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Unit V: Part - A

2023-24 (Odd): 1st Semester

BE in CV, CY, EC, EI, IM

**ME113AT: Fundamentals of Mechanical Engineering**

(Category: Engineering Science)

(Theory)

ESC: ‘C’ Section

# Unit – V
# MECHATRONICS AND ENERGY SOURCES


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## Unit V



## Mechatronics >>

06 Hrs

- Introduction
- Evaluation of Mechatronic system, Measurement
- Control System, Basic Elements of Control System
- Applications:
  - Water Level Controller
  - Washing Machine
  - Engine management system (EMS)
  - Anti-Lock Braking System (ABS)

## Energy Sources>>

- Introduction
- Applications of Energy sources like
  - Fossil Fuels
  - Nuclear Fuels
  - Hydel
  - Solar
  - Wind and
  - Bio-Fuels
- Environmental Issues like
  - Global warming and
  - Ozone depletion

| Unit-V | 6 Hrs |
|---|---|
| **Mechatronics:**<br>Introduction: Evolution of Mechatronic system, measurement; control system, basic elements of control system, Applications-water level controller, washing machine, Engine management system (EMS), Anti-lock Braking System (ABS).<br>**Energy Sources:**<br>Introduction and applications of Energy sources like Fossil fuels, Nuclear fuels, Hydel, Solar, wind, and bio-fuels, Environmental issues like Global warming and Ozone depletion. | |

## Mechatronics>>

- Introduction
- Evaluation of Mechatronic system
- Measurement

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## Introduction:

- Mechatronics is a natural stage in the evolutionary process of modern engineering design.

- The development of the computer, and then the microcomputer, embedded computers, and associated information technologies and software advances, made mechatronics an imperative in the latter part of the twentieth century.

- In other words, technologies and developed products will be incorporating electronics more and more into mechanisms, intimately and progressively, and making it impossible to tell where one ends and the other begins.

# Introduction:

- The term "Mechatronics" was coined in 1969 by a senior engineer of a Japanese Yasakawa Electric Company to refer to the use of electronics in mechanical control.

- In trademark application documents, Yasakawa defined mechatronics in this way:

The word, Mechatronics,

is composed of "mecha" from mechanism and the "tronics" from electronics

- The definition of mechatronics has evolved since the original definition by the Yasakawa Electric Company.

# Mechatronics>>

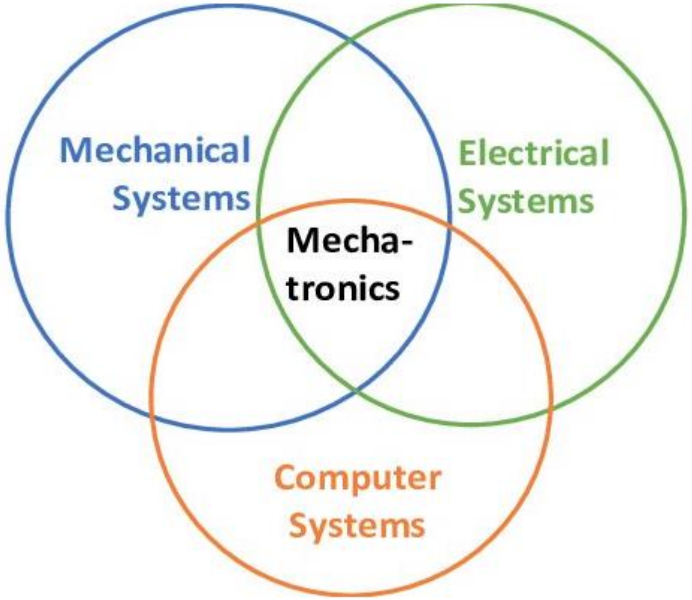
- The definition of mechatronics continued to evolve after Yasakawa suggested the original definition.
- One oft quoted definition of mechatronics was presented by Harashima, Tomizuka, and Fukada in 1996.

In their words, Mechatronics is defined as
the synergistic integration of mechanical engineering with electronics and intelligent computer control in the design and manufacturing of products and process.

That same year, another definition was suggested by Auslander and Kempf:
Mechatronics is the application of complex decision making to the operation of physical systems.

Yet another definition due to Shetty and Kolk appeared in 1997:
Mechatronics is a methodology used for the optimal design of electromechanical products.

More recently, found the suggestion by W. Bolton:
A mechatronic system is not just a marriage of electrical and mechanical systems and is more than just a control system; it is a complete integration of all of them.



# Mechatronics>>



All these definitions agree that Mechatronics is an interdisciplinary field, in which the following disciplines act together:

**Mechanical systems:**

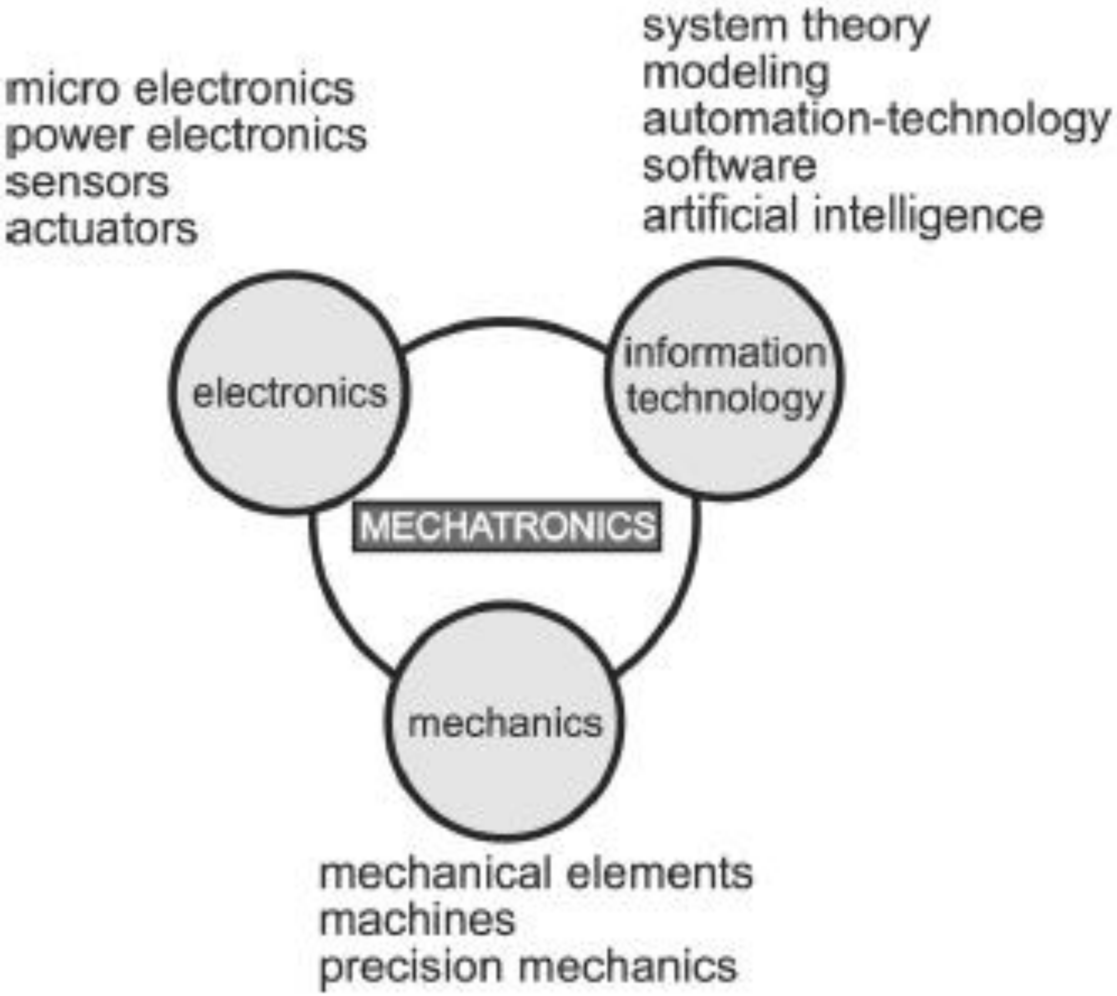
Mechanical elements, machines, precision mechanics

**Electronic systems:**

Microelectronics, power electronics, sensor and actuator technology and

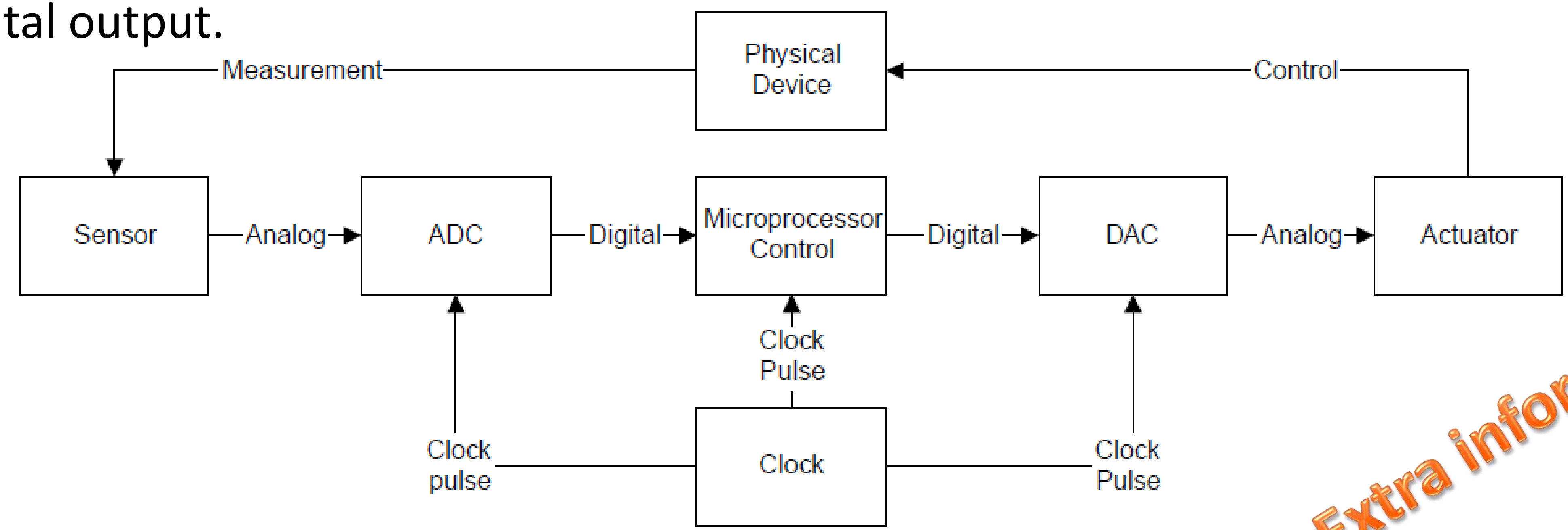
**Information technology:**

Systems theory, automation, software engineering, artificial intelligence.



# A Typical Mechatronics system>>

- Figure shows a typical mechatronic system with mechanical, electrical, and computer components.
- The process of system data acquisition begins with the measurement of a physical value by a sensor.
- The sensor is able to generate some form of signal, generally an analog signal in the form of a voltage level or waveform.
- This analog signal is sent to an analog-to-digital converter (ADC).
- Commonly using a process of successive approximation, the ADC maps the analog input signal to a digital output.




A Typical Mechatronics system

Extra information...

# A Typical Mechatronics system>>

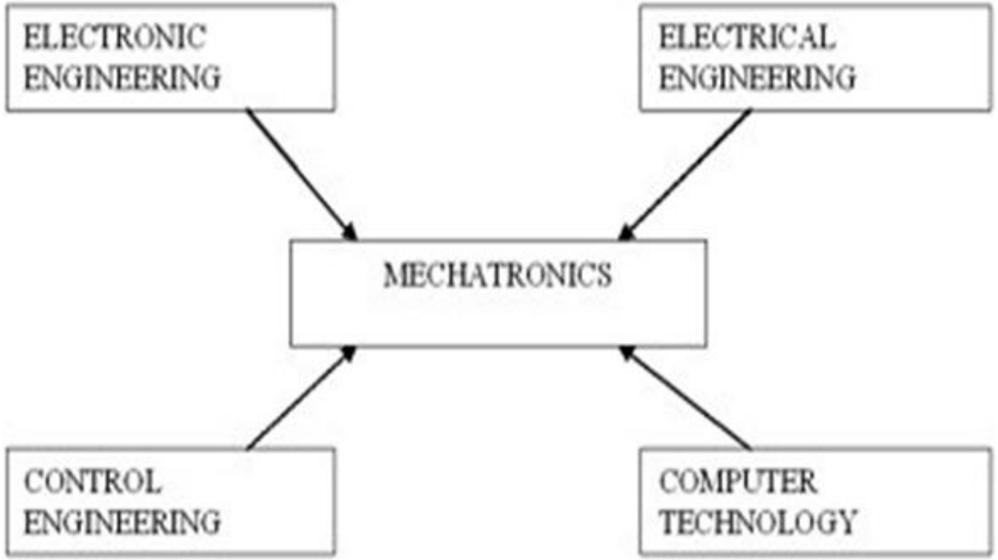
- This digital value is composed of a set of binary values called bits (often represented by 0s and 1s).
- The set of bits represents a decimal or hexadecimal number that can be used by the microcontroller.
- The microcontroller consists of a microprocessor plus memory and other attached devices.
- The program in the microprocessor uses this digital value along with other inputs and preloaded values called calibrations to determine output commands.

