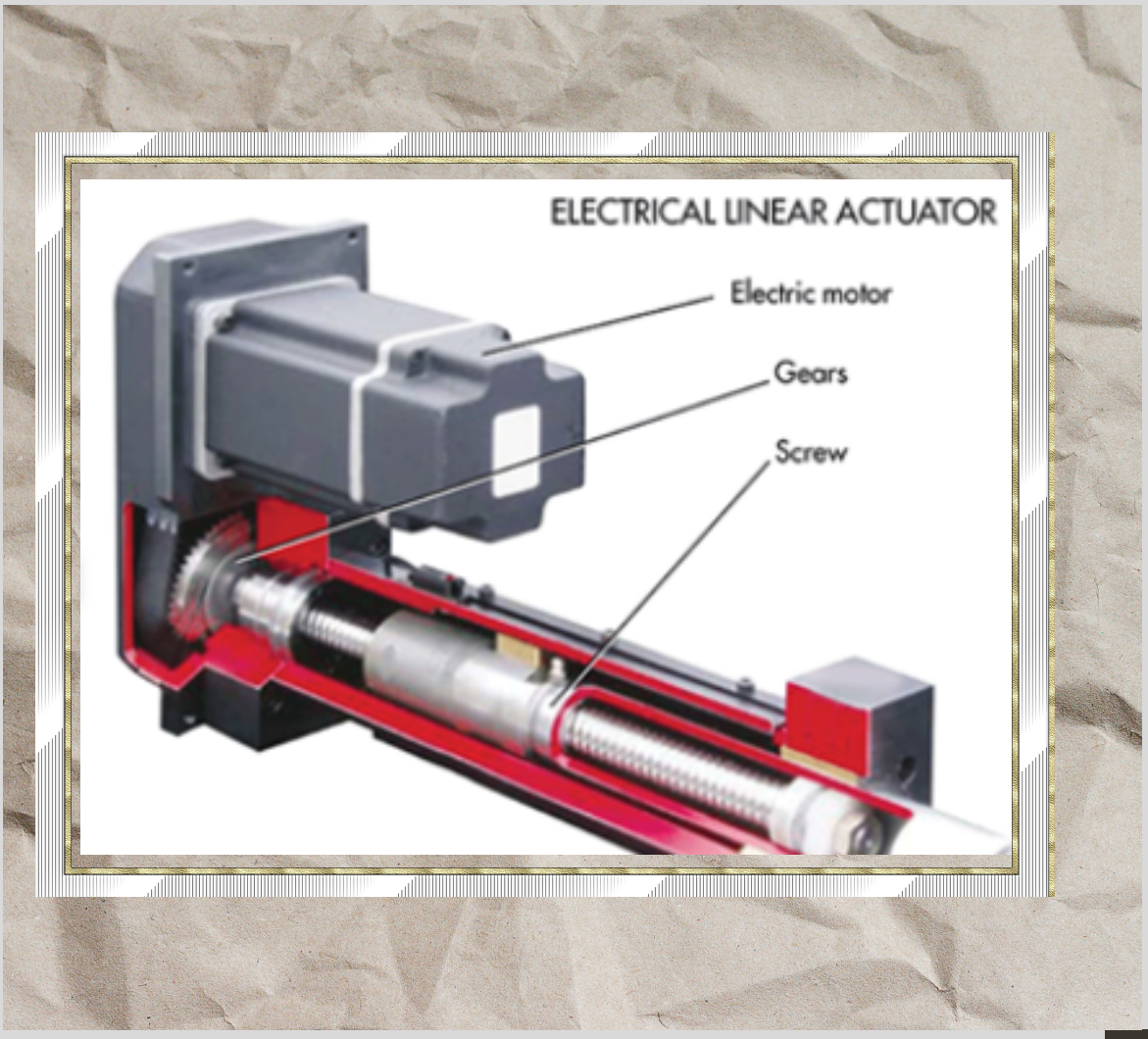
CHAPTER 1 → INTRODUCTION TO CONTROL SYSTEM

- ✓ Describe an electrical, pneumatic and hydraulic control.
- ✓ Identify general terms used in process control.
- ✓ Identify basic process control system

CHAPTER 1 → INTRODUCTION TO CONTROL SYSTEM

ELECTRICAL CONTROL

Electric linear actuators convert electrical energy into torque. A mechanically connected electric motor rotates the lead screw. A threaded lead or ball nut with a thread corresponding to the screw is prevented from rotating with the screw. When the screw rotates, the nut will be driven along the thread. The direction the nut moves depends on the direction in which the screw rotates and also returns the actuator to its original position

