

PART A

UNIT 1

Introduction
to

Mechatronic Systems

Learning objectives

By the end of this the student should be able to

- ✓ Understand the meaning of 'mechatronics' and its evolution
- ✓ Define a system
- ✓ Understand different types of system
- ✓ Differentiate between measurement and control systems
- ✓ Identify measurement and control systems and their elements along with their functions
- ✓ Advancements in the field of mechatronics with microprocessor based controllers

Overview

- Mechatronics is the integration of Electronic, electrical, Computer technology and control engineering with Mechanical engineering.
- This field provides a wide range of applications relevant to both industry and household appliances
- The word was coined by Japanese to highlight the integrated approach

Evolution

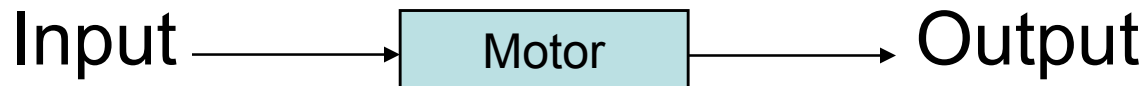
1. Primary level mechatronics: This incorporates I/O devices such as sensors to activate valves
2. Secondary level mechatronics: Integrates electronics into electrically controlled devices such as cassette players
3. Third level mechatronics: Introduces 'smart system' by incorporating application specified integrated circuits (ASIC) like CNC machines, Automatic washing machines
4. Fourth level mechatronics: Incorporates 'intelligent control' with fault detection and isolation (FDI) capability systems and fuzzy logic.

Systems

- System can be thought of as a unit which has an input and output devices and is prepared to perform some defined function.
- It is not important here to discuss the function of the process but only concerned with the input and the output

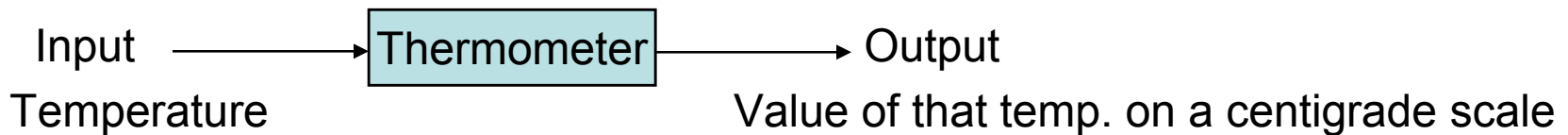
Ex: A motor can be thought of as system with electric input and rotation of the shaft as the output.

A system can be a **measurement system** or a **control system**



Measurement system

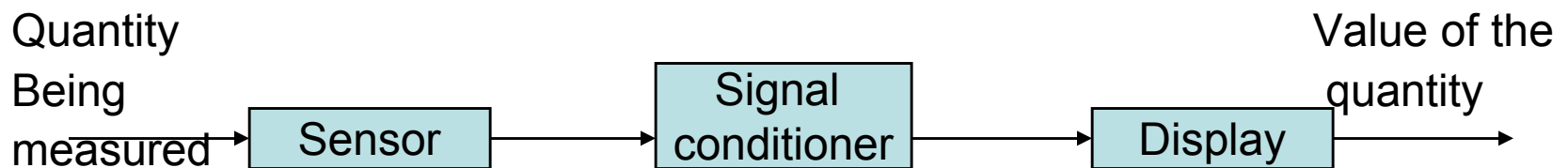
- It can be thought of as a black box carrying out the action of measurement.
- It has an input quantity to be measured and the output as the value of that quantity



Elements of measurement system

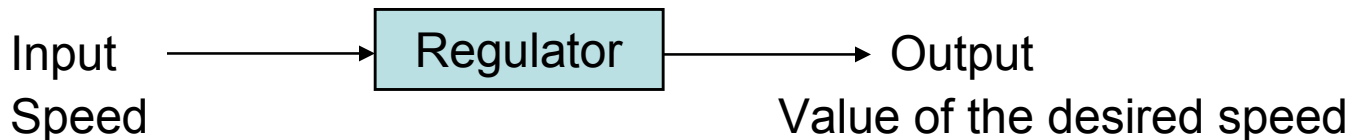
A measurement system consists of the following elements

1. Sensor: responds to the quantity being measured by as its output a signal related to the quantity. Ex: Thermocouple
2. Signal conditioner: this is the unit that takes the signal from sensor and transforms it to such a condition that it can be either displayed or controlled. Ex: Amplifier
3. Display unit: this is where the output from the signal conditioner is seen. Ex: Dial indicator