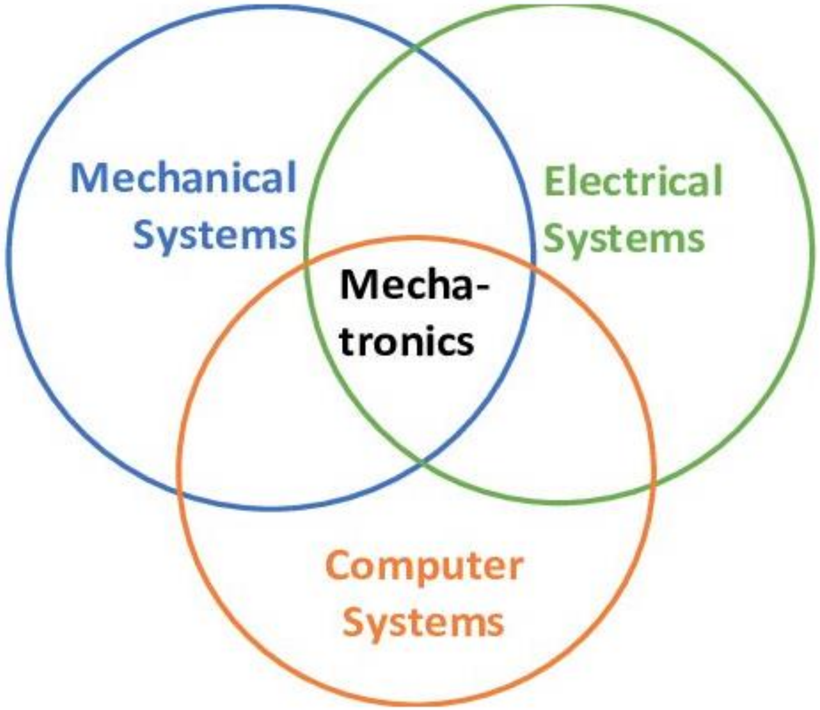
- Like the input to the microprocessor, these outputs are in digital form and can be represented by a set of bits.
- A digital-to-analog converter (DAC) is then often used to convert the digital value into an analog signal.
- The analog signal is used by an actuator to control a physical device or affect the physical environment.
- The sensor then takes new measurements and the process repeated, thus completing a feedback control loop. Timing for this entire operation is synchronized by the use of a clock.

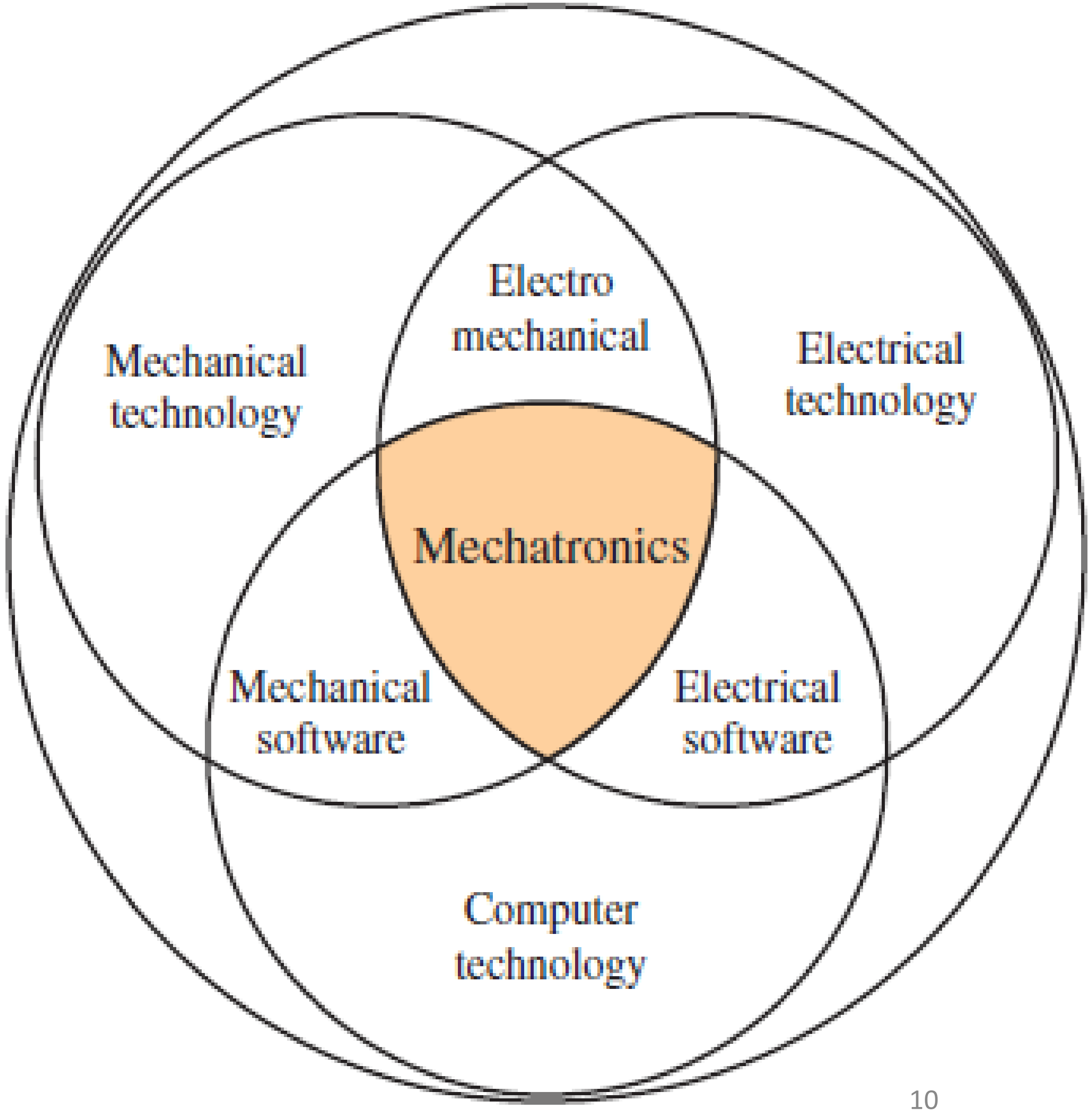
Extra information...

# Domain of Mechatronics:





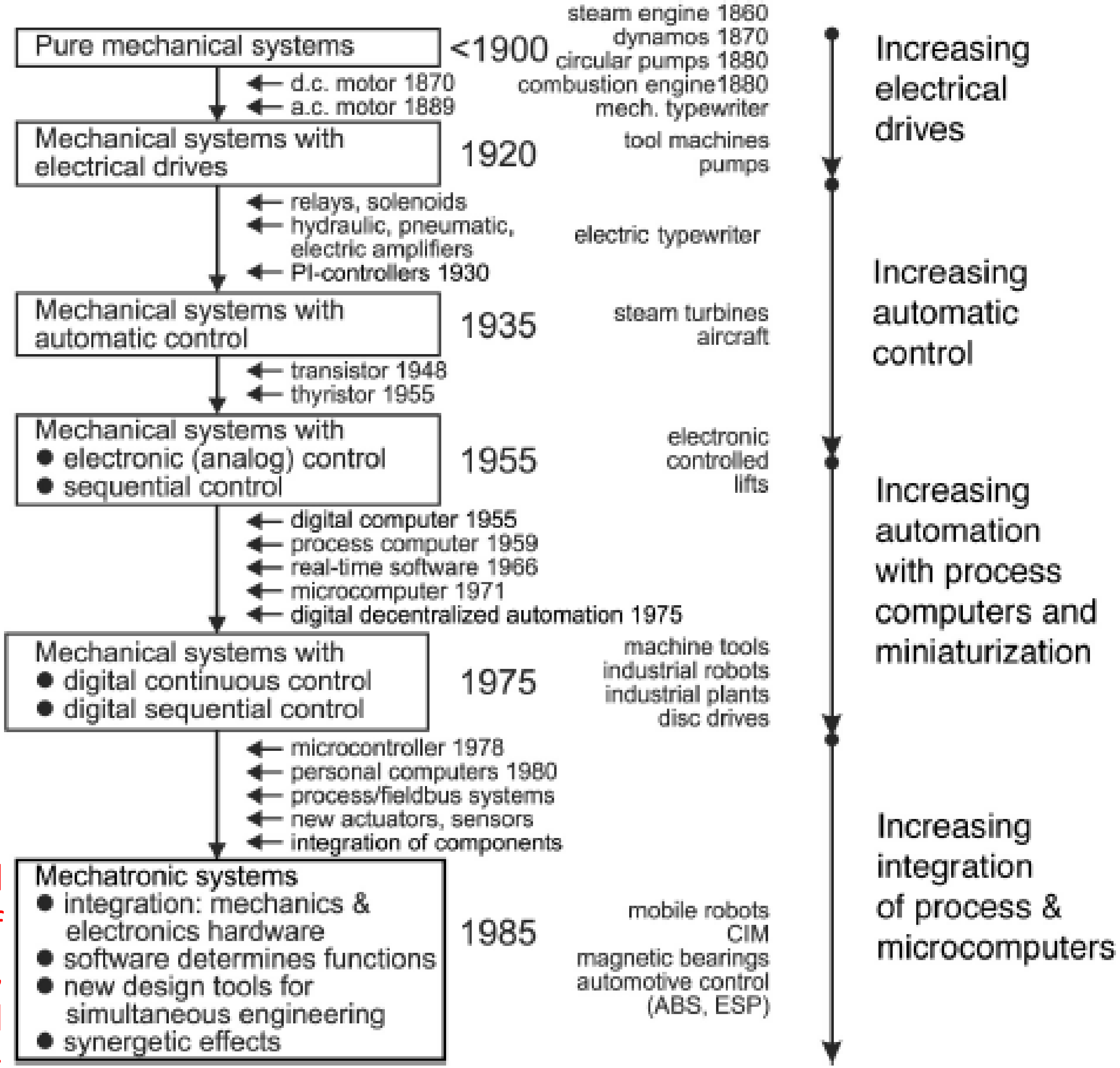



# Historical Development of Mechatronic system:

- In several technical areas the integration of products or processes and electronics can be observed.
- This is especially true for mechanical systems which developed since about 1980.
- These systems changed from electro-mechanical systems with discrete electrical and mechanical parts to integrated electronic-mechanical systems with sensors, actuators, and digital microelectronics.
- These integrated systems, are called mechatronic systems, with the connection of MECHAnics and elecTRONICS

Extra information...




Historical Development of Mechanical, Electrical, and Electronic Systems

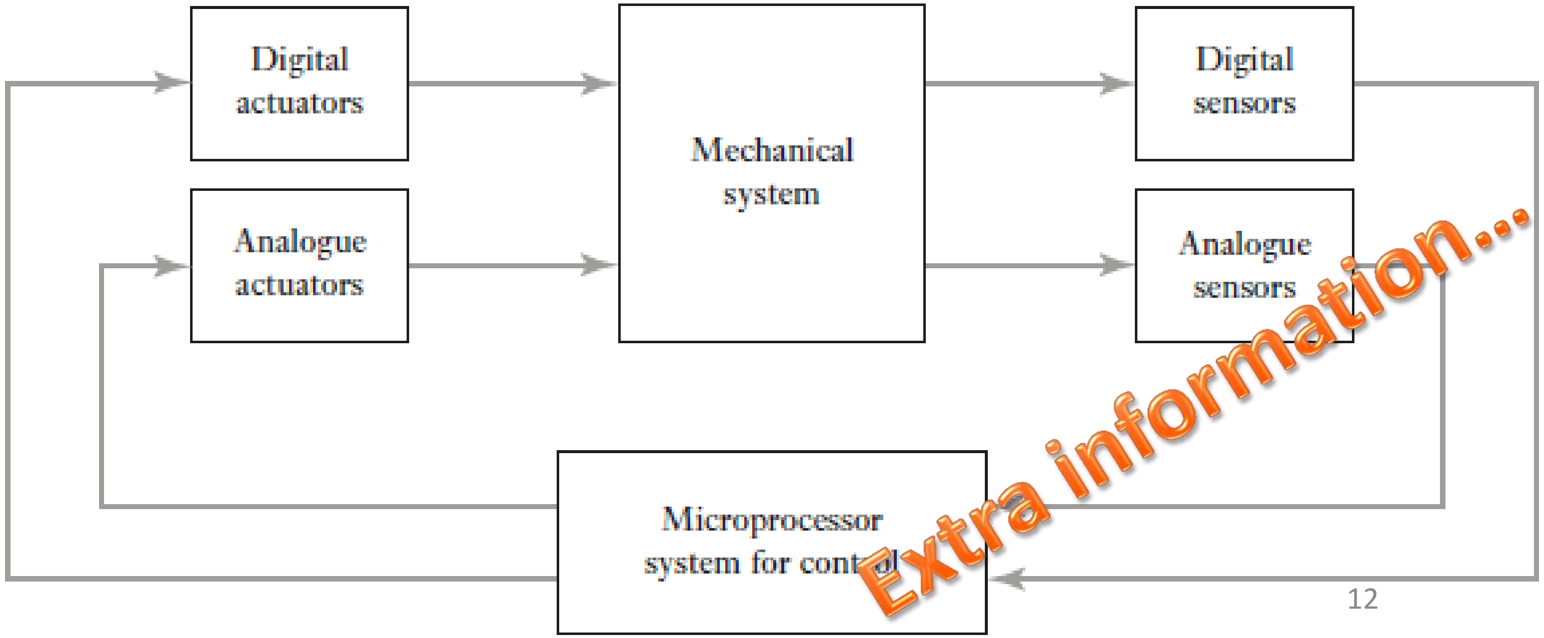
# Key elements of Mechatronics systems:

The study of mechatronic systems can be divided into the following areas of specialty:

1) Physical Systems
2) Sensors and Actuators
3) Signals and Systems
4) Computers and Logic Systems
5) Software and Data Acquisition

As the field of mechatronics continues to mature, the list of relevant topics associated with the area will most certainly expand and evolve.