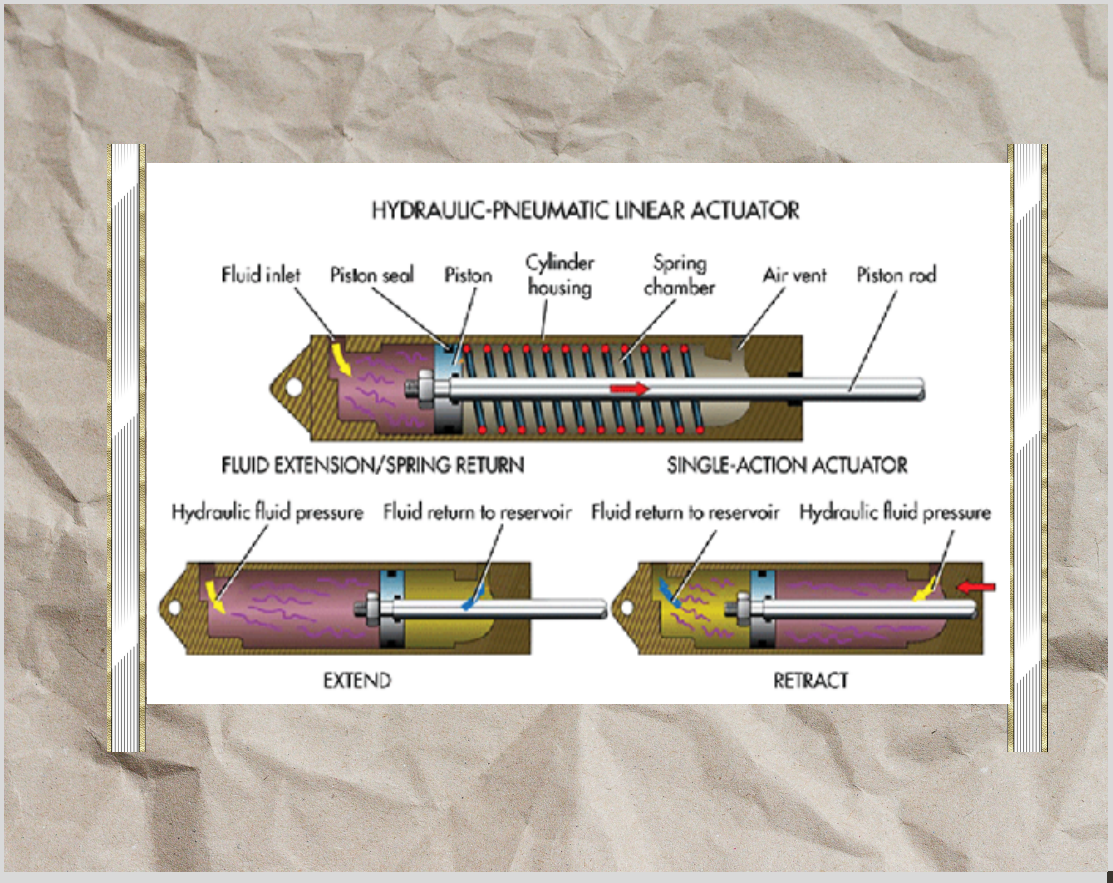


CHAPTER 1 → INTRODUCTION TO CONTROL SYSTEM

HYDRAULIC AND PNEUMATIC CONTROL

Pneumatic linear actuators consist of a piston inside a hollow cylinder. Pressure from an external compressor or manual pump moves the piston inside the cylinder. As pressure increases, the cylinder moves along the axis of the piston, creating a linear force. The piston returns to its original position by either a spring-back force or fluid being supplied to the other side of the piston.

Hydraulic linear actuators operate similarly to pneumatic actuators, but an incompressible liquid from a pump rather than pressurized air moves the cylinder.



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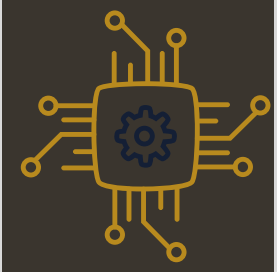
CHAPTER 1 → INTRODUCTION TO CONTROL SYSTEM

HYDRAULIC AND PNEUMATIC CONTROL



• PNEUMATIC EXAMPLES:

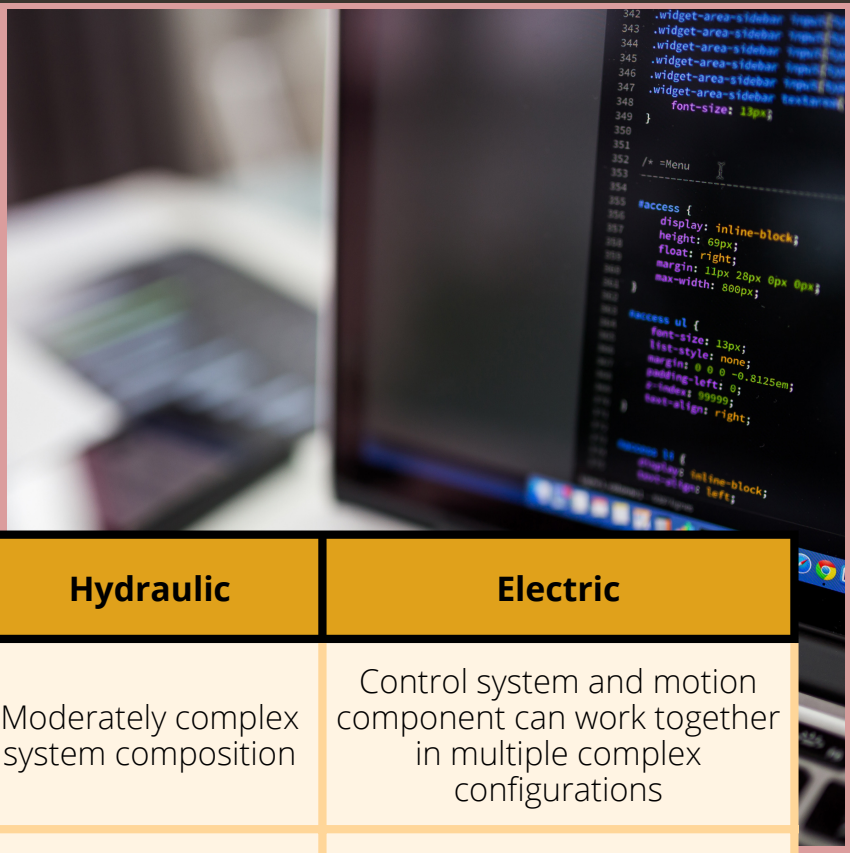
- Precision drills used by dentists
- Pneumatic brakes
- Nail gun
- Dentist chair
- Stamping
- Water spraying system.
- Automatic door
- Position and speed control system
- Industrial process control

• HYDRAULIC EXAMPLES:

- Dump truck lift
- Hydraulic lift to lift cars
- Jaws of lift
- Engine control system
- Power stering
- Break
- Driving mechanism for large ships

