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ACE 316

Elective -1: Mechatronics-1

3rd year- 1st Semester

Lecture-3

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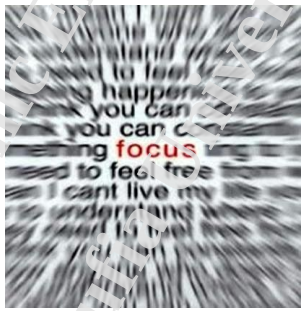
Lectures Policy

- الإحترام المتبادل
- الاختلاف لا يفسد للود قضية
- المشاركة الفعالة
- البشاشة والابتسام



Chapter 1: Introduction to Mechatronics

- What is “Mechatronics” ?
- Evolution of Mechatronics
- Advantages and disadvantages of Mechatronics
- Mechatronics Applications
- Elements of Mechatronics System
- Measurement System

Chapter Objectives

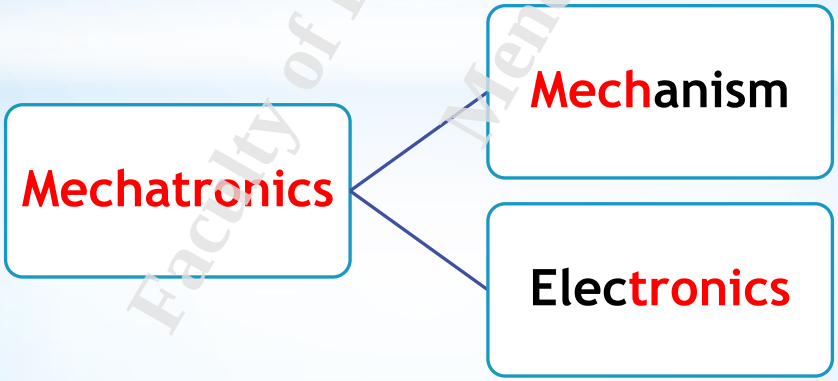
- Trace the **origin of mechatronics**;
- Understand the **key elements of mechatronics systems**;
- Relate with **everyday examples of mechatronics systems**;
- Appreciate **how mechatronics integrates knowledge from different disciplines** in order to realize engineering and consumer products that are useful in everyday life.

Mechanical electronics

What is "Mechatronics" ?

- The word mechatronics was **originated** from Japan (Yasakawa Electric Company) in the late 1960s, spread through Europe, and is now commonly used round the globe.

- "The word, mechatronics, is composed of '**mecha**' from **mechanism** and the '**tronics**' from **electronics**.



Mechanical Electronics

What is "Mechatronics" ?

- Mechatronics **solves technological problems** using interdisciplinary knowledge consisting of mechanical engineering, electronics, and computer technology.

- In 1996, Harashima, Tomizuka, and Fukuda **defined mechatronics** as being "**the synergistic integration of mechanical engineering, with electronics and intelligent computer control in the design and manufacturing of industrial products and processes**."

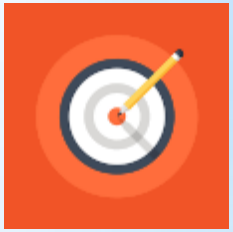
- Bolton presented yet another definition by saying "**a mechatronic system is not just a marriage of electrical and mechanical systems and is more than just a control system; the mechatronic system is a complete integration of all of them**."

Mechanical Mechatronics

What is "Mechatronics" ?