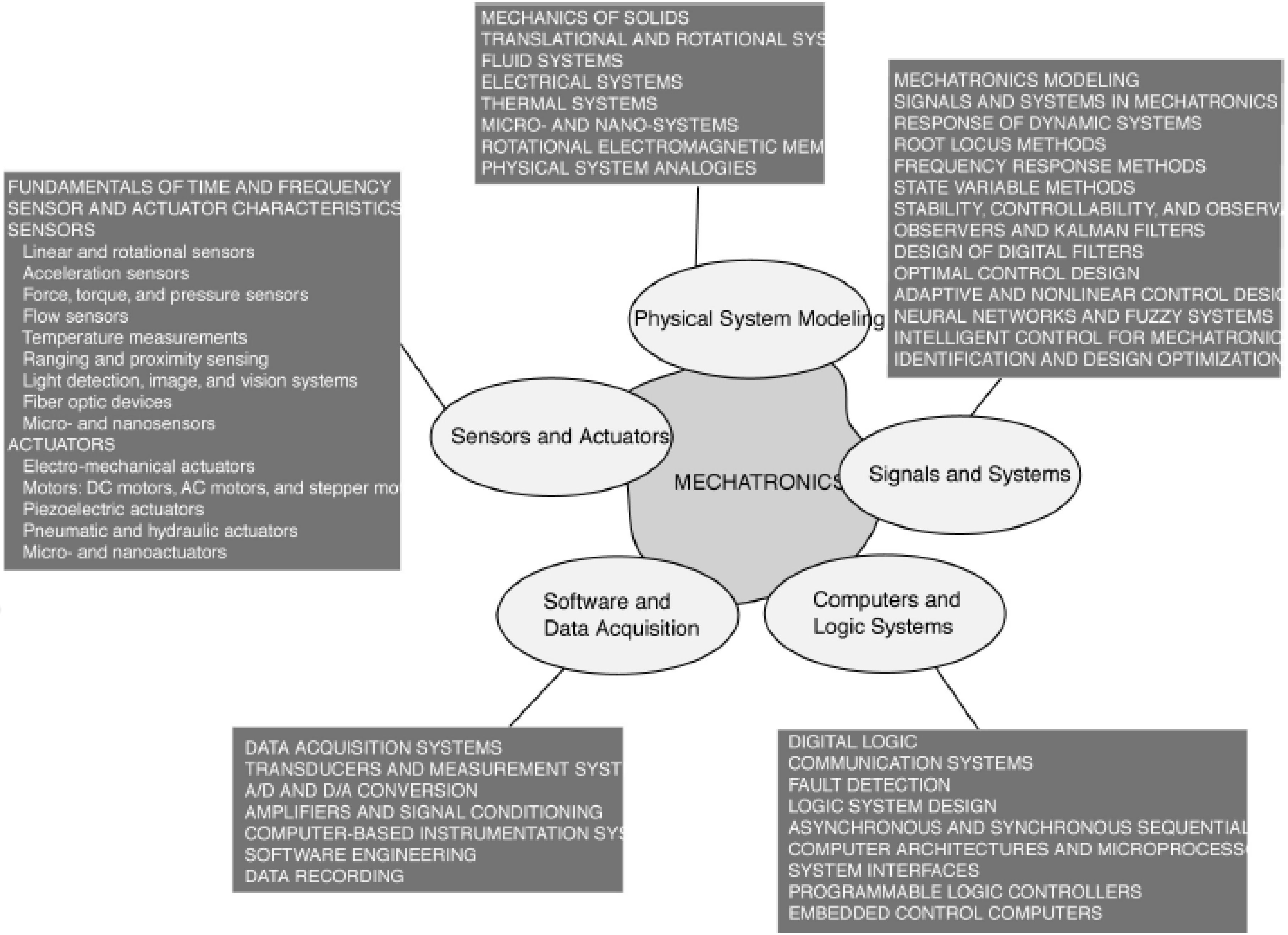
Mechatronics brings together areas of technology involving sensors and measurement systems, drive and actuation systems, and microprocessor systems (Figure), together with the analysis of the behaviour of systems and control systems.




The basic elements of a mechatronic system

# Key elements of Mechatronics systems:

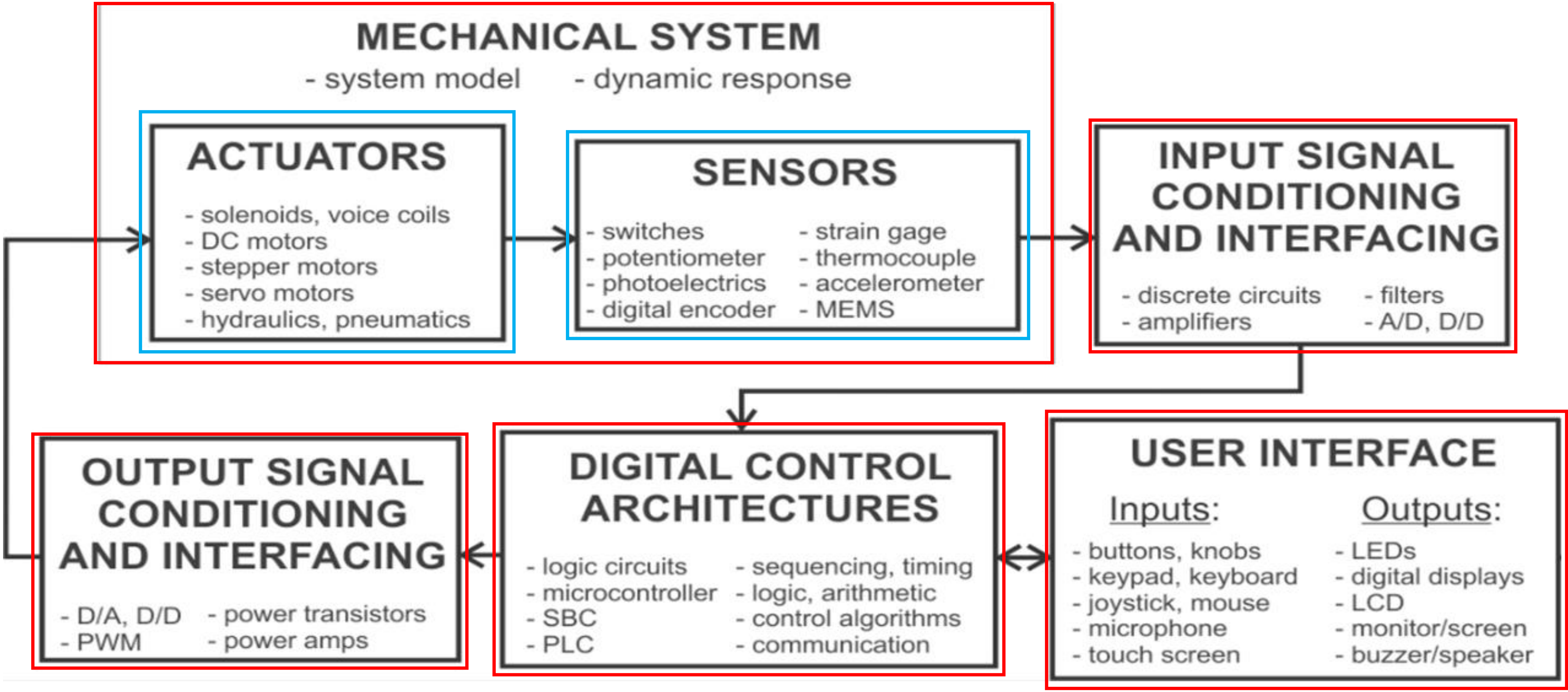
1) Physical Systems Modeling
2) Sensors and Actuators
3) Signals and Systems
4) Computers and Logic Systems
5) Software and Data Acquisition




Extra information...

# Key elements of Mechatronics systems:






**MEMS:** Micro-ElectroMechanical System
**A/D** : Analog-to-Digital Converter
**D/A** : Digital-to-Analog Converter

**PWM:** Pulse Width Modulation
**SBC** : Sensotronic Brake Control
**PLC** : Programmable Logic Controllers

# Key elements of Mechatronics systems:



## A few terminologies:

MEMS stands for micro-electromechanical system and is an umbrella term for a wide range of microfabrication designs, methods and mechanisms that involve realising moving mechanical parts at the microscopic scale.

An analog-to-digital converter (ADC) is used to convert an analog signal such as voltage to a digital form so that it can be read and processed by a microcontroller. Most microcontrollers nowadays have built-in ADC converters. It is also possible to connect an external ADC converter to any type of microcontroller

D/A converter converts digital signals into analog format, and A/D converter converts analog into digital.

The acronym PWM stands for Pulse Width Modulation. For motor controllers, PWM can refer to both the input signal and the method the controller uses to control motor speed. To control the speed of the motor the controller must vary the perceived input voltage of the motor.

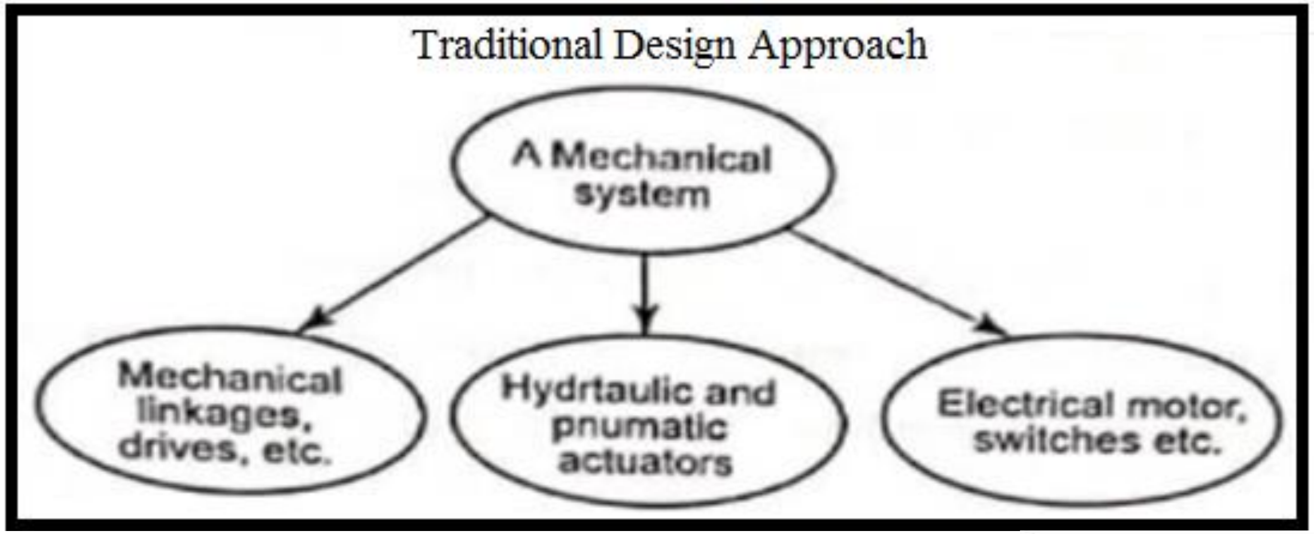
Sensotronic Brake Control (SBC) is an electro-hydraulic brake system, where the wheel brake cylinders on a vehicle are operated through a servomechanism. SBC transforms the conventional hydraulic brake into a more powerful mechatronic system in which, a large number of mechanical components are only replaced by electronics which has simplified braking for driver and opened the new page for future and scope for brake-by-wire systems like never before

Programmable Logic Controllers (PLCs) are industrial computers, with various inputs and outputs, used to control and monitor industrial equipment based on custom programming. PLCs come in many different sizes and form factors

Engineering Lifecycle Management (ELM) is a platform that integrates the product development tools to manage requirements, modeling, simulation, testing, and collaborative workflow allows planning