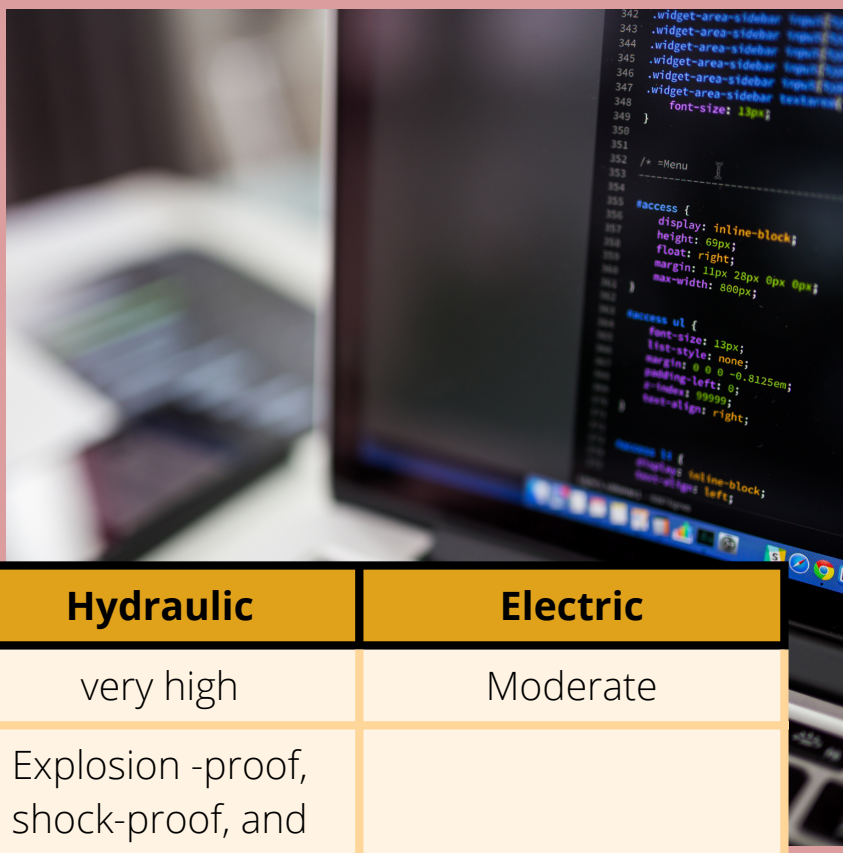
LOADING ...

ADVANTAGES & DISADVANTAGES OF ELECTRICAL, PNEUMATIC AND HYDRAULIC CONTROL



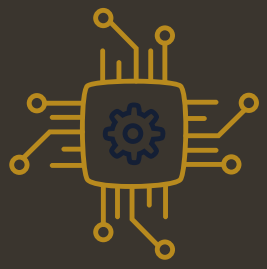
Chracteristics	Pneumatic	Hydraulic	Electric
Complexity	simple system composition	Moderately complex system composition	Control system and motion component can work together in multiple complex configurations
Peak power	high	very high	high
Control	simple valves	user must	Flexibility of motion control capabilities with electronic controller
position Accuracy	very difficult to achieve position accuracy	Mid-stroke positioning requires additional components and user support	Positioning capabilities and velocity control allow for synchronization
speed	very high speeds	Moderate speeds	Moderate speeds
Load ratings	high Load ratings	Extremely high load ratings	Can be high depending on the speed and positioning desired
Lifetime	moderate lifetime guarantee-easy to replace if need be	proper maintenance, it can last a long lifetime	With proper maintenance, it can last a long lifetime

ADVANTAGES & DISADVANTAGES OF ELECTRICAL, PNEUMATIC AN HYDRAULIC CONTROL



Chracteristics	Pneumatic	Hydraulic	Electric
Acceleration	very high	very high	Moderate
Shock Loads	Able to handle shock loads	Explosion -proof, shock-proof, and spark-proof	
Enviromental	high noise levels	Hydrulic fluids leaks and disposal	Minimal
Utilities	compressor, power, pipes	pump, power, pipes	Power only option
Efficiency	Low	Low	High
Reliability	Excellent	Good	Good
Maintenance	High amount of Maintenance	High user-maintenance throughout the life of the system	Little to no maintenance except for when replacement are necessary
Purchase cost	Low cost	High cost	High cost
Operating cost	Moderate cost	High cost	Low cost

GENERAL TERMS USED IN PROCESS CONTROL



System

An arrangement of physical components connected or related in such a manner as to form and/or act as an entire unit.

Input

The stimulus, excitation or command applied to a control system, typically from an external energy source, usually in order to produce a specified response from the control system.

Control System

An arrangement of physical components connected or related in such a manner as to command, direct, or regulate itself or another system.

Output

The actual response obtained from a control system. It may or may not be equal to the specified response implied by the input.

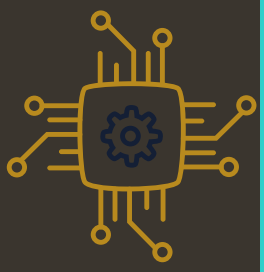
GENERAL TERMS USED IN PROCESS CONTROL

Disturbances

A disturbance is a signal that tends to adversely affect the value of the system. It is an unwanted input of the system.

Setpoint

Desired controlled variables of the desired control



Error

The difference between the measured value compared to the setpoint

Feedback

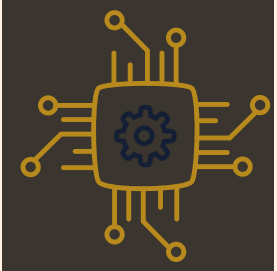
Property of a closed-loop system which permits the output (or some other controlled variable) to be compared with the input to the system (or an input to some other internally situated component or subsystem) so that the appropriate control action may be formed as some function of the output and input.