Control system

- Control means regulate, manipulate or adjust
- Body temperature control is the natural control system
- This can be thought of as a black box which is used to control the output to a particular value or a sequence of values

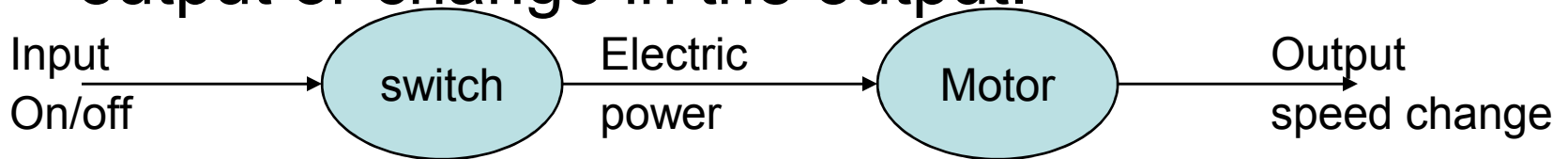


Elements of control system

- Feed back unit is the most important element of the control system
- Ex: body temperature control
- There are two basic forms of control systems, viz. open loop and closed loop system

Open loop systems

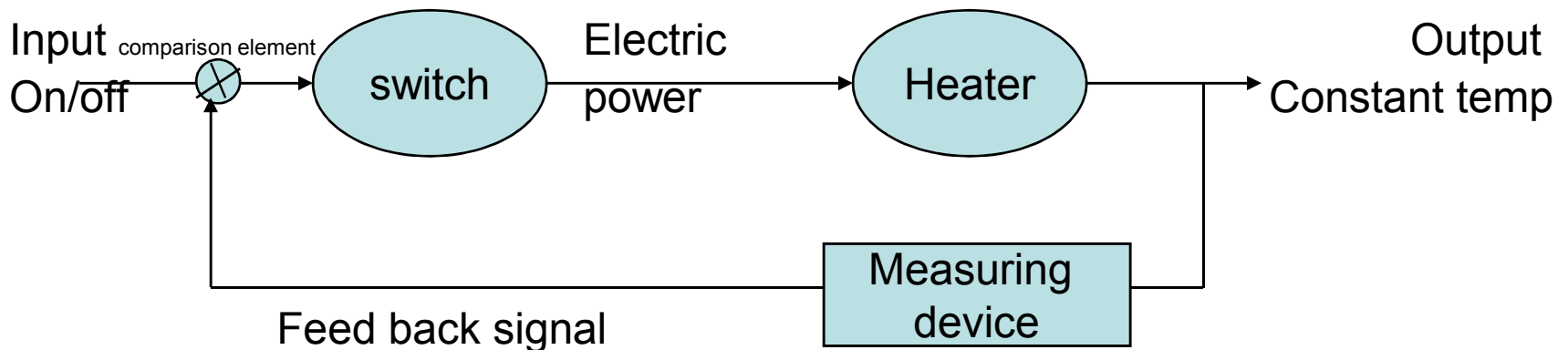
- Open loop system is a control system in which the output is dependent on the input but the input or controlling action is independent of the output or change in the output.



- It is relatively simple, low cost, easy to understand and maintain, stability and reliability is relatively good
- Its disadvantages are inaccuracy, slow in response, no optimized control