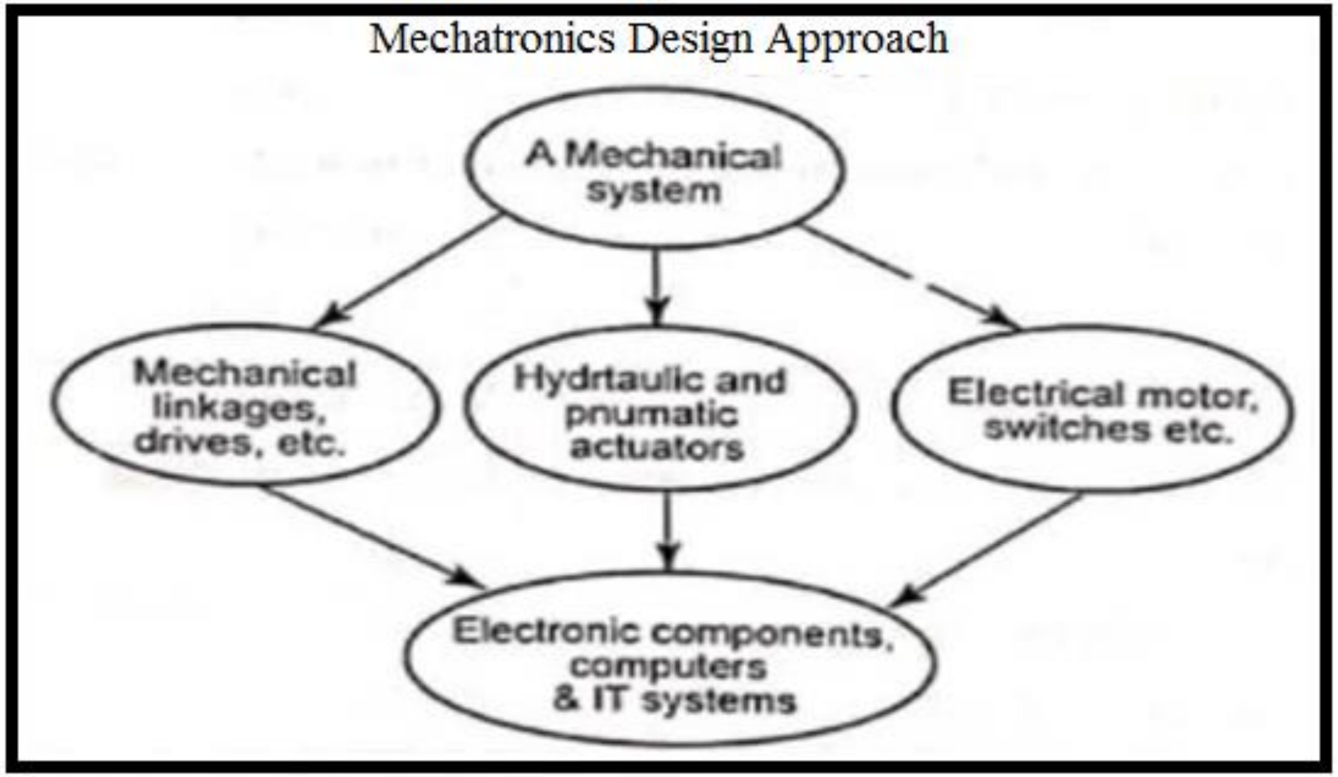
Extra information...

# Mechatronics Design Process:

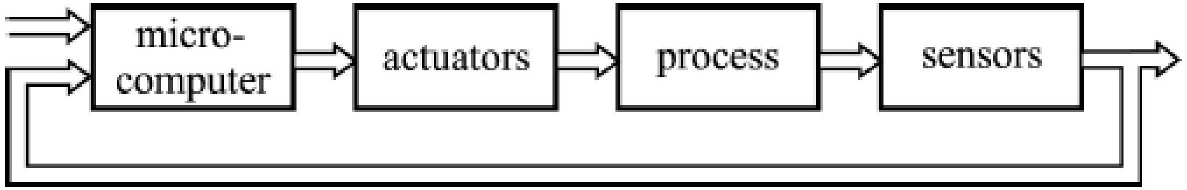



<<Traditional
Design Approach

Mechatronics
Design Approach >>



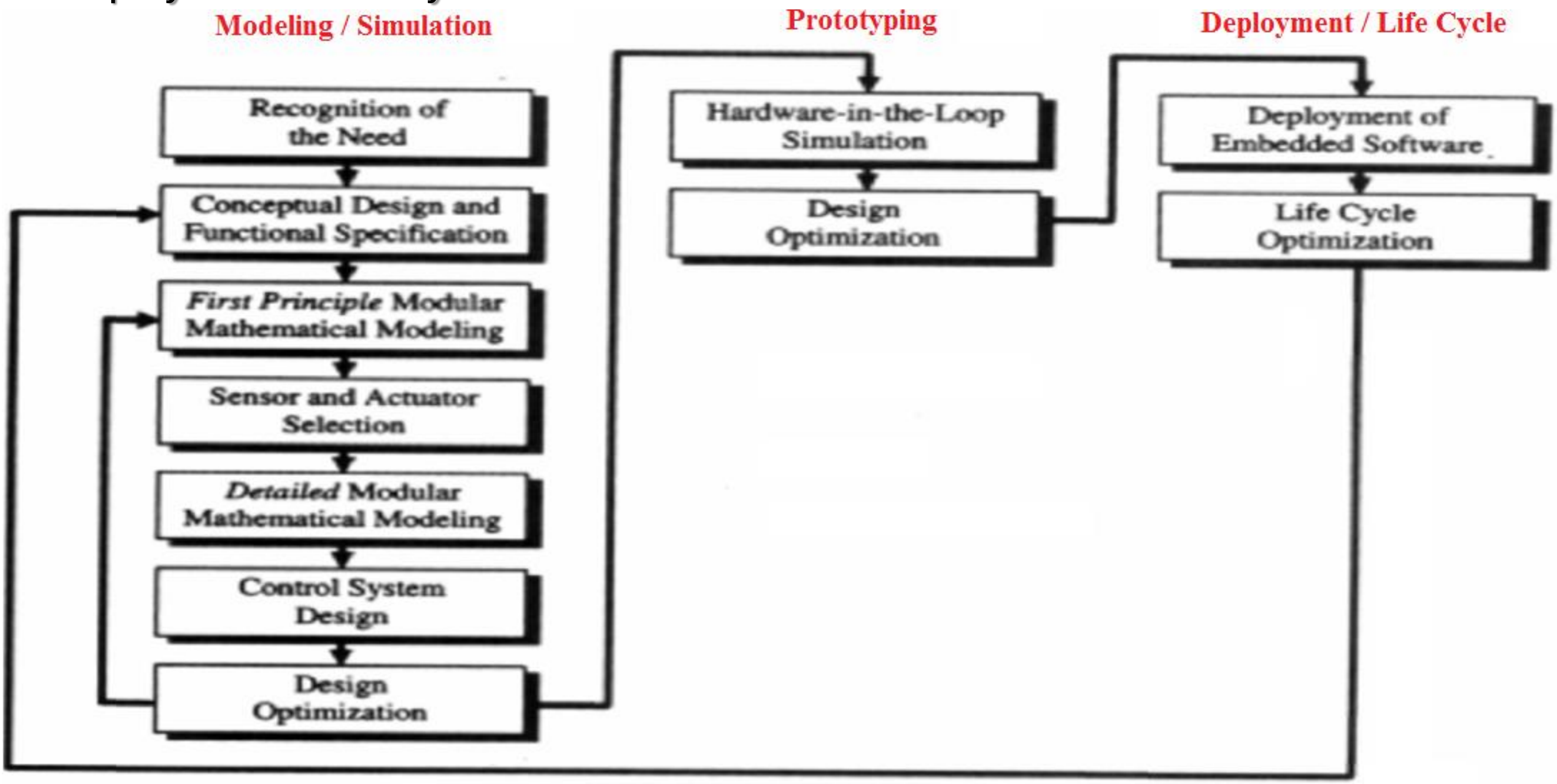

General scheme of a (classical)
Mechanical-Electronic System




General scheme of a (classical) mechanical-electronic system

# Phases of Mechatronic System Design Process:

- Modeling & Simulation
- Prototyping
- Deployment / Life Cycle




Engineering Lifecycle Management (ELM) is a platform that integrates the product development tools to manage requirements, modeling, simulation, testing, and collaborative workflow allows planning

# Comparison of Traditional and Mechatronic Design:

Concurrent Design, has motivated the combination of mechanical and electrical engineering with software engineering into a single design step to improve the obtained design solution synergically

| TRADITIONAL | MECHATRONICS |
|---|---|
| Sequential approach | Concurrent approach |
| Process controlled by relay logic | Microprocessor based programmable logic controller |
| More wiring to control computer and control room | Reduced wiring and machine cycles stored and executed via local control loops |
| Manual handling processes for loading and unloading | Use of general purpose robotic for handling,<br>Automatic tool changing |
| Maintenance on a preventive or breakdown basis | Based on in–line diagnostics and condition monitoring |

# Properties of Conventional and Mechatronic Design Systems

Properties of Conventional and Mechatronic Design Systems

| | Conventional Design | Mechatronic Design |
|---|---|---|
| | **Added components** | **Integration of components (hardware)** |
| 1 | Bulky | Compact |
| 2 | Complex mechanisms | Simple mechanisms |
| 3 | Cable problems | Bus or wireless communication |
| 4 | Connected components | Autonomous units |
| | **Simple control** | **Integration by information processing (software)** |
| 5 | Stiff construction | Elastic construction with damping by electronic feedback |
| 6 | Feedforward control, linear (analog) control | Programmable feedback (nonlinear) digital control |
| 7 | Precision through narrow tolerances | Precision through measurement and feedback control |
| 8 | Nonmeasurable quantities change arbitrarily | Control of nonmeasurable estimated quantities |
| 9 | Simple monitoring | Supervision with fault diagnosis |
| 10 | Fixed abilities | Learning abilities |

Extra information...

# Fundamentals of Mechanical Engineering

## MECHATRONICS AND ENERGY SOURCES

### Assignment – Unit 5a - 01

<<for Practice>>

1) Explain with neat sketch ….
2) Brief about …..

Note:

i) Use new A4 size sheets, provide 1” left and top margin for each sheet.
ii) Write Roll No., Name (at right top), Topic and Assignment No. (at top Middle) in the 1st sheet.
iii) Use red pen to write the questions and blue or black pen for answer
iv) Draw neat sketches using instruments (avoid free hand sketching)

# Control System :

- A control system can be understood as a system which for some particular input(s) is used to control its output to some particular value, give a particular sequence of events or give an event if certain conditions are met.

- Example:
  - ✓Central heating system
  - ✓Domestic washing machine
  - ✓Safety lock system

- Two basic forms of control systems are
  - ✓Open Loop Control System and
  - ✓Closed Loop Control System

# Open Loop Control System :

A Control System which doesn't have any feedback connected to it is called as Open Loop System.

These types of systems don't depend upon its output
i.e., in open loop systems, output is not used as a control variable for the system and it has no effect on the input.

Open loop systems are one way signal flow systems.
As these systems doesn't contain any feedback i.e., the output is not fed back to the input, these are also known as Non-Feedback Systems.

The following image shows a simple block diagram of an Open Loop System.


Basic elements of an open loop control system are:

- Control element
- Correction element
- Process

Example:

Time based bread toaster

- Control is exercised by setting a timer which determines the length of time for which the bread is toasted.
- The brownness of the resulting toast is determined solely by this preset time.
- There is no feedback to control the degree of browning to a required brownness.

# Open Loop Control System :

open loop control systems are used in many applications in day-to-day life.

Some of the popular systems, which are designed based on the concept of open loop control systems, are mentioned below:

- Electric Bulb
- Electric Hand Drier
- Time based Bread Toaster
- Automatic Water Faucet
- TV Remote Control
- Electric Drier for clothes
- Shades or Blinds on a window
- Stepper Motor or Servo Motor
- Inkjet Printers
- Door Lock System
- Traffic Control System
- Washing Machine

## Advantages of Open Loop Control System

The main advantages of the open loop control system are listed below:

- Open Loop Control Systems are very simple and easy to design.
- These are considerably cheaper than other types of control systems.
- Maintenance of an open loop control system is very simple.
- Generally, open loop systems are stable up to some extent.
- These types of systems are easy to construct and are convenient to use.

## Disadvantages of Open Loop control System

The disadvantages of open loop system are:

- The bandwidth of open loop control system is less.
- The non-feedback system doesn’t facilitate the process of automation.
- Open loop systems are inaccurate in nature and also unreliable.
- If their output is affected by some external disturbances, there is no way to correct them automatically as these are non-feedback systems.