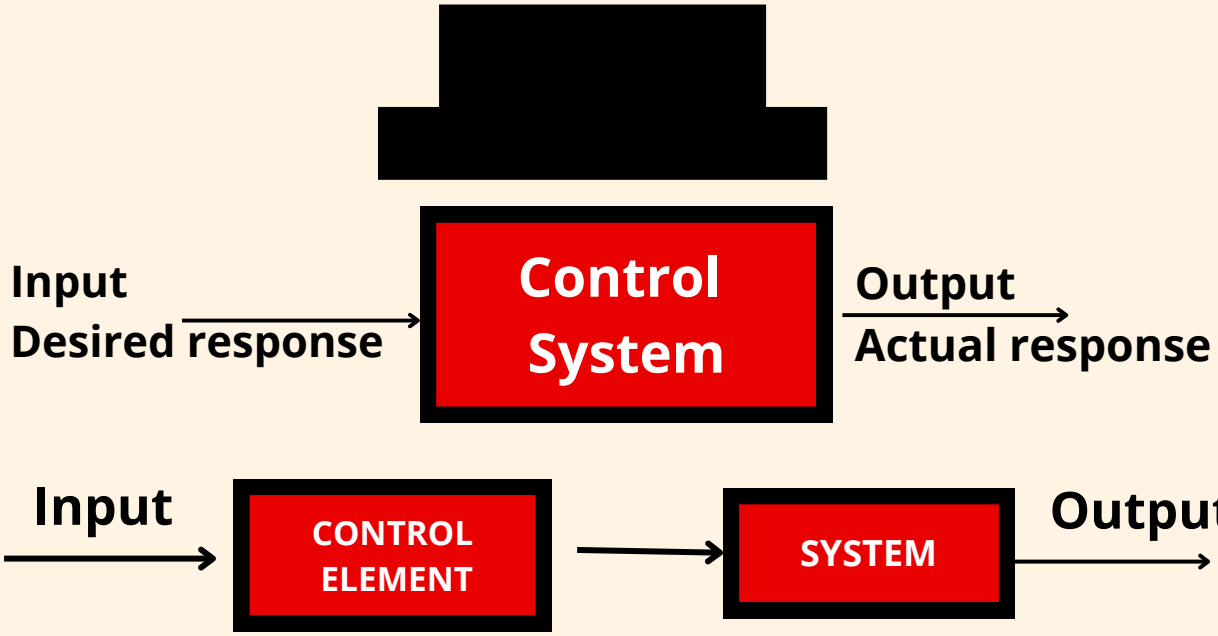
WHAT IS A CONTROL SYSTEM?

- A system controlling the operation of another system.
- A system that can regulate itself and another system.
- A control system is a device, or set of devices to manage, command, direct or regulate the behaviour of other device or system.

WHAT IS A CONTROL SYSTEM?

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



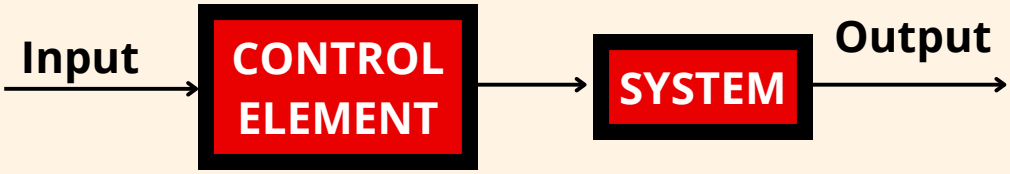


EXAMPLES

Human beings, plants, animals, aircrafts, helicopters automobile
single input single output system (SISO)
Multiple input multiple output system (MIMO)

WHAT IS A CONTROL SYSTEM?

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



EXAMPLES

Refrigerator, Air Conditioner, Power System

WHAT IS A CONTROL SYSTEM?