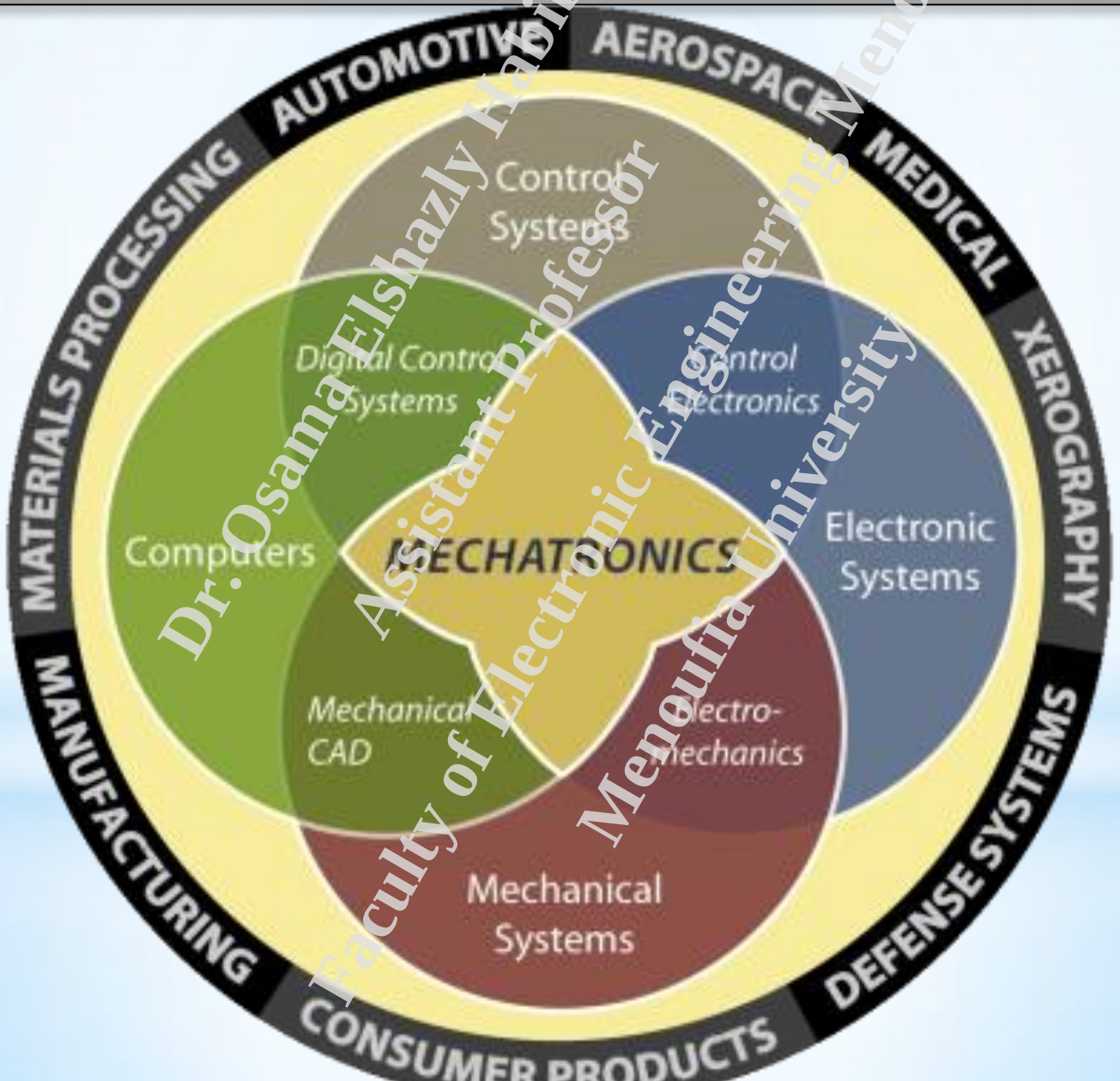
- Mechatronics is the field of study concerned with the **design**, **selection**, **analysis**, and **control** of systems that combine mechanical elements with electronic components, including computers and/or microcontrollers.