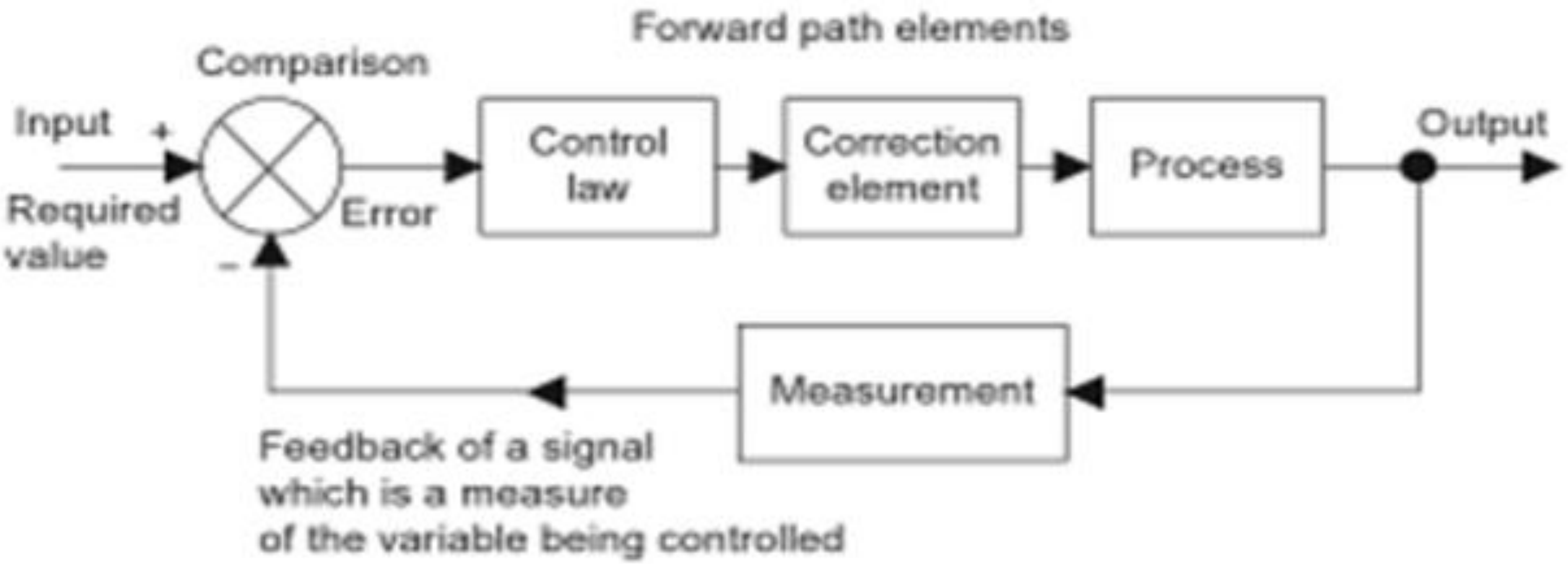
# Closed Loop Control System :

Basic elements of a closed loop control system are:

- Comparison element
- Control law
- Correction element
- Process
- Measurement element

## Example:

- Automatic water level control, Central heating control




Basic elements of a closed loop control system

# Closed Loop Control System :

Closed loop control systems are used in many applications in day-to-day life.

Some of the popular systems, which are designed based on the concept of closed loop control systems, are mentioned below:

- Motion sensed Electric Bulb
- Automated door system
- A/c System
- Automatic washing machine

## Closed loop control systems advantages and disadvantages

Closed loop control systems have positives and negatives, including the following.

Advantages

- can control for external factors
- more reliable and stable output
- resilient to disturbances and changes
- more resource-efficient

Disadvantages

- more complex
- requires tuning or integration
- susceptible to oscillation or runaway conditions
- sensor failure can cause unwanted system performance

# Open Loop and Closed Loop Control Systems :

## A Comparison >>

### Open-loop systems :

- These systems have the advantage of being relatively simple and consequently low cost with generally good reliability.
- However, they are often inaccurate since there is no correction for error.

### Closed-loop systems :

- These systems have the advantage of being relatively accurate in matching the actual to the required values.
- They are, however, more complex and so more costly with a greater chance of breakdown as a consequence of the greater number of components.

Extra information...

# Control system of a Mechatronic System:

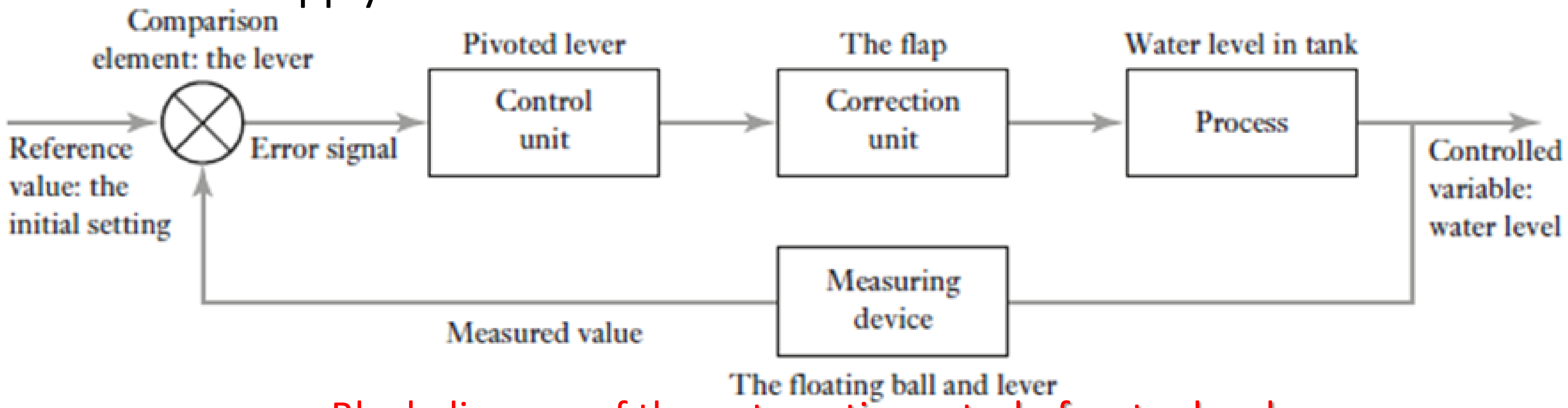
- The control system for a mechatronic system can be classified as either
  - A discrete event control system or
  - A feedback control system
- In discrete event system, the controller controls the execution of a sequence of events.
- In a feedback control system, the controller controls one or more variables using feedback sensors and feedback control laws.

  Example:
  - Automatic water level controller
  - Automatic camera
- A few systems /Applications considered are:
  - Water level controller
  - Washing Machine
  - Engine Management System (EMS)
  - Anti-lock braking System (ABS)

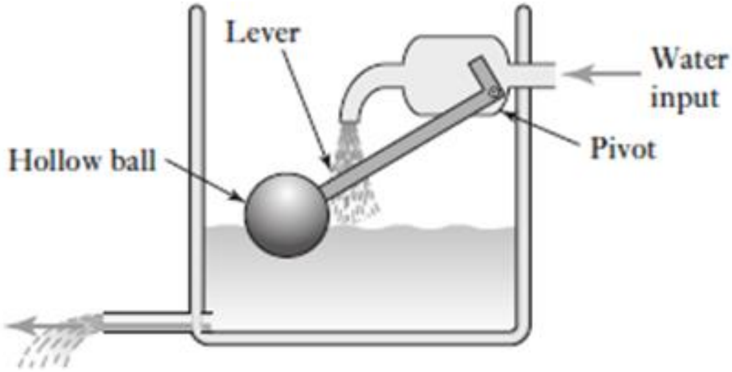
# Water Level Controller >>



- **Figure shows** an example of a simple control system used to maintain a constant water level in a tank.
- **The reference value** is the initial setting of the lever arm arrangement so that it just cuts off the water supply at the required level.
- **When water** is drawn from the tank the float moves downwards with the water level.
- **This causes** the lever arrangement to rotate and so allows water to enter the tank.
- **This flow continues** until the ball has risen to such a height that it has moved the lever arrangement to cut off the water supply.




Block diagram of the automatic control of water level




Schematic diagram

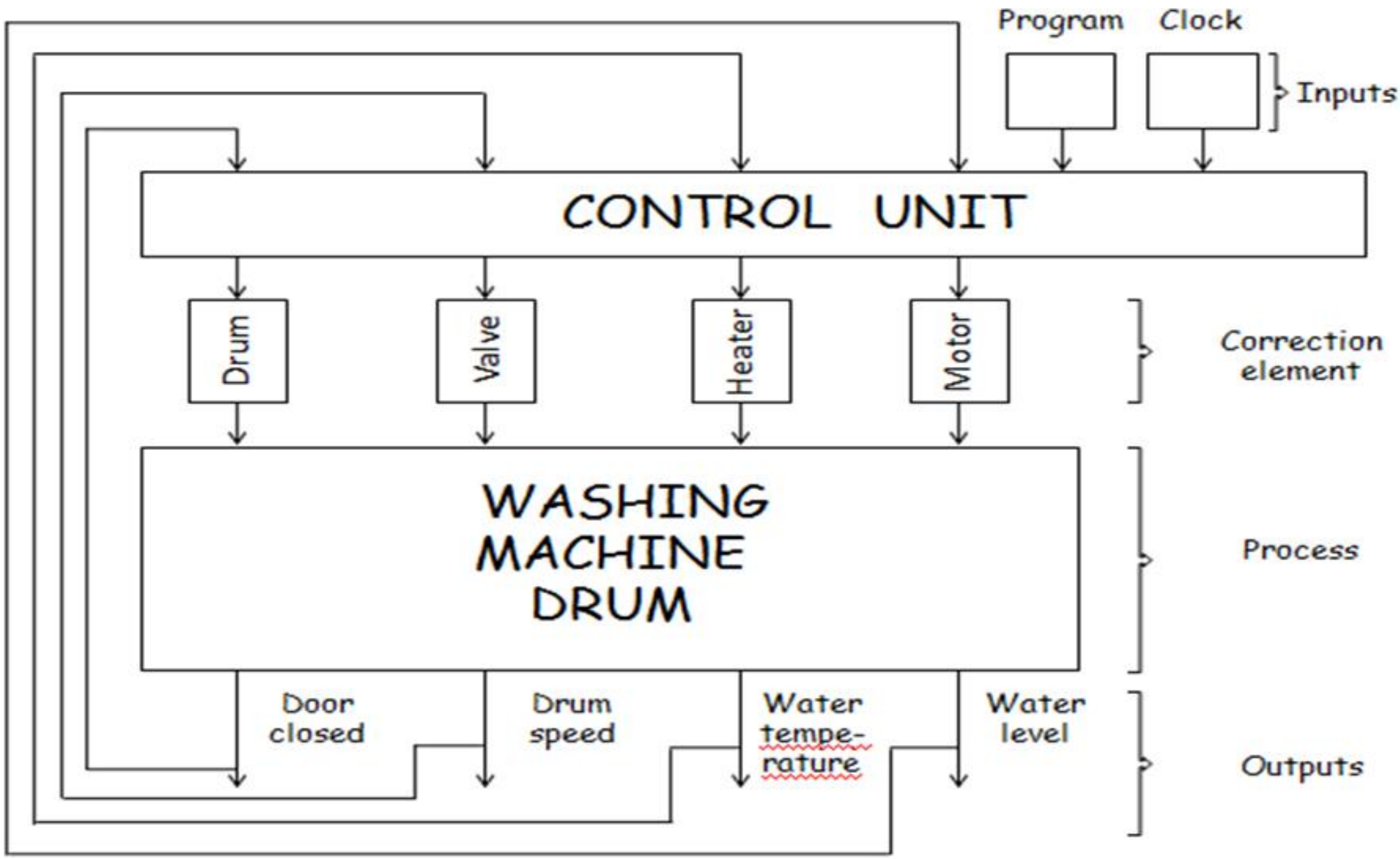
- **It is a closed-loop** control system with the elements being:
  - **Controlled variable** – water level in tank
  - **Reference value** – initial setting of the float and lever position
  - **Comparison element** – the lever
  - **Error signal** – the difference between the actual and initial settings 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 floating ball and lever

# Washing Machine >>



- **With modern washing machines**, the controller is a microprocessor and the program is not supplied by the mechanical arrangement of cams but by a software program.
- **The microprocessor** controlled washing machine can be considered an example of a mechatronics approach in that a mechanical system has become integrated with electronic controls.
- **As a consequence**, a bulky mechanical system is replaced by a much more compact microprocessor to carry out the necessary operations such as:
  - Pre-wash cycle
  - The main wash cycle
  - The rinse part of the operation
  - The final part of the operation