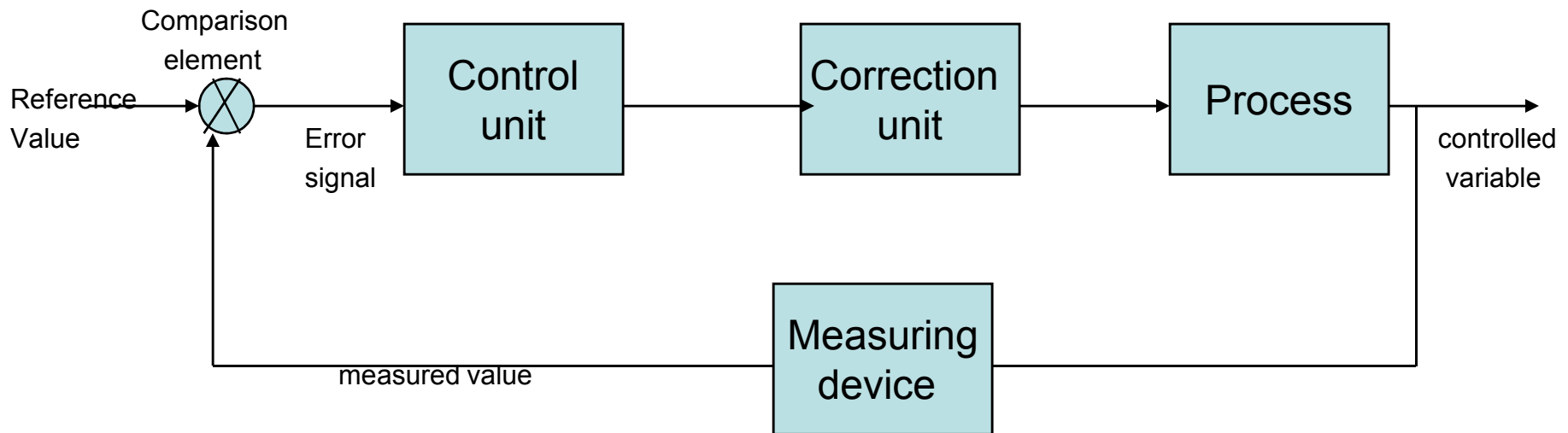
Closed loop system

Here the output is dependant on the input and also the output decides the further input. It is characterized by a feedback system, which permits the output to be compared against the input and make necessary changes



- Closed loop systems are relatively accurate due to feed back control, however they are complex and obviously costly.
- They have greater chances of breakdown as the number of components are more.

Elements of closed loop systems



1. Comparison element
2. Control element
3. Correction element
4. Process element
5. Measurement element

1. Comparison element

This compares the required or reference value of the variable condition being controlled with the measured value of what is being achieved and produces an error signal.

Error signal = reference value signal – measured value signal

- The feed back is said to be negative feedback when the signal which is fed back subtracts from the input value.
- The feed back will be positive when the signal fed back adds to the input signal

2. Control element

This decides what action to take when it receives an error signal may be to operate a switch or to open a valve

A control unit can be mechanical system which is fixed or a programmable system which can be altered by reprogramming

3. Correction unit

This produces a change in the process to correct or change the controlled condition