❖ Working definition

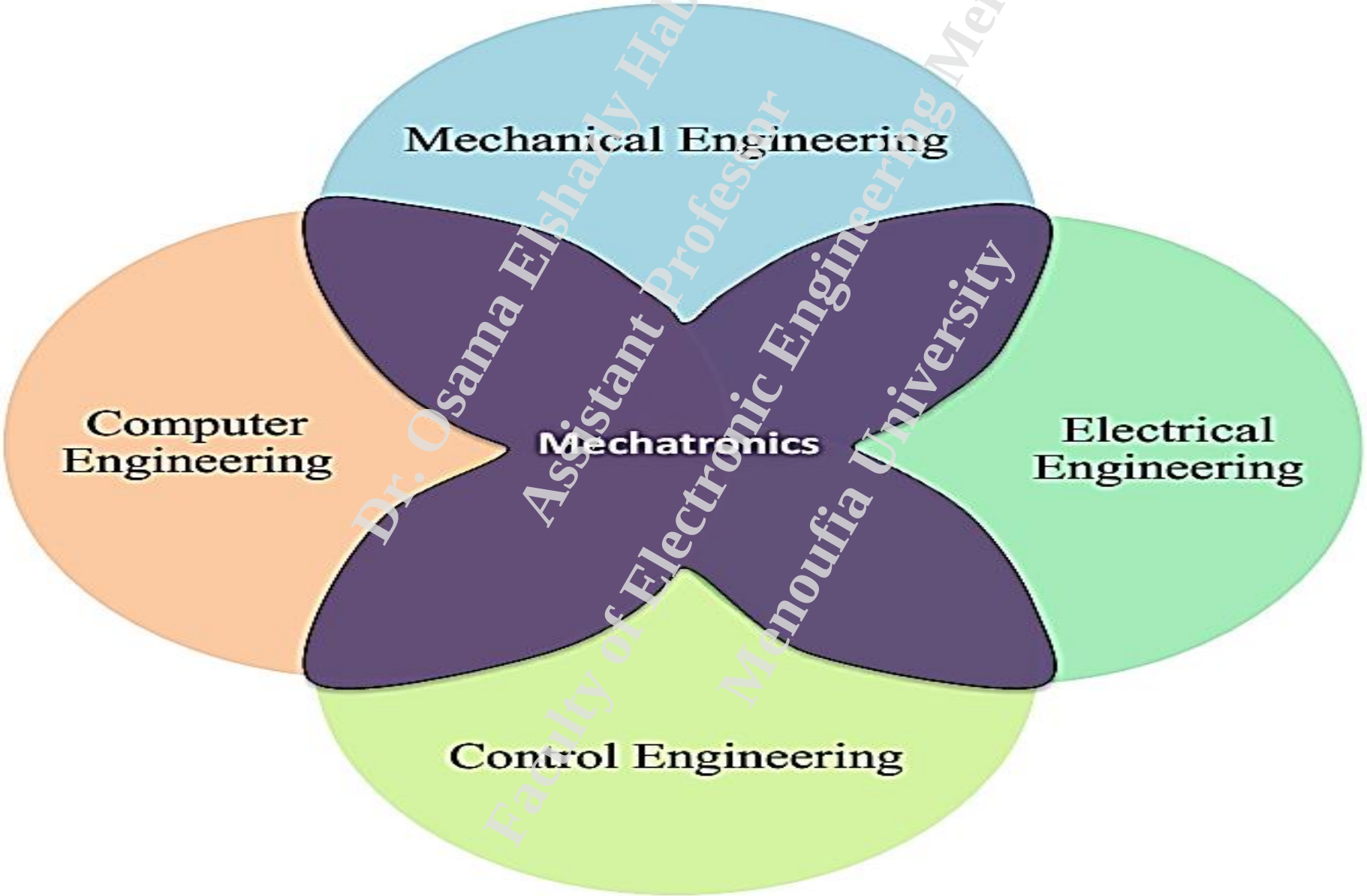


- **Mechatronics** is the synergistic integration of sensors, actuators, signal conditioning, power electronics, decision and control algorithms, and computer hardware and software to manage complexity, uncertainty, and communication in engineered systems.

Disciplinary foundations of Mechatronics



So



So

- Mechatronics can also be termed as replacement of mechanics with electronics **or enhance** mechanics with electronics.
- **For example**, in modern automobiles, mechanical fuel injection systems are now replaced with electronic fuel injection systems.
- This replacement made the automobiles more efficient and less pollutant.
- With the help of microelectronics and sensor technology, mechatronics systems are providing high levels of precision and reliability.

So

- By employment of reprogrammable microcontrollers or PLC, it is now easy to add new functions and capabilities to a product or a system.
- Today's **domestic washing machines** are "intelligent" and **four-wheel passenger automobiles** are equipped with safety installations such as air-bags, parking (proximity) sensors, antitheft electronic keys etc.

Evolution of Mechatronics

- Technological advances in design, manufacturing, and operation of engineered products/devices/processes can be traced through:

  - **Industrial revolution**
  - **Semiconductor revolution**
  - **Information revolution**

- **Industrial Revolution**

- Allowed design of products and processes for energy conversion and transmission thus allowing the use of energy to do useful work.