**Figures shows** the basic washing machine system and gives a rough idea of its constituent elements.



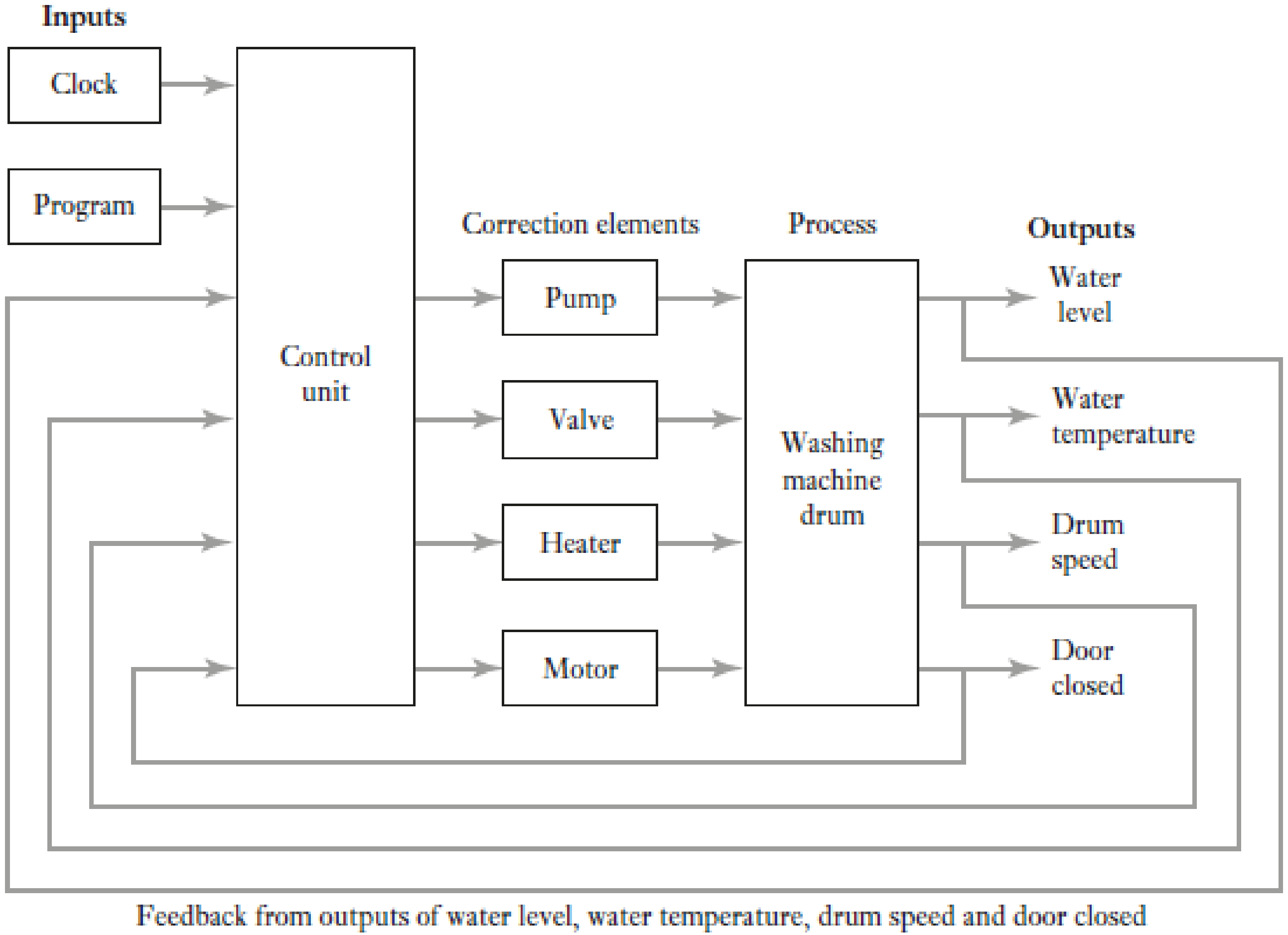

Block diagram of Automatic Washing Machine

# Automatic Washing Machine >>



- For the pre-wash cycle an electrically operated valve is opened when a current is supplied and switched off when it ceases.
- This valve allows cold water into the drum for a period of time determined by the profile of the cam or the output from the microprocessor used to operate its switch.
- However, since the requirement is a specific level of water in the washing machine drum, there needs to be another mechanism which will stop the water going into the tank, during the permitted time, when it reaches the required level.
- A sensor is used to give a signal when the water level has reached the preset level and give an output from the microprocessor which is used to switch off the current to the valve.
- In the case of a cam-controlled valve, the sensor actuates a switch which closes the valve admitting water to the washing machine drum.
- When this event is completed, the microprocessor, or the rotation of the cams, initiates a pump to empty the drum.

Extra information...

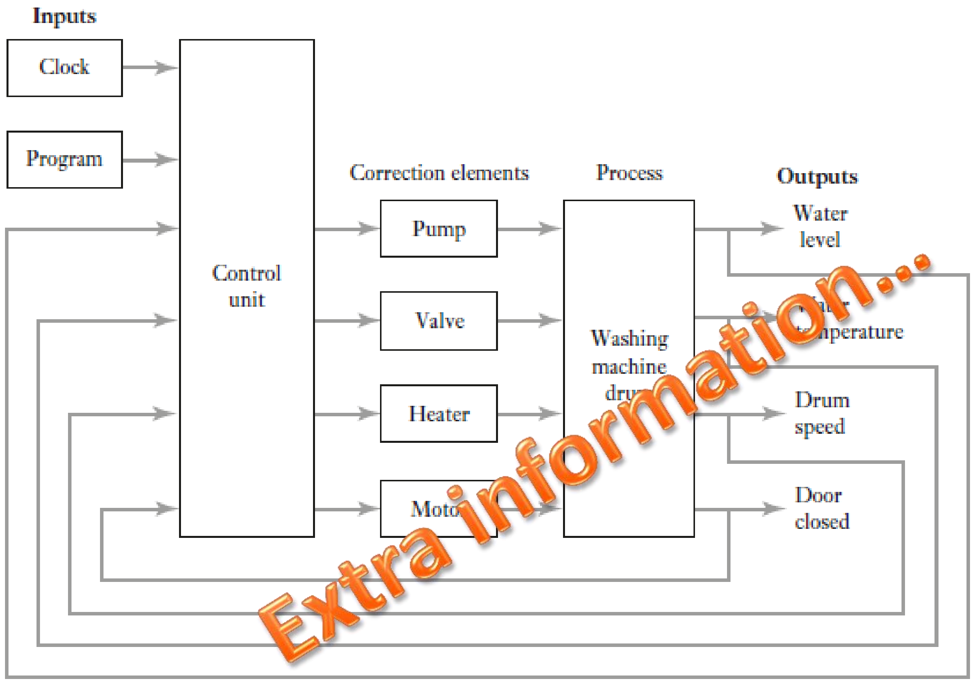



Block diagram of Automatic Washing Machine

# Automatic Washing Machine >>



- **For the main wash cycle**, the microprocessor gives an output which starts when the pre-wash part of the program is completed; in the case of the cam-operated system the cam has a profile such that it starts in operation when the pre-wash cycle is completed.
- **It switches** a current into a circuit to open a valve to allow cold water into the drum. This level is sensed and the water shut off when the required level is reached. The microprocessor or cams then supply a current to activate a switch which applies a larger current to an electric heater to heat the water. A temperature sensor is used to switch off the current when the water temperature reaches the preset value.
- **The microprocessor or cams** then switch on the drum motor to rotate the drum. This will continue for the time determined by the microprocessor or cam profile before switching off. Then the microprocessor or a cam switches on the current to a discharge pump to empty the water from the drum.
- **The rinse part of the operation** is now switched as a sequence of signals to open valves which allow cold water into the machine, switch it off, operate the motor to rotate the drum, operate a pump to empty the water from the drum, and repeat this sequence a number of times.
- **The final part of the operation** is when the microprocessor or a cam switches on just the motor, at a higher speed than for the rinsing, to spin the clothes.



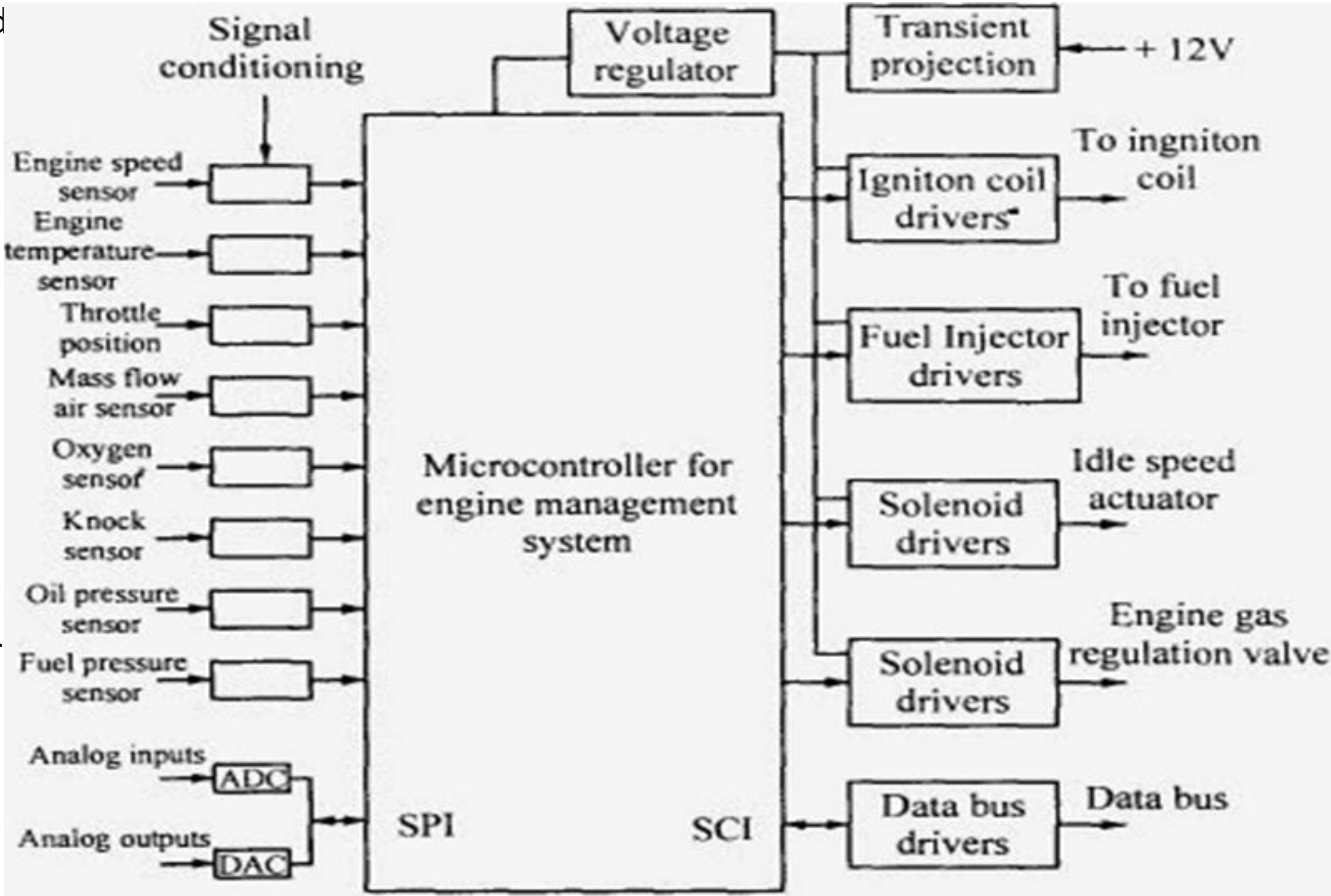

Feedback from outputs of water level, water temperature, drum speed and door closed

# Engine Management System (EMS) >>



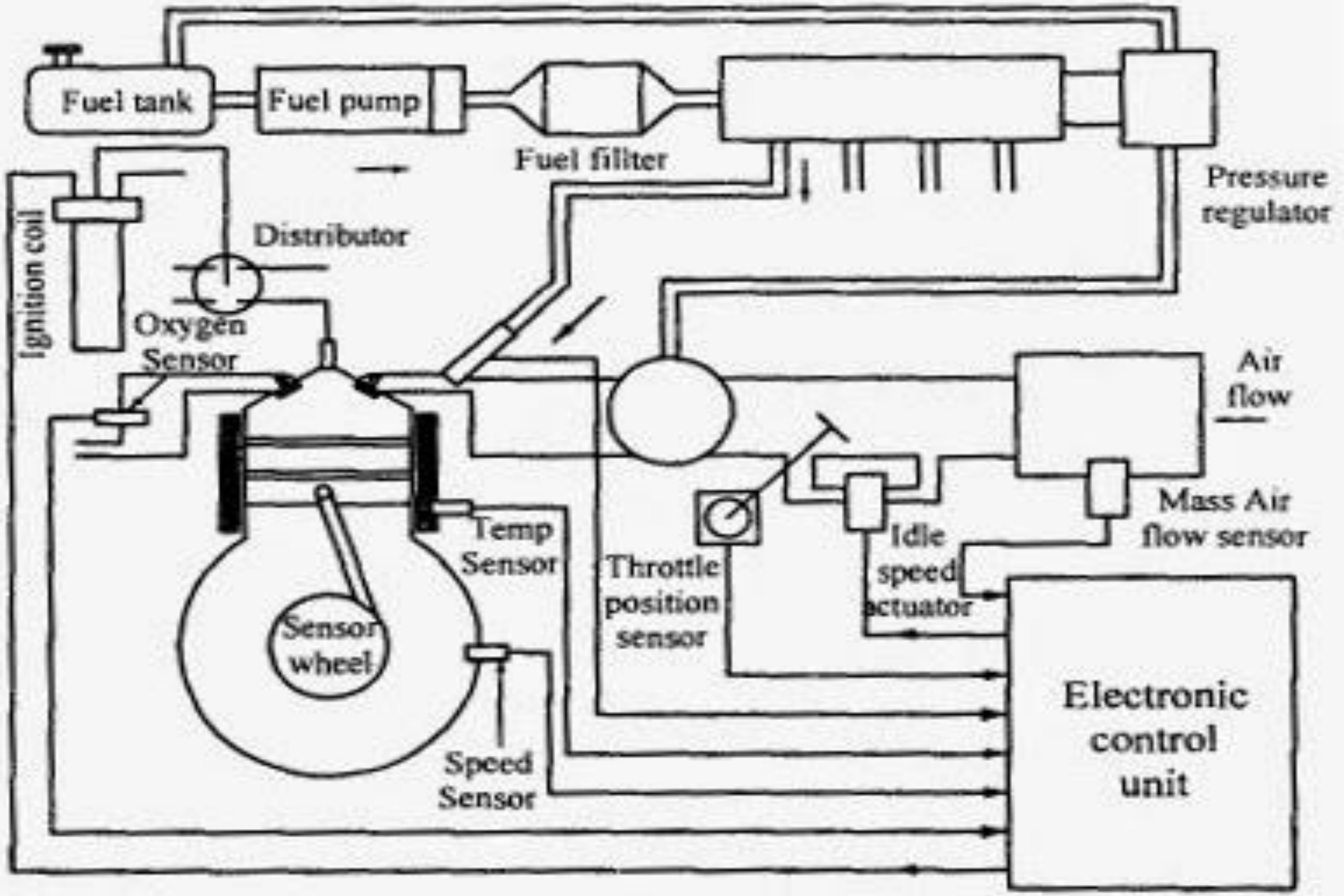
- **The engine management system** of an automobile is responsible for managing the ignition and fuelling requirements of the engine.
- **With a four-stroke internal combustion engine** there are several cylinders, each of which has a piston connected to a common crankshaft and each of which carries out a four-stroke sequence of operations.
- **The pistons of each cylinder** are connected to a common crankshaft and their power strokes occur at different times so that there is continuous power for rotating the crankshaft.
- **The power and speed of the engine** are controlled by varying the ignition timing and the air–fuel mixture.
- **With modern automobile engines** this is done by a microprocessor.