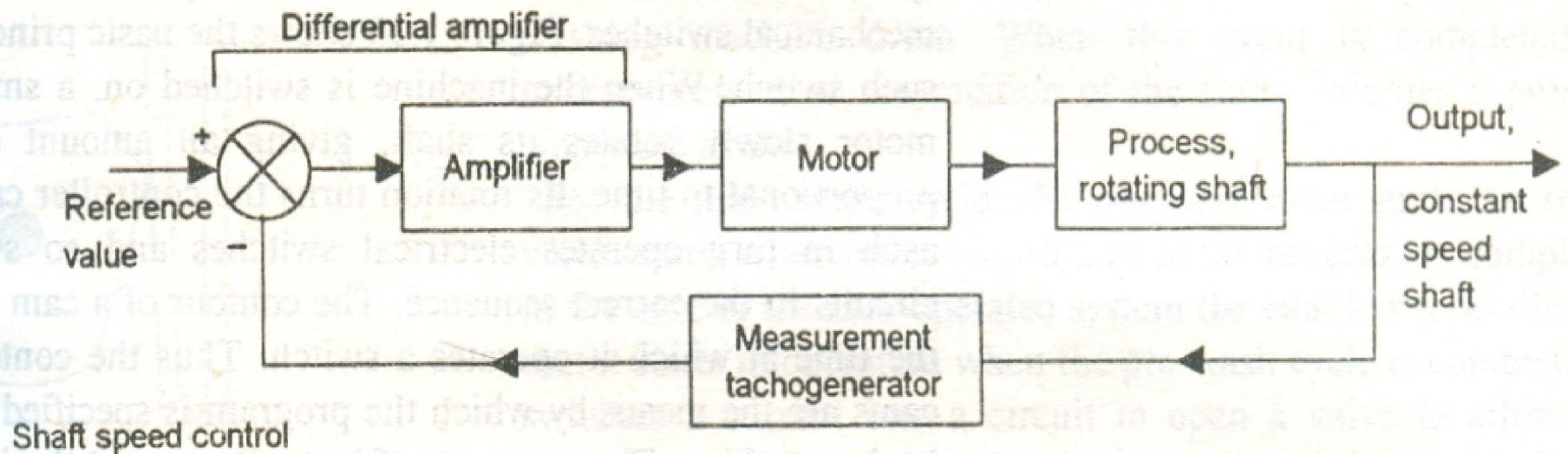
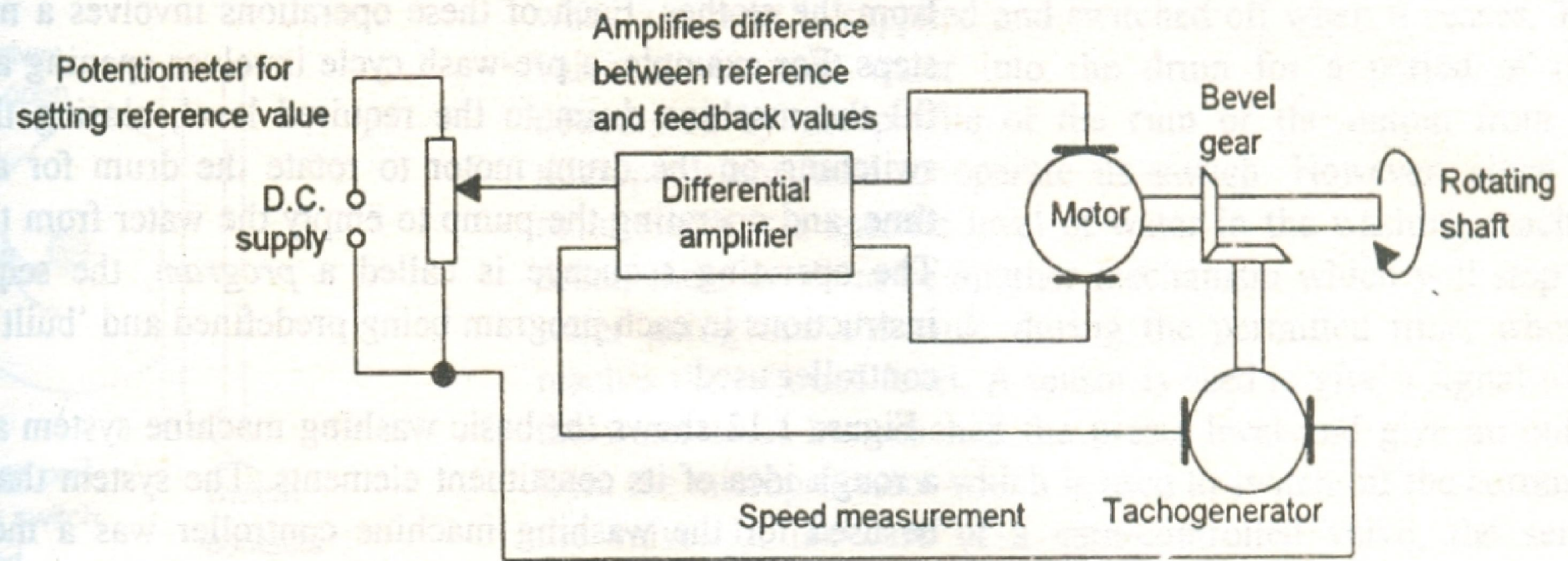
The term actuator is used for the element that does the job of correction

4. Process element

the process is what is being controlled. It could be the temperature of the room or the speed of the fan, etc.