Evolution of Mechatronics

➢ Industrial Revolution

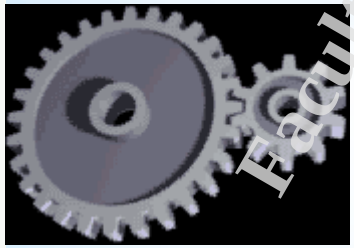
❖ Engineering designs of this era were largely mechanical

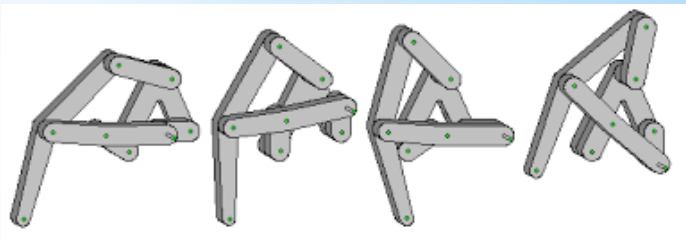
➢ e.g., operations of motion transmission, sensing, actuation, and computation were performed using mechanical components such as cams, gears, levers, and linkages).

❖ Purely mechanical systems suffer from:

➢ Power amplification inability.

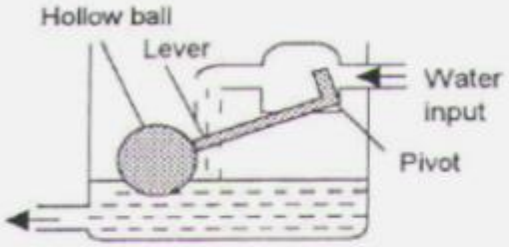
➢ Energy losses due to tolerances, inertia, and friction.