**Figure shows** the basic elements of a microprocessor control system.
**For ignition timing**, the crankshaft drives a distributor which makes electrical contacts for each spark plug in turn and a timing wheel. This timing wheel generates pulses to indicate the crankshaft position.




Block diagram of Engine Management System

# Engine Management System (EMS) >>



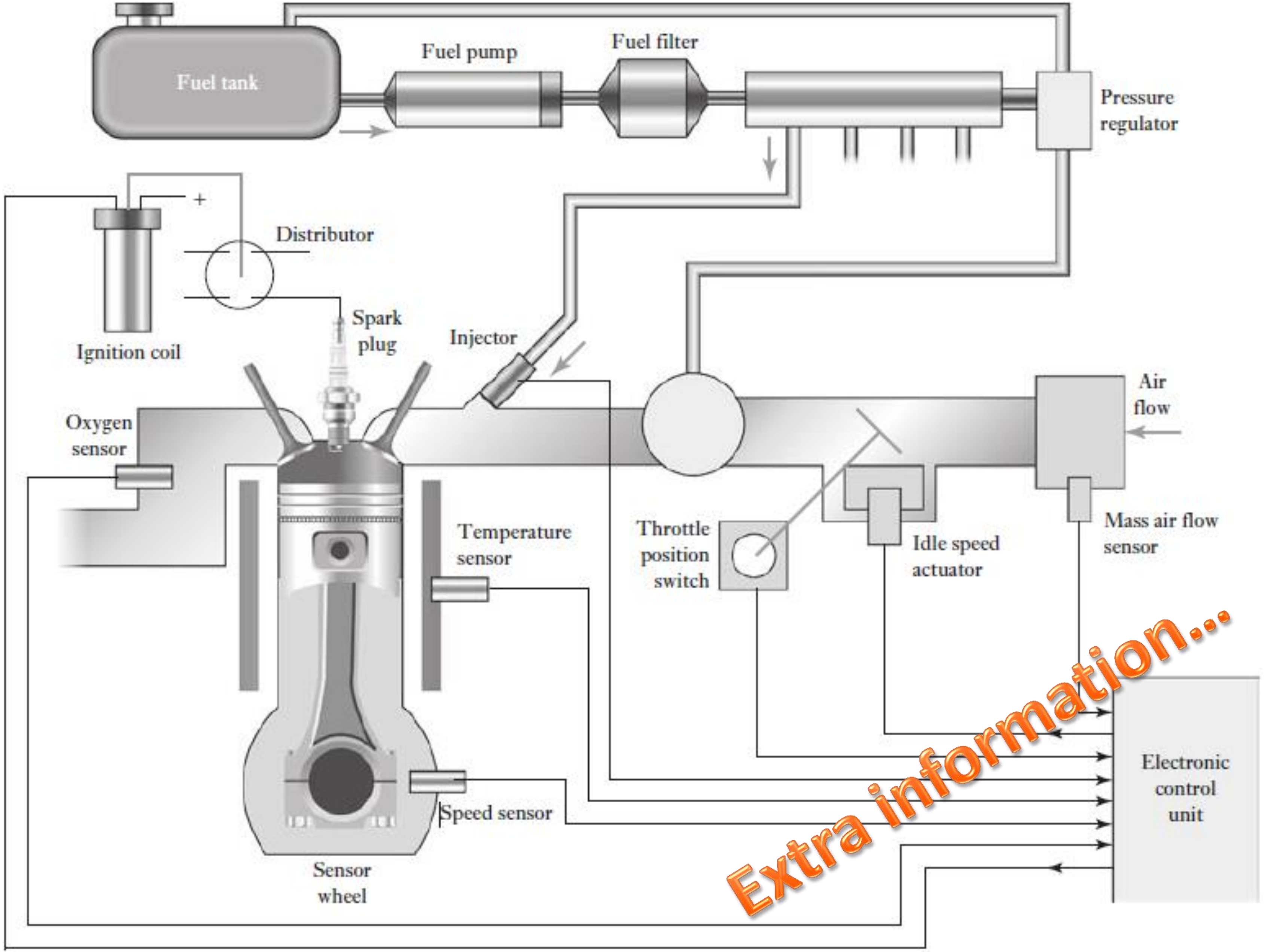

*Engine management system with sensors and actuators*

Schematic diagram of Engine Management System

# Engine Management System (EMS) >>



- **The engine control unit** (ECU) aims to ensure that the engine operates at optimal conditions at all times and includes such items as fuel-injection control, carburettor control, spark-timing control, idle-speed control and anti-knock control.
- **It does this by reading values** from many sensors within the engine bay, interpreting the results and then adjusting engine actuators accordingly.
- **Transmission control** is primarily involved in automatic transmissions. Often a single engine control unit is used for both engine and transmission control. The engine control unit includes a microcontroller, with the operating software stored in EPROMs or flash memory.
- **Figure illustrates** some of the basic inputs and outputs for an engine control system.

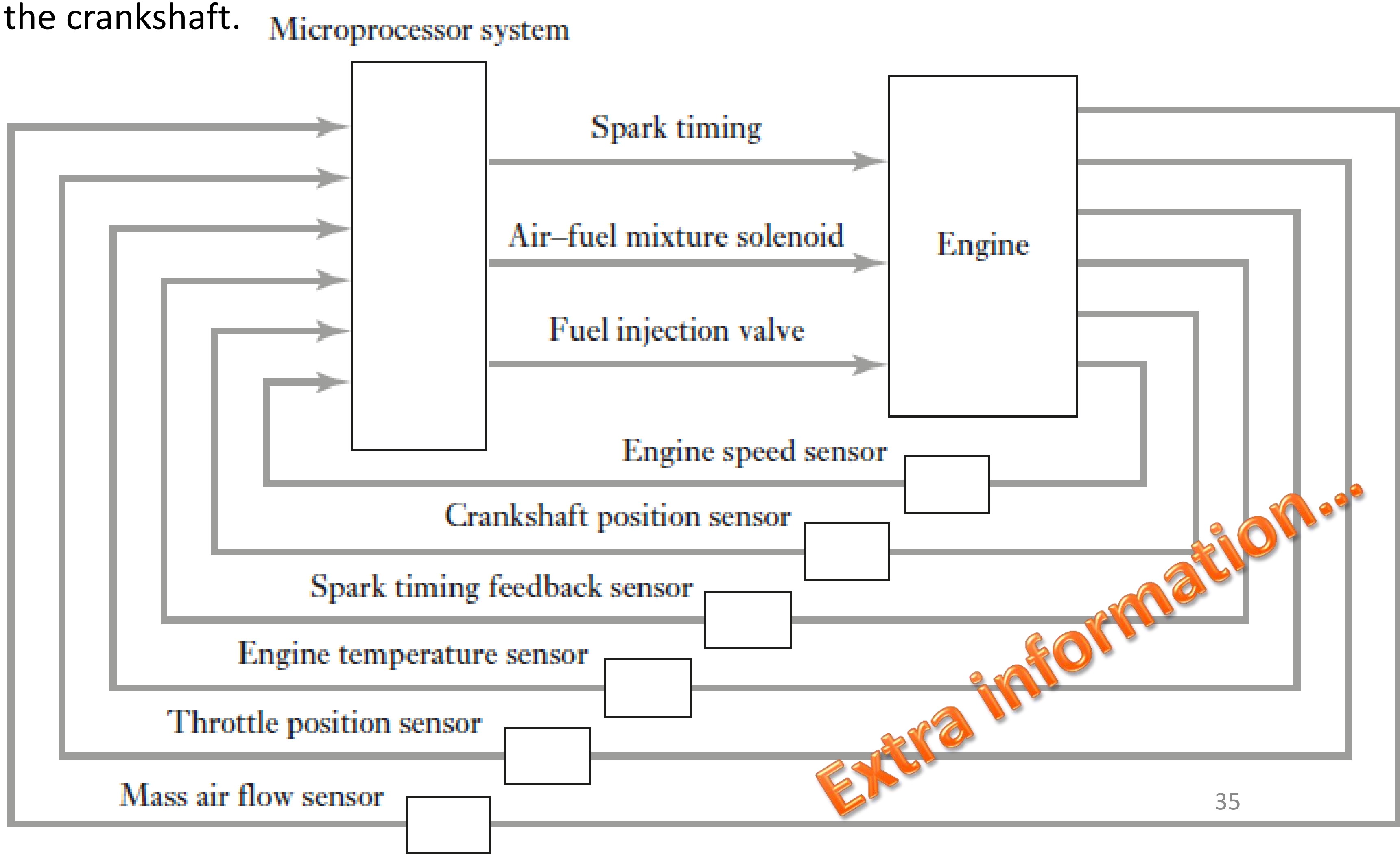



Schematic diagram of Engine Control System

# Engine Management System (EMS) >>

- The engine management system of an automobile is responsible for managing the ignition and fuelling requirements of the engine.
- With a four-stroke internal combustion engine there are several cylinders, each of which has a piston connected to a common crankshaft and each of which carries out a four-stroke sequence of operations.
- The pistons of each cylinder are connected to a common crankshaft and their power strokes occur at different times so that there is continuous power for rotating the crankshaft.
- The power and speed of the engine are controlled by varying the ignition timing and the air–fuel mixture.
- With modern automobile engines this is done by a microprocessor.

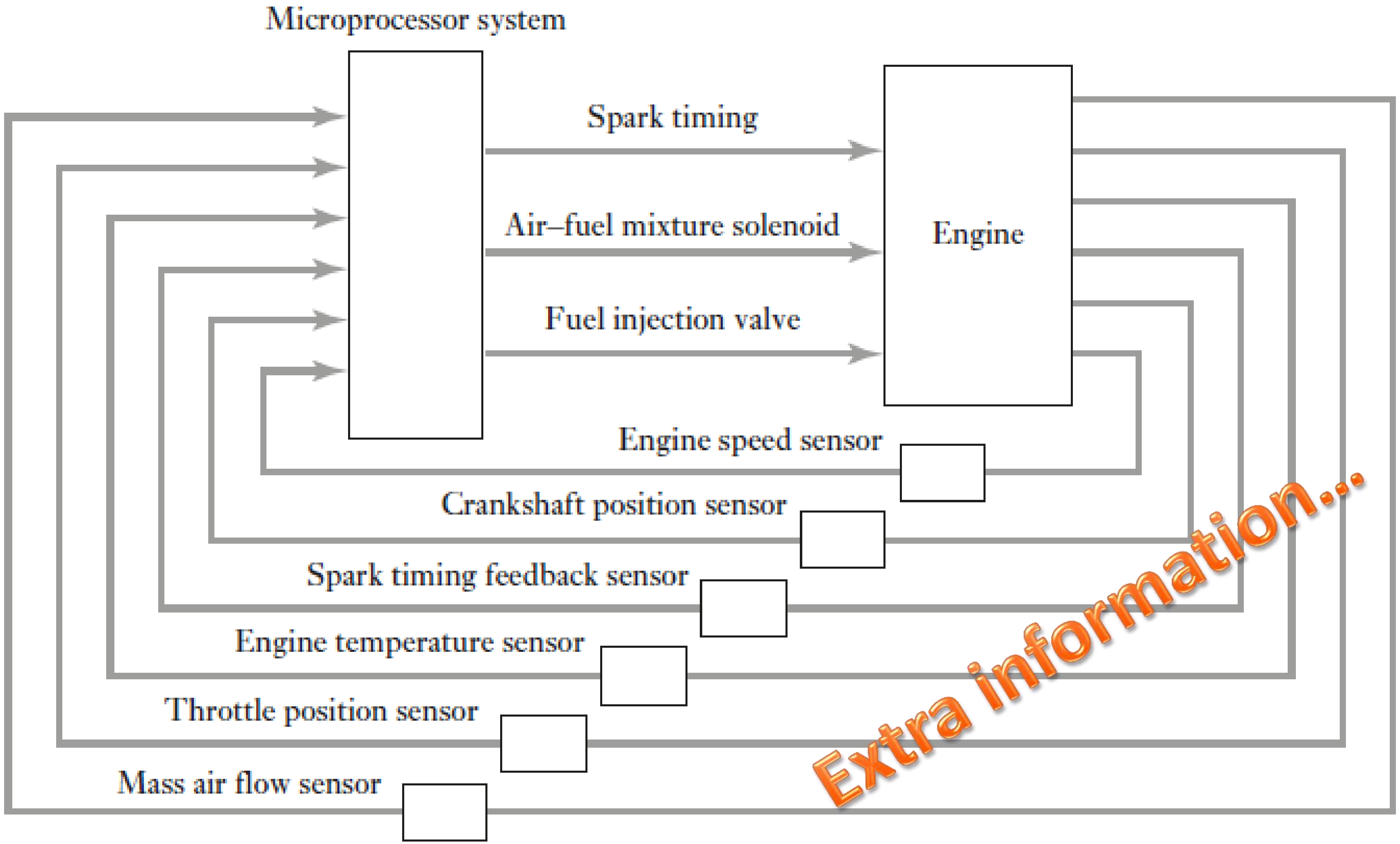
Figure shows the basic elements of a microprocessor control system.
For ignition timing, the crankshaft drives a distributor which makes electrical contacts for each spark plug in turn and a timing wheel.
This timing wheel generates pulses to indicate the crankshaft position.