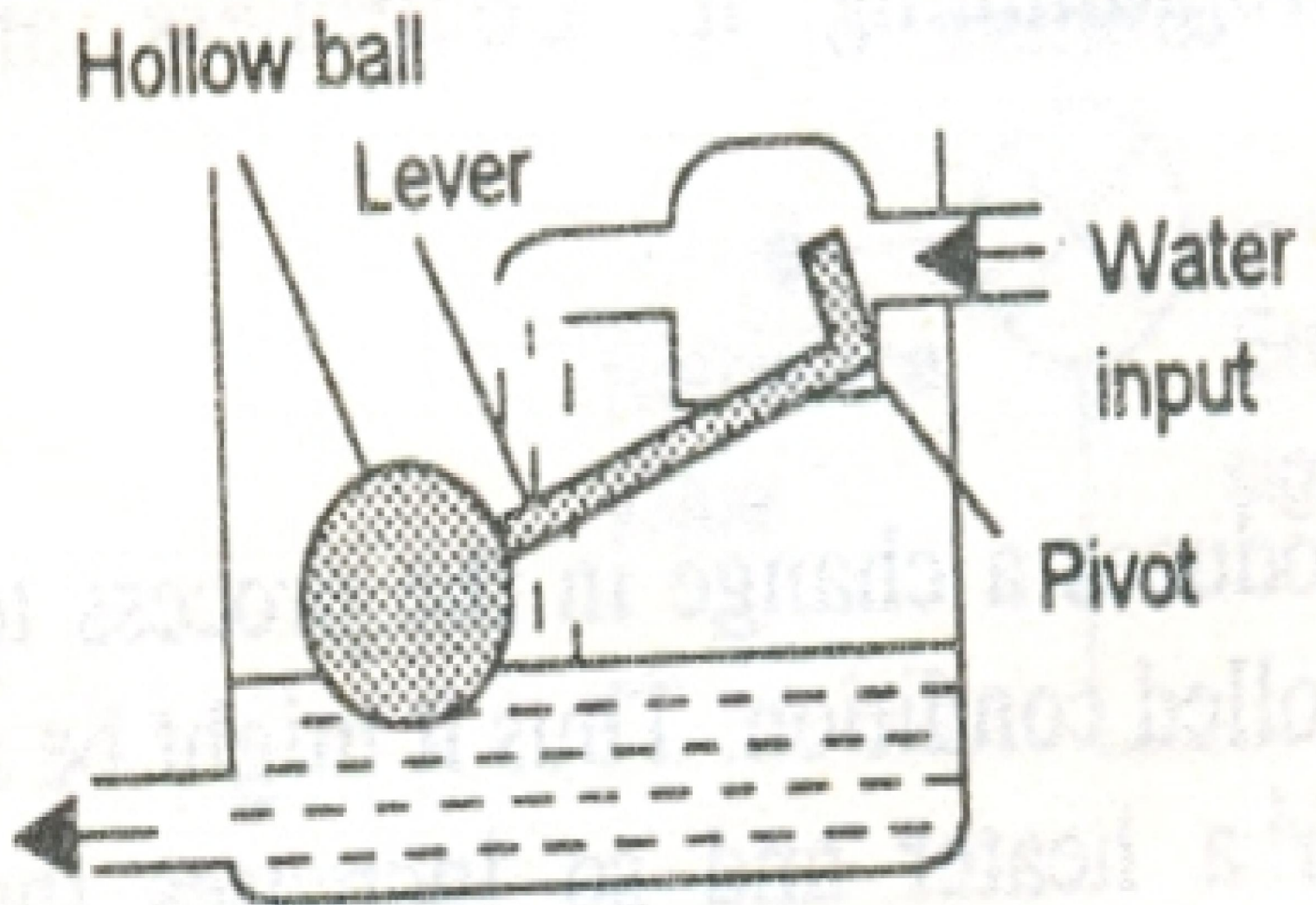
5. Measurement element

This produces a signal related to the variable condition of the process that is being controlled. In other words this actually measures the output value.



Various elements of controlling the room temperature

- ✓ Controlled variable – the room temperature
- ✓ Reference value – the required room temperature
- ✓ Comparison element – the person comparing the measured value with the required value
- ✓ Error signal – the difference between the measured and the required value
- ✓ Control unit – the person
- ✓ Correction unit – the switch
- ✓ Process – the heating by the heater
- ✓ Measuring device – the thermometer