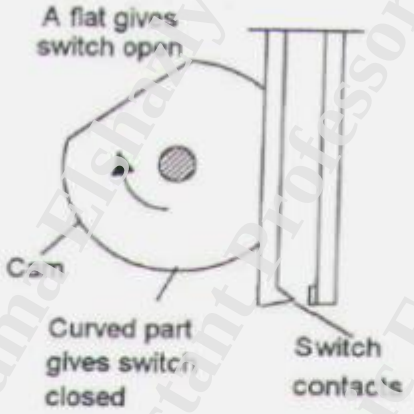


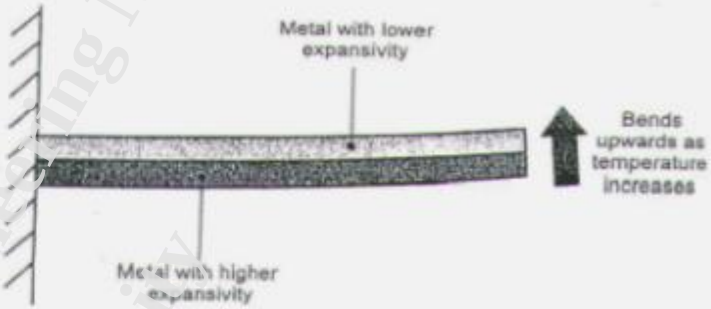
Evolution of Mechatronics

Examples of Predominantly Mechanical Designs

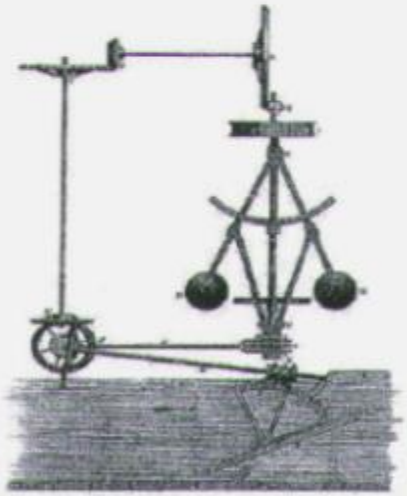


Float Valve

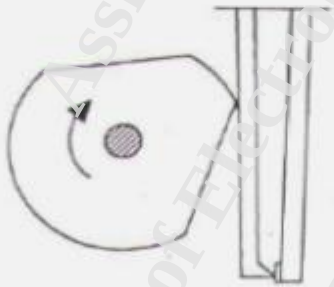




Bi-metallic Strip

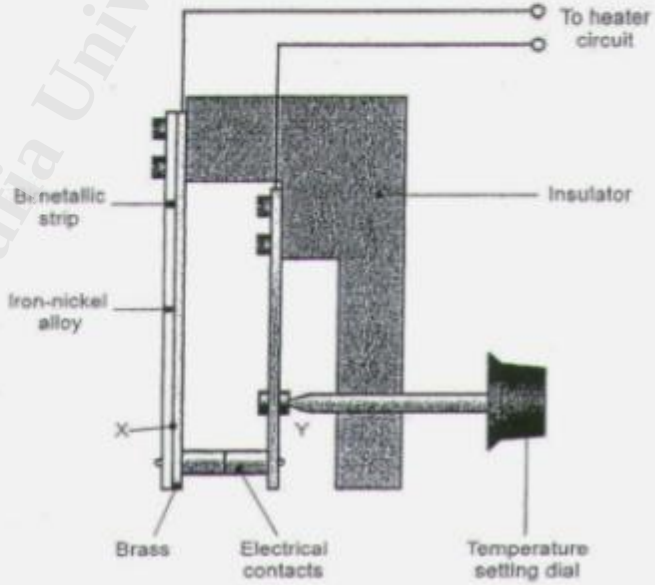


Watt's Governor



Rotation of the cam closing the switch contacts

Cam Operated Switch

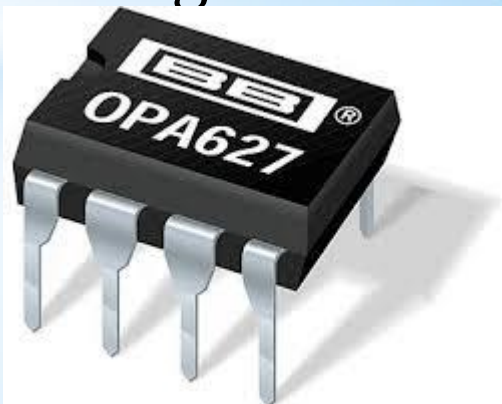


Thermostat

Evolution of Mechatronics

➢ Semiconductors Revolution

- ❖ Led to the creation of integrated circuit (**IC**) technology.
- ❖ Effective, miniaturized, power electronics could amplify and deliver needed amount of power to actuators.
- ❖ Signal conditioning electronics could filter and encode sensory data in **analog/digital** format.
- ❖ Hard-wired, on-board, discrete analog/digital ICs provided rudimentary computational and decision-making circuits for control of mechanical devices.



Evolution of Mechatronics

➢ Information Revolution

- ❖ Development of **VLSI technology** led to the introduction of microprocessor, microcomputer, and microcontroller.
- ❖ Now computing hardware is everywhere, cheap, and small.
- ❖ As computing hardware can be effortlessly interfaced with real world electromechanical systems, it is now routinely embedded in engineered products/processes for decision-making.
- ❖ **Result**: Highly efficient products and processes are now being developed by judicious selection and integration of sensors, actuators, signal conditioning, power electronics, decision and control algorithms, and computer hardware and software.

Evolution of Mechatronics

- Mechatronics has evolved through the following stages:

• **Primary Level Mechatronics**: Integrates electrical signaling with mechanical action at the basic control level for e.g. fluid valves and relay switches

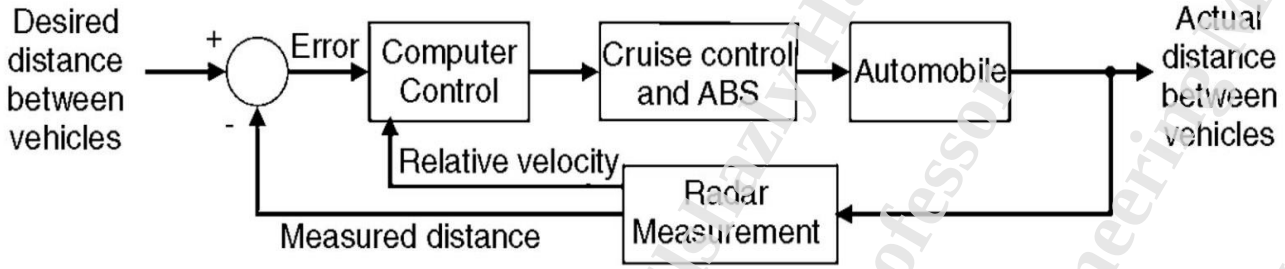
• **Secondary Level Mechatronics:** Integrates microelectronics into electrically controlled devices for e.g. cassette tape player.