Block diagram of Engine Management System

# Engine Management System (EMS) >>

- The microprocessor then adjusts the timing at which high-voltage pulses are sent to the distributor so they occur at the ‘right’ moments of time.
- To control the amount of air–fuel mixture entering a cylinder during the intake strokes, the microprocessor varies the time for which a solenoid is activated to open the intake valve on the basis of inputs received of the engine temperature and the throttle positi
- The amount of fuel to be injected into the air stream can be determined by an input from a sensor of the mass rate of air flow, or computed from other measurements, and the microprocessor then gives an output to control a fuel injection valve.
- Note that the above is a very simplistic indication of engine management.

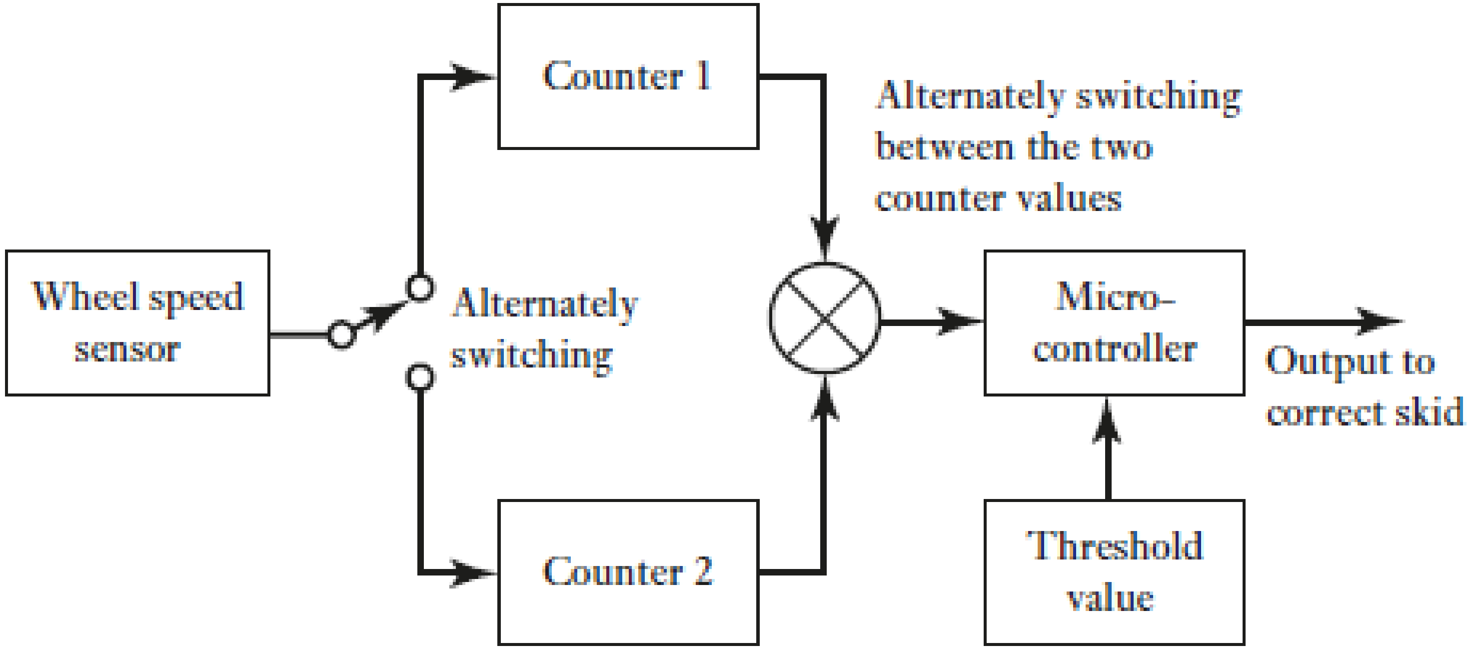



Block diagram of Engine Management System

# Anti-Lock Braking System (ABS) >>



- An example of a control system used in automobiles is the anti-lock braking system (ABS).
- The main component of an ABS system consists of two counters which alternately measure the speed of a wheel as shown in the Figure.
- If the earlier wheel speed exceeds the later wheel speed by a preset value then a skid condition is considered to have occurred.
- The ABS system then generates an electrical signal which reduces the hydraulic pressure sufficiently to eliminate the locked brake.
- The wheel speed sensor generally used is a variable reluctance tacho-generator consisting of a ferrous toothed wheel which, as it rotates, produces pulses in a pick-up coil.
- The pulses when counted give a measure of the wheel speed.
- A magnetic sensor is chosen because, unlike optical sensor systems, it is not affected by the inevitable contamination of the wheel and sensor by mud and water.

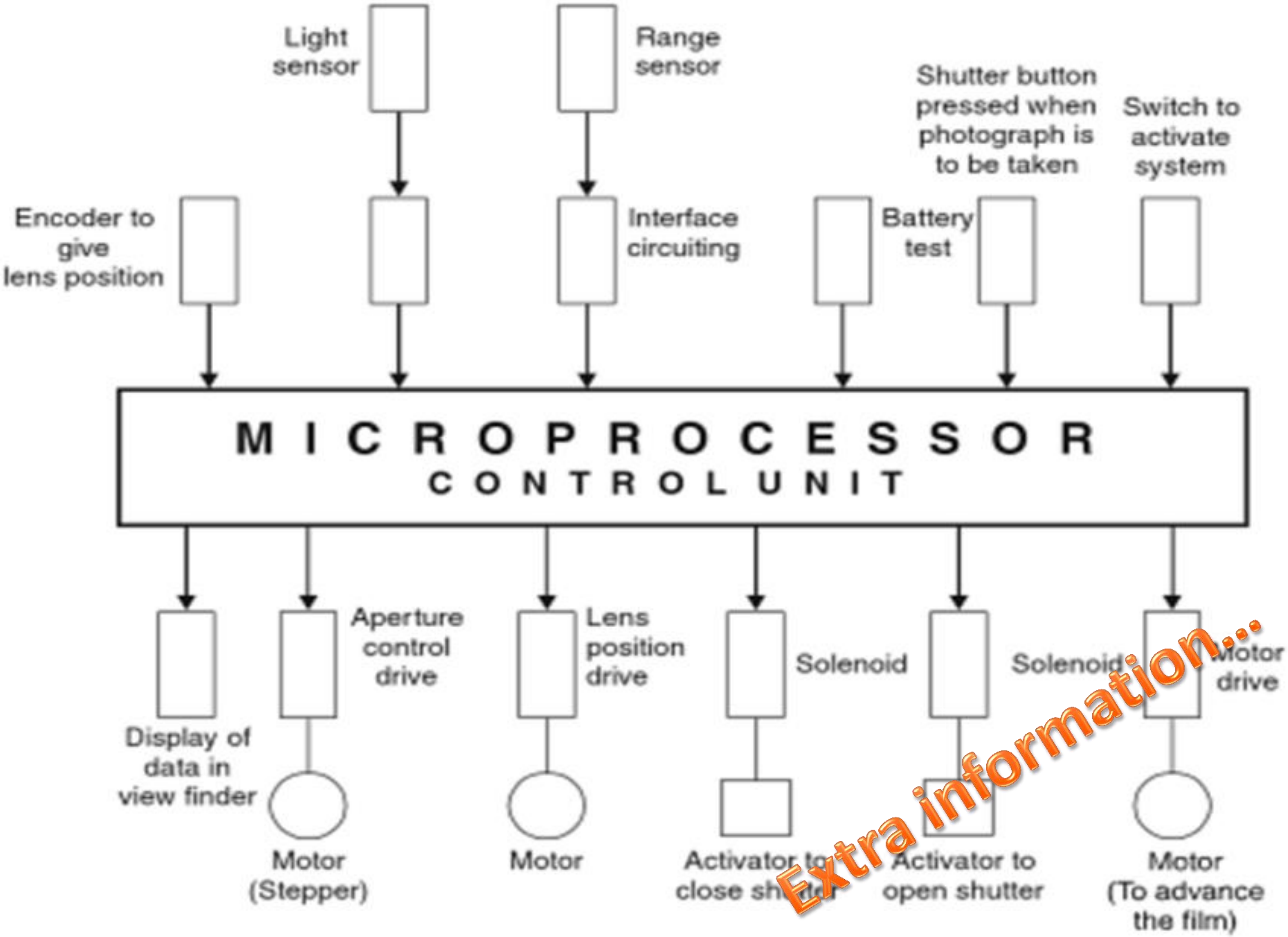



Block diagram of Anti-lock braking system

# Automatic Camera >>

The mechatronics system in use in an automatic camera for adjusting the aperture for correct exposures involves a mechanism for adjusting the size of the diaphragm.

when a microprocessor controller gives a signal to, say, move the lens for focusing in an automatic camera then it takes time before the lens reaches its position for correct focusing.




Block diagram of Automatic Camera

# Fundamentals of Mechanical Engineering

## MECHATRONICS AND ENERGY SOURCES

### Assignment – Unit 5a - 02

<<for Practice>>

1) Explain with neat sketch ….
2) Brief about …..

Note:

i) Use new A4 size sheets, provide 1" left and top margin for each sheet.
ii) Write Roll No., Name (at right top), Topic and Assignment No. (at top Middle) in the 1$^{st}$ sheet.
iii) Use red pen to write the questions and blue or black pen for answer
iv) Draw neat sketches using instruments (avoid free hand sketching)

# Course Outcomes (COs):

| | |
|---|---|
| **Course Outcomes: After completing the course, the students will be able to:-** | |
| **CO 1** | Understand the knowledge of various properties of Engineering materials and their Joining processes |
| **CO 2** | Elucidate the principles and operation of vision system in product inspection. |
| **CO 3** | Illustrate the Energy sources, mechanical drives and electrical drives in industrial applications |
| **CO 4** | Understand about Mechatronics, Automation and Robotics in Industrial Applications |

# References:

| | |
|---|---|
| **Reference Books** | |
| 1. | Elements of Mechanical Engineering, K. R. Gopalakrishna, Subhas Publications, 18th Edition. ISBN 5551234002884 |
| 2. | Material Science & Engineering- William D Callister, 2 / 10th Edition, ISBN 978-1-119-45520-2. |
| 3. | Welding Technology (PB), Khanna O P, Dhanpat Rai publication, 4th Edition, ISBN 9383182555. |
| 4. | Electric and Hybrid Vehicles, Design Fundamentals – Iqbal Husain, CRC Press, 2nd Edition, 2010. ISBN – 13-978-1439811757. |
| 5. | Modern Electric, Hybrid Electric & Fuel Cell Vehicles, Fundamentals, Theory and Design - Mehrdad Ehsani, CRC Press, 1st Edition, 2005. ISBN – 13- 978-0849331541. |
| 6. | Mechatronics – Electronic control systems in Mechanical and Electrical Engineering, William Bolton, Pearson, 6th Edition, ISBN: 978-1-292-07668-3, 2015. |

# Assessment and Evaluation Pattern:

| CONTINUOUS INTERNAL EVALUATION | | |
|---|---|---|
| **ASSESSMENT AND EVALUATION PATTERN**<br>Theory & quizzes questions are to be framed using Bloom's Taxonomy Levels - Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating | | |
| **WEIGHTAGE** | **CIE (50%)** | **SEE (50%)** |
| **A. QUIZZES:** Each quiz is evaluated for 10 marks | | |
| Quiz-I for 10 Marks | **20** | ***** |
| Quiz-I for 10 Marks | | |
| **B. TESTS:** Each test will be conducted for 50 Marks adding upto 100 marks. Final test marks will be reduced to 40 | | |
| Test – I for 50 Marks | **40** | ***** |
| Test – II for 50 Marks | | |
| **C. EXPERIENTIAL LEARNING:**<br>Fabrication of prototype of energy generator – 10 marks<br>Fabrication of Mechatronics/Electrical/Mechanical drive prototype components– 20 marks<br>Prototype models of Robot – 10 marks | **40** | ***** |
| **TOTAL MARKS FOR THE COURSE (A+B+C)** | **100** | **100** |

# Practice to Prepare

## ***All The Best***