- **REQUIREMENT OF GOOD CONTROL SYSTEM**

Accuracy

Sensitivity

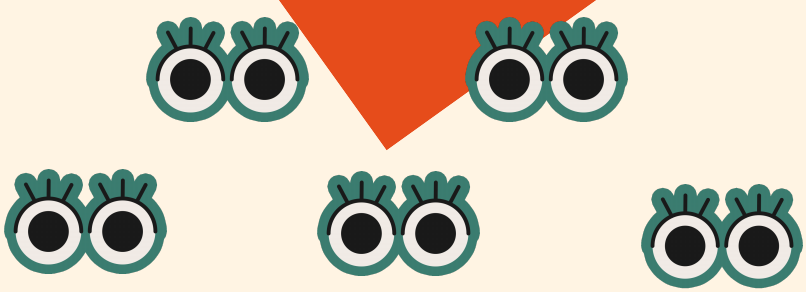
Noise

Oscillation

Speed

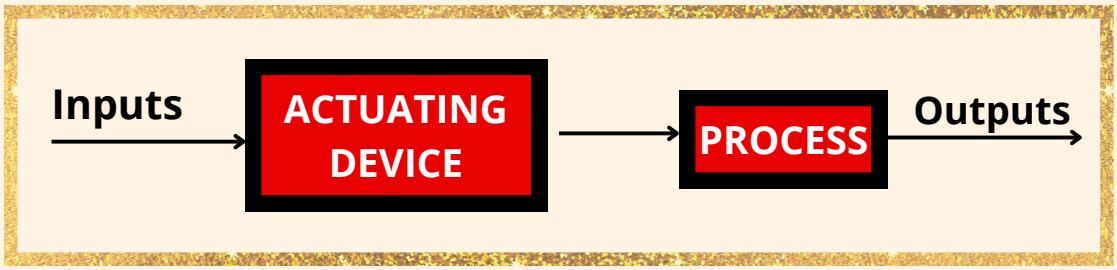
Stability

Bandwidth



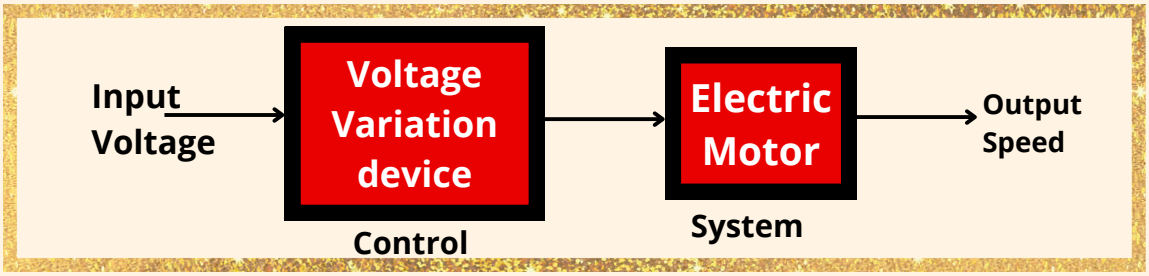
BASIC COMPONENT OF CONTROL SYSTEM

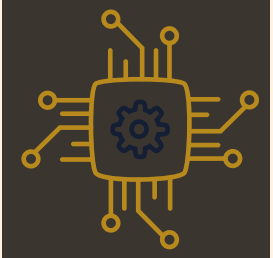
- Objectives of control (Inputs)
- Control system components (Controller, plant, actuator, sensor,...)
- Results (Outputs)



APPLICATION OF CONTROL SYSTEM

- Used in electrical system to control voltage current in electrical system
- Used to control the position and accelaration of during system
- Used to control or regulate the machine parameters like displacement, acceleration in mechanical systems
- Used in medical field to regulate, temperature, pressure in medical instrument

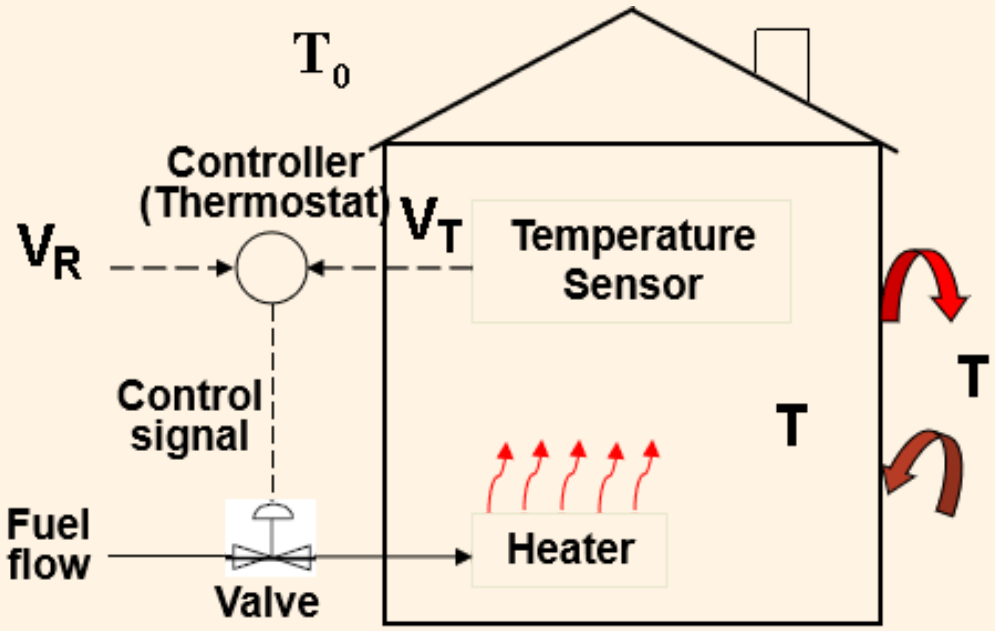




EXAMPLE OF CONTROL SYSTEM

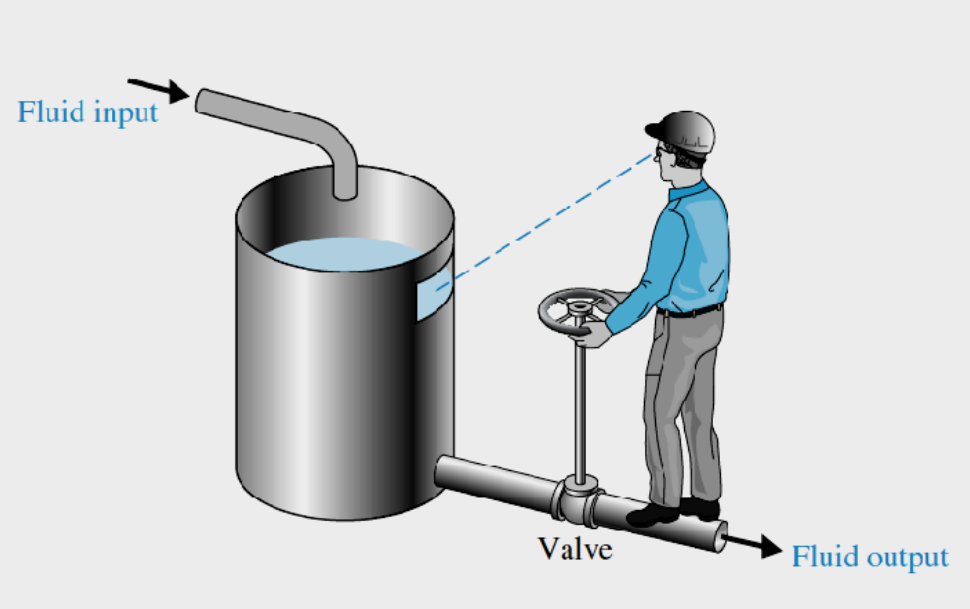
- **TEMPERATURE CONTROL SYSTEM**

  - Reference Temperature
  - Measured Temperature
  - Disturbance
    (heat transfer: door, window, wall, etc.)