Various elements of controlling the water level in the tank

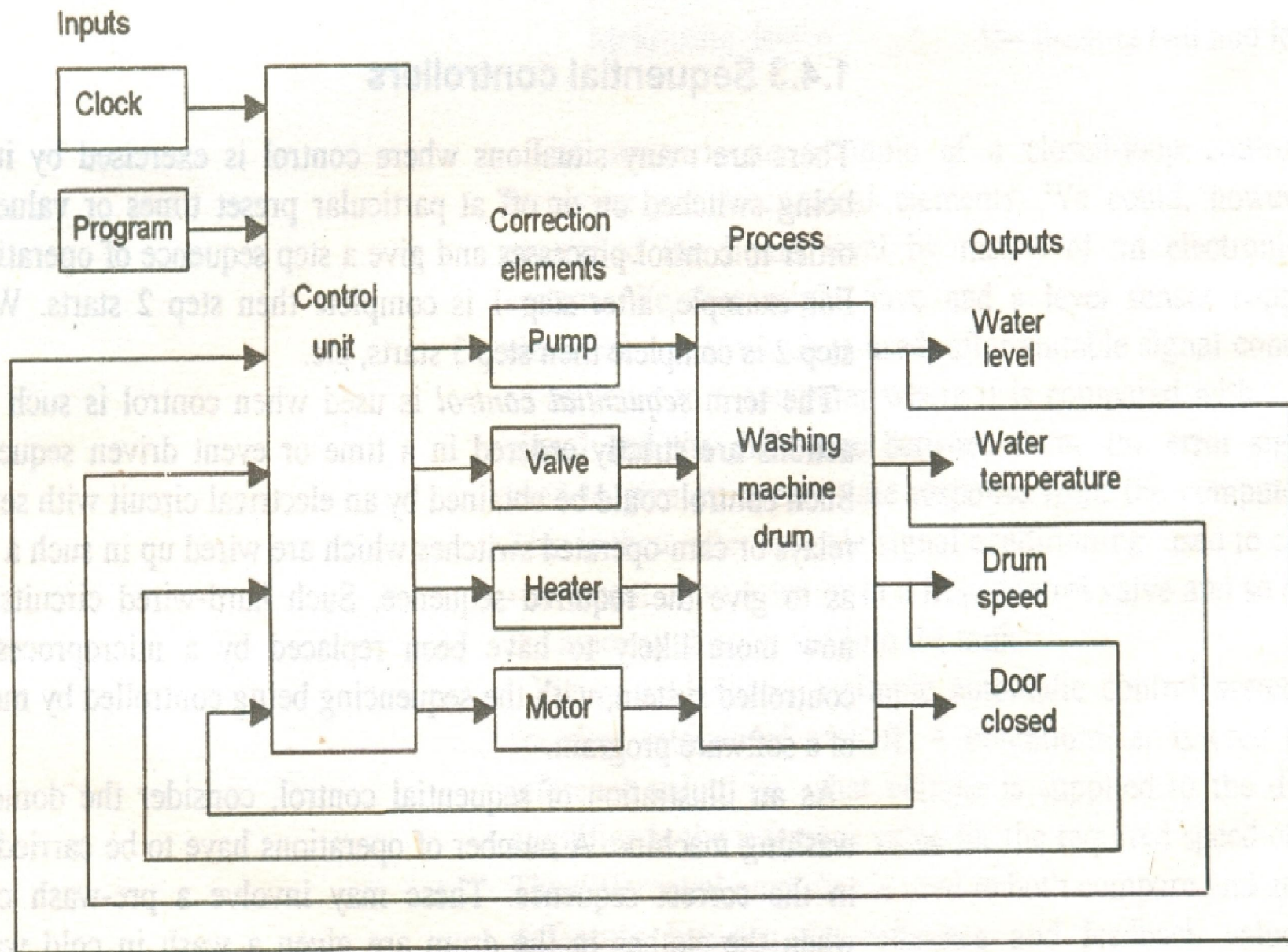
Various elements of controlling the water level in the tank

- ✓ Controlled variable – the water level in the tank
- ✓ Reference value – initial setting of the float to the level required
- ✓ Comparison element – the lever
- ✓ Error signal – the difference between the measured and the initial setting of the lever positions
- ✓ Control unit – the pivoted lever
- ✓ Correction unit – the flap opening or closing the water supply
- ✓ Process – the water level in the tank
- ✓ Measuring device – the float ball and the lever

Sequential controllers

The above term is used when control is exercised in such a way that the actions are strictly ordered in a time or event driven sequence

Ex: Washing machine which can be controlled either by programmed controller or CAM operated switch