• **Tertiary Level Mechatronics:** Incorporates advanced control strategy using microelectronics, microprocessors and other application specific integrated circuits for e.g. microprocessor based electrical motor used for actuation purpose in robots.

• **Quaternary Level Mechatronics:** This level attempts to improve smartness a step ahead by introducing intelligence (artificial neutral network and fuzzy logic) and fault detection and isolation (F.D.I.) capability into the system.

Evolution of Mechatronics

The Automobile Development



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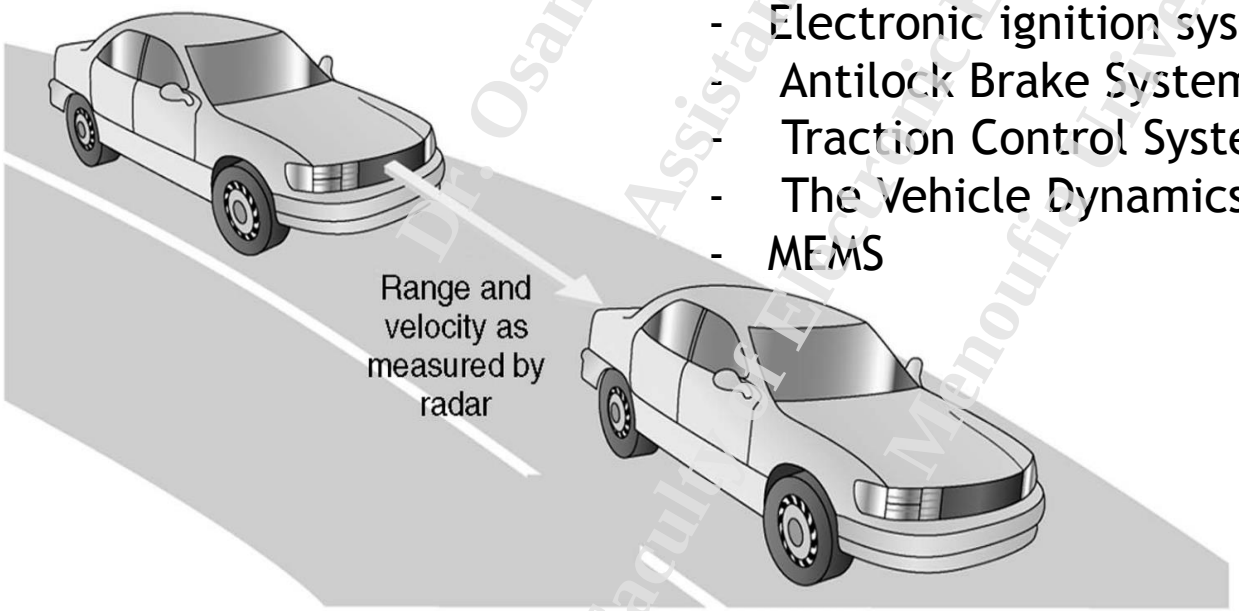


- Radio (1960)
- Ignition Time
- Electronic ignition system (1970)
- Antilock Brake System (ABS) (1970)
- Traction Control System (TCS) (mid-1990)
- The Vehicle Dynamics Control (VDC) (late -1990)
- MEMS

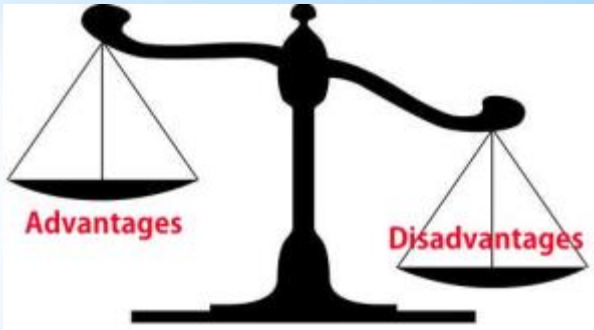
Automobiles: 30–60 microcontrollers, up to 100 electric motors, about 200 pounds of wiring, a multitude of sensors, and thousands of lines of software code

Evolution of Mechatronics

The Copy Machine

Advantages of Mechatronics