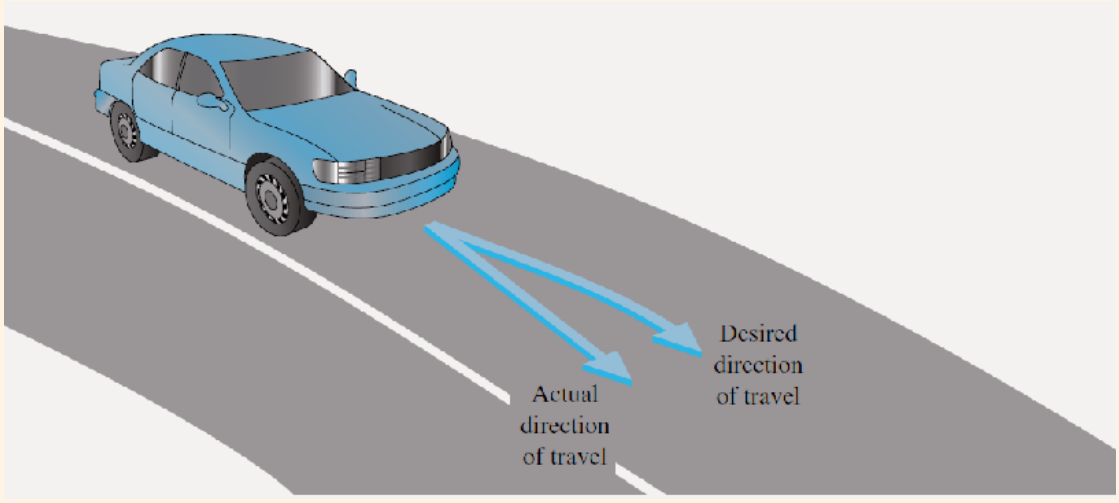


EXAMPLE OF CONTROL SYSTEM

- **MANUALLY WATER LEVEL CONTROL SYSTEM**



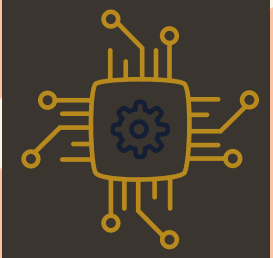
- **AUTOMOBILE STEERING CONTROL SYSTEM**



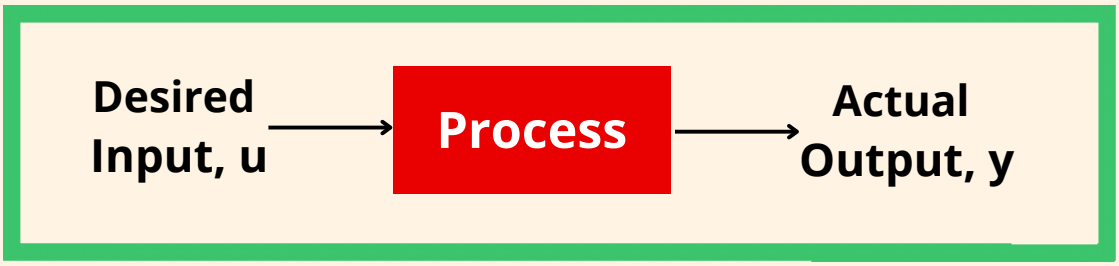
TYPES OF CONTROL SYSTEM

1 OPEN LOOP CONTROL SYSTEM

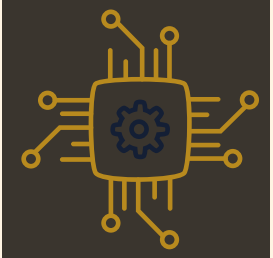
2 CLOSED LOOP CONTROL SYSTEM



OPEN LOOP SYSTEM / FEEDFORWARD



- The actual output y has no effect to the input u.



- Output is directly controlled by input
- Does not have feedback structure
- Non feedback system

Example :

✓Electric iron ✓ Electric fan ✓Water tank ✓Immersion heater

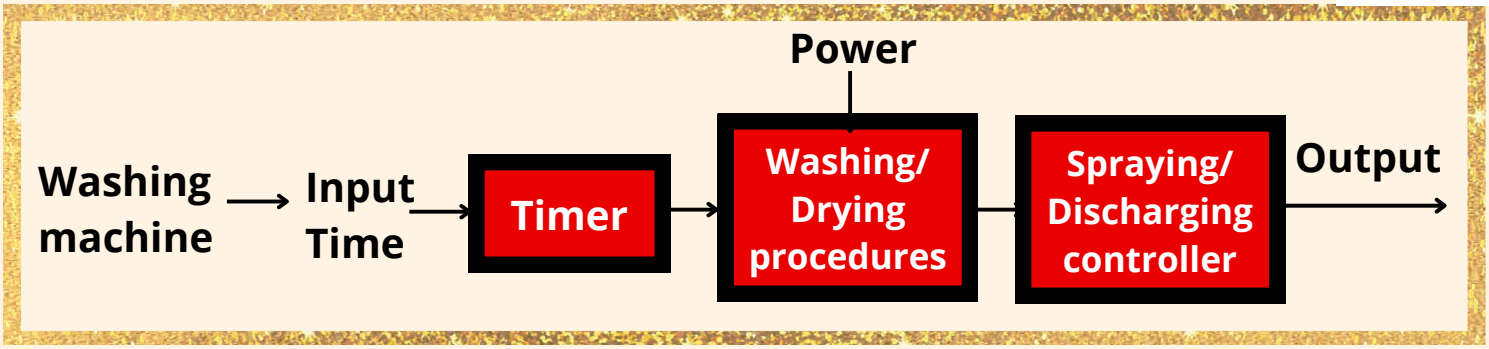
OPEN LOOP SYSTEM / FEEDFORWARD

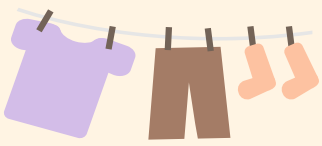
Advantages & Disadvantages of Open Loop Control System