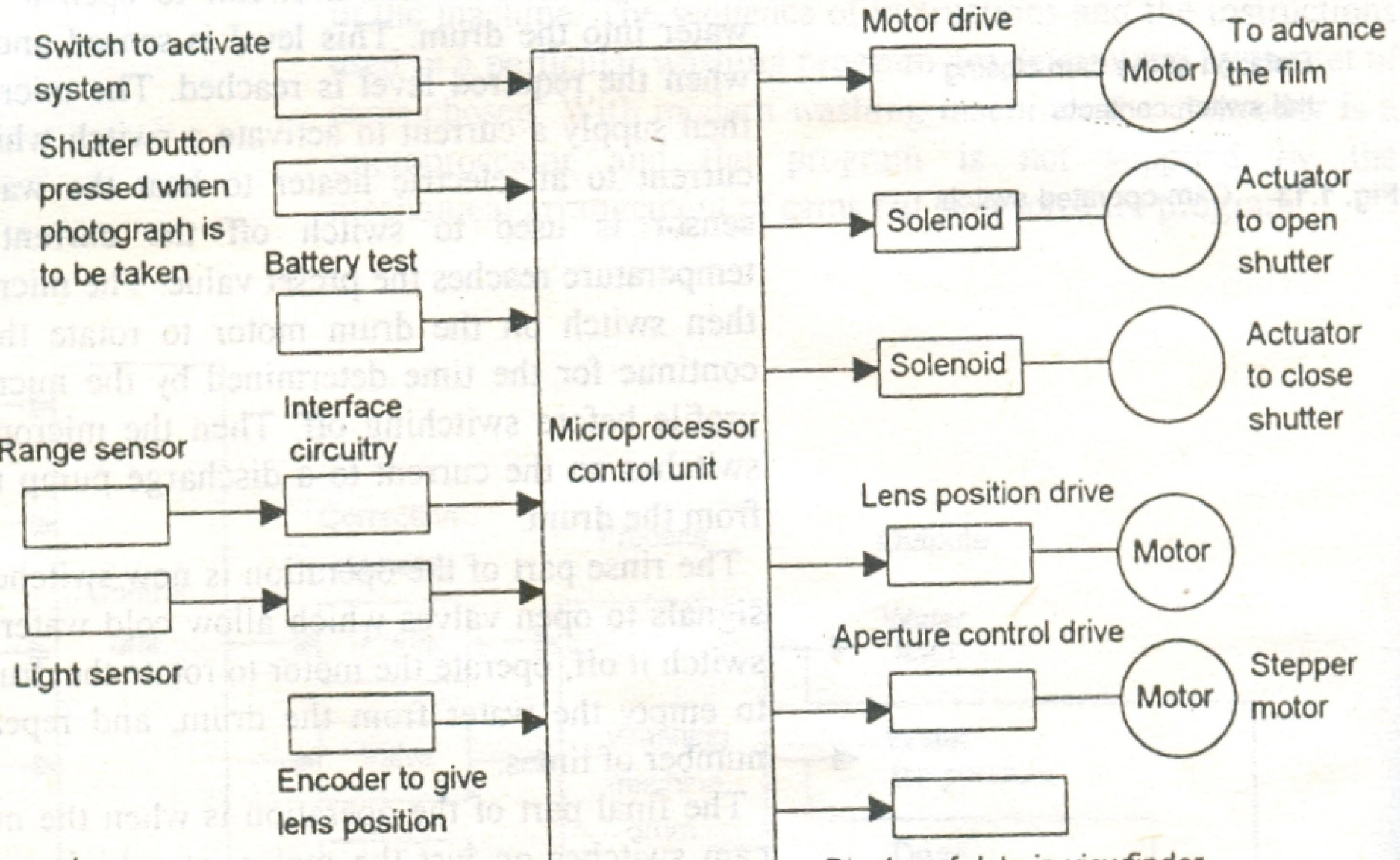


Feedback from outputs of water level, water temperature, drum speed and door closed