Advantages	Disadvantages
Simple in construction and design	They are inaccurate.
Economical	They are unreliable.
Easy to maintain	Any change in output cannot be corrected automatically.
Generally stable	

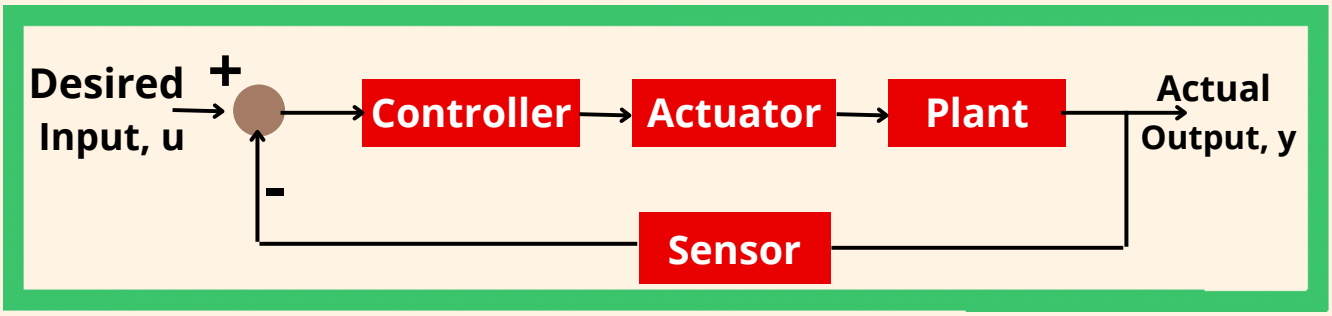
EXAMPLE BLOCK DIAGRAM OF OPEN LOOP SYSTEM

Washing machine control system





CLOSE LOOP SYSTEM / FEEDBACK



Output y has relation with input u and use their difference (error) as means of control through feedback

-Output has an effect on the control action of the input
- Output is feedback to the input
- desirable responses to commands
-good regulation against disturbance
- low sensitivity to changes in the parameters

Types of Feedback :

There are two types of feedback :–

- Positive feedback
- Negative feedback

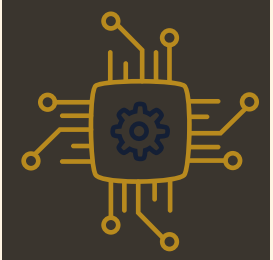
Example :

- -Voltage stabilizers
- -Automatic Electric Iron
- -Water Tanks with Float Ball

CLOSE LOOP SYSTEM / FEEDBACK

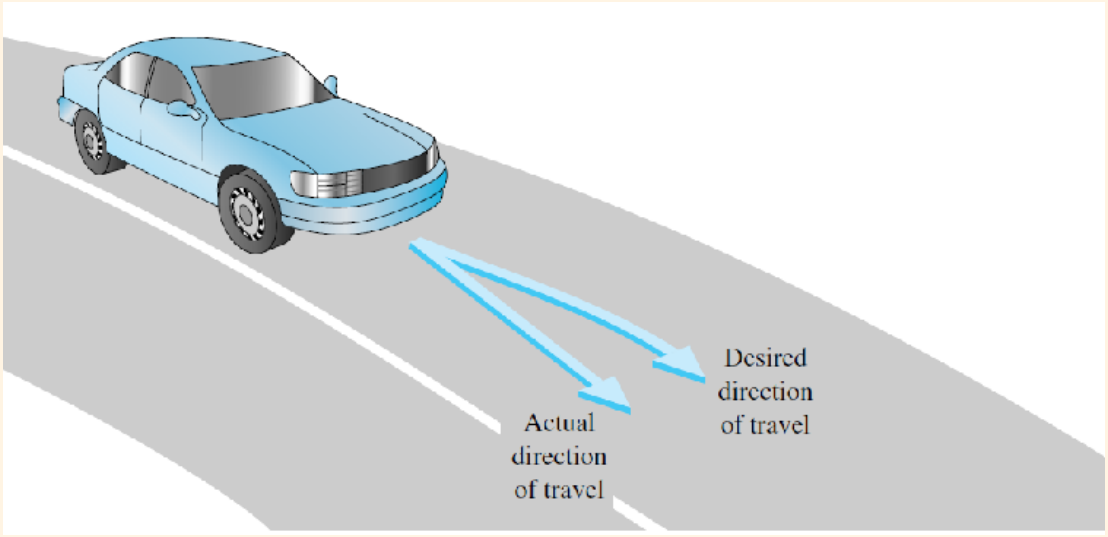
Advantages & Disadvantages of Close Loop Control System