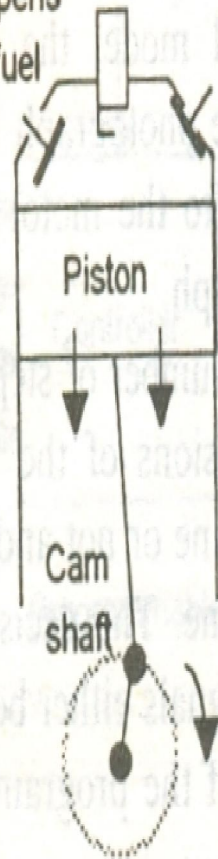
Microprocessor based controllers

1. Automatic camera
2. Automatic engine system

Microprocessor based controllers



Valve opens
for air-fuel
intake



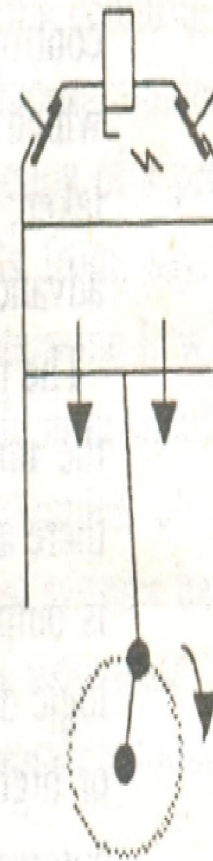
Intake stroke



Compression stroke

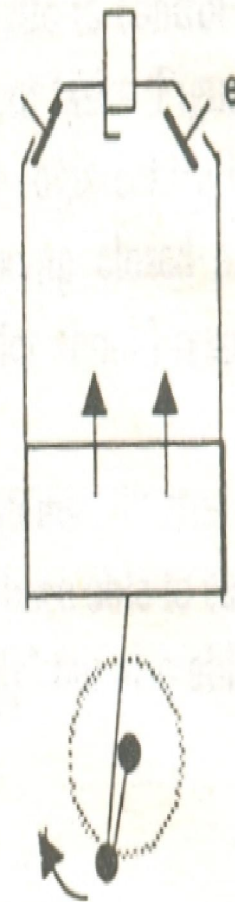
Mixture
compressed

Spark for ignition



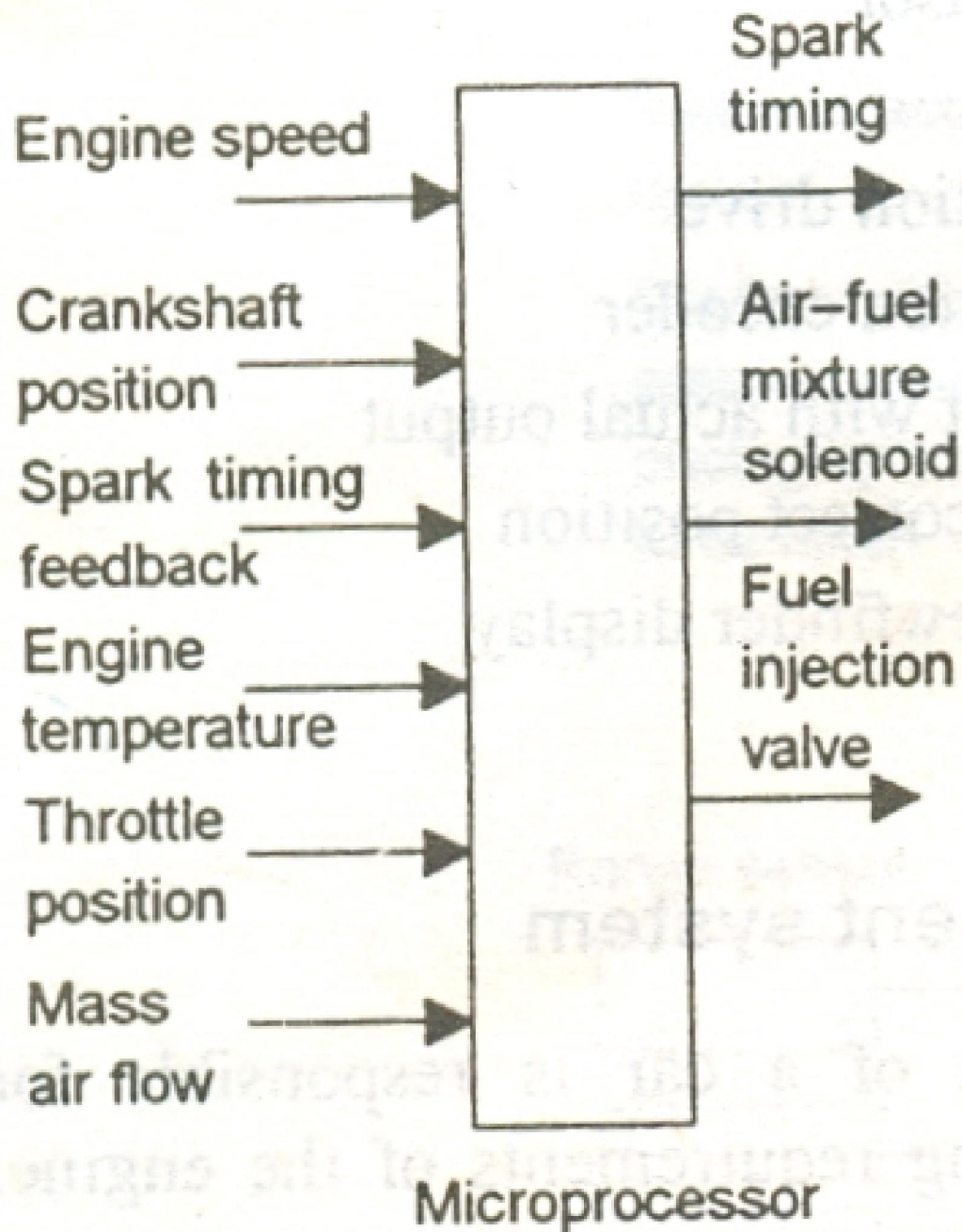
Power stroke

Hot gases
expand



Exhaust stroke

Valve opens
to vent
exhaust
gases



Advantages of mechatronics

1. The products are of high quality
2. The synergy produces a good performance characteristics
3. High degree of flexibility
4. Machine utilisation is high
5. Capital expenses are reduced as a mechatronic parts are better than sum of its parts
6. They are user friendly and are highly reliable

Disadvantages of mechatronics

1. The existing system has to be replaced by the new system which is a very expensive process
2. Hence the initial cost will be high
3. Very difficult to obtain human resource from various fields at one place
4. Specific problems have to be dealt by specific people only