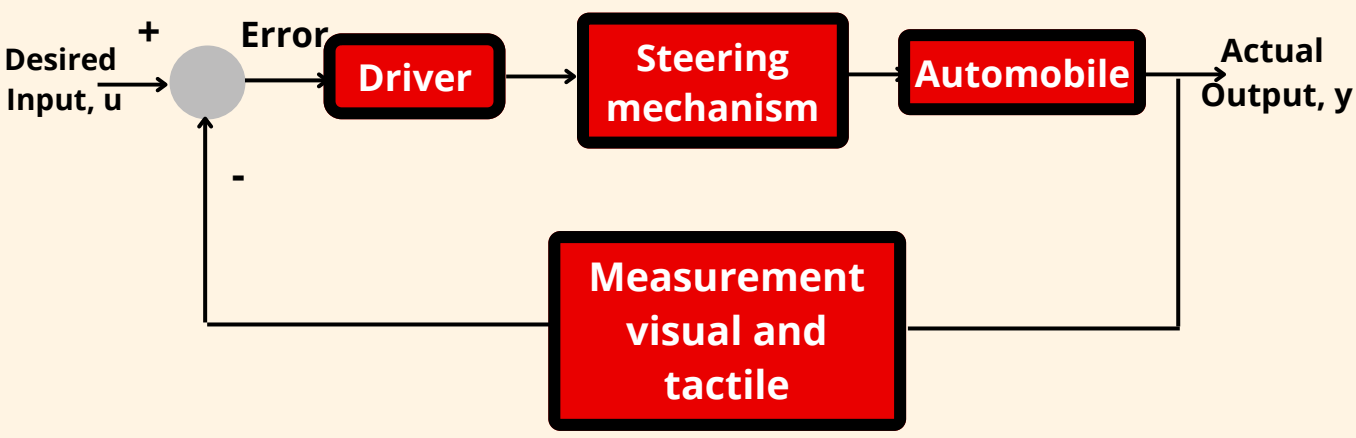
Advantages	Disadvantages
Closed loop control systems are more accurate even in the presence of non-linearity.	They are costlier.
Highly accurate as any error arising is corrected due to presence of feedback signal.	They are complicated to design.
Bandwidth range is large.	Required more maintenance.
Facilitates automation	Feedback leads to oscillatory response.
The sensitivity of system may be made small to make system more stable.	Overall gain is reduced due to presence of feedback
This system is less affected by noise.	Stability is the major problem and more care is needed to design a stable closed loop system.



EXAMPLE BLOCK DIAGRAM CLOSED LOOP SYSTEM

AUTOMOBILE STEERING CONTROL SYSTEM

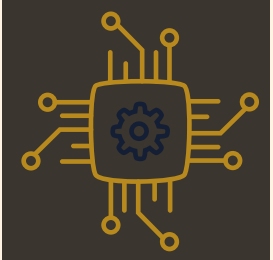




OPEN LOOP & CLOSE LOOP SYSTEM

Differentiate between Open loop and closed loop control system

Open loop control system	Closed loop control system
The feedback element is absent	The feedback element is always present
An error detector is not present	An error detector is always present
It is stable one	It may become unstable
Easy to construct	Complicated construction
It is an economical	It is costly
Having small bandwidth	Having large bandwidth
It is inaccurate	It is accurate
Less maintenance	More maintenance
It is unreliable	It is reliable



POP QUIZ 1

QUESTION 1

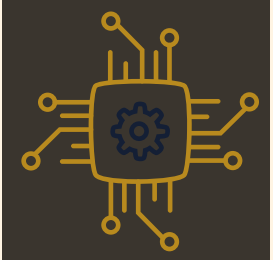
State whether the equipment uses an open loop control system or close loop

- Toaster
- Clothes drier
- TV remote control.
- Thermostat Heater
- water control system using a turbine

AUTOMATIC CONTROL SYSTEM

- In early stages of machinery invention, those machines were not equipped with good control systems and categorized as open loop control system.
- To improve the precision of the control systems, operators were engaged to control
- Machines and they played an important role as sensors and decision-makers.
- They compared the inputs with the status needed, then provided feedback and made decision (their brains).
- Afterwards, they adopted some procedures to stabilize the systems and minimized the errors the manual operation in the system become a kind of closed loop control system.

AUTOMATIC CONTROL SYSTEM



- After the trustable sensors, processors and driving devices were well developed, automatic machinery gradually replaced those manual ones.
- Under the conditions of clear and repeated procedures, and those procedures which are operated by automatic adjustment system instead, automatic control machinery is more suitable for use.
- Therefore, those automatic controlled machines are suitable for boring and repeated works.
- After the emergence of processors and new models of sensors, manual control systems were gradually and easily replaced by computer control systems. Therefore, machinery becomes **AUTOMATIC CONTROL SYSTEM**.

ADVANTAGES AND DISADVANTAGES OF AUTOMATIC CONTROL SYSTEM

ADVANTAGES	DISADVANTAGES
Increase in productivity	Lower skill levels of workers
Reduced lead time	High initial investment
Safer working conditions	Retrenchment or unemployment
Better product quality	Not economically justifiable for small scale production

POP QUIZ 1

QUESTION 2

Label the blank block diagram of automatic toaster in Figure 1

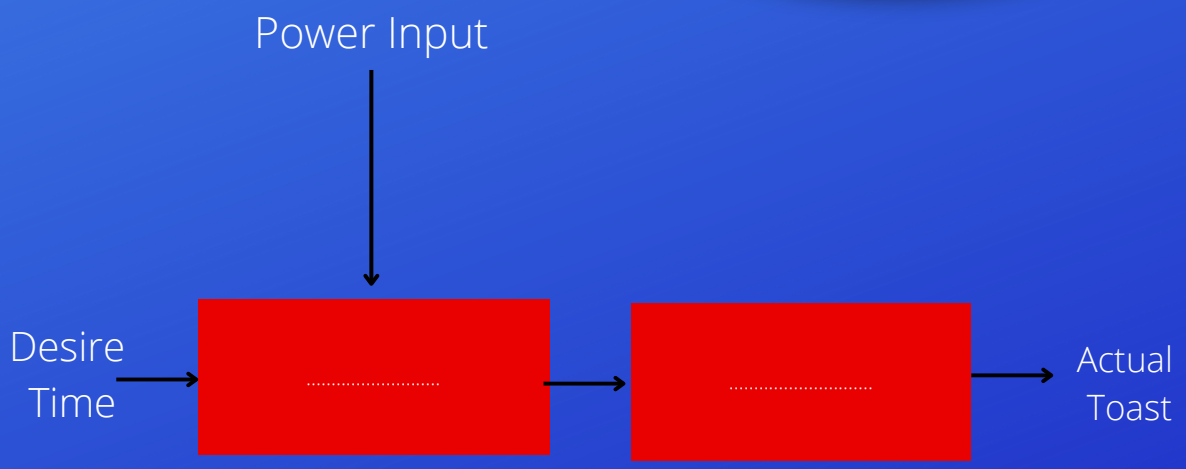


Figure 1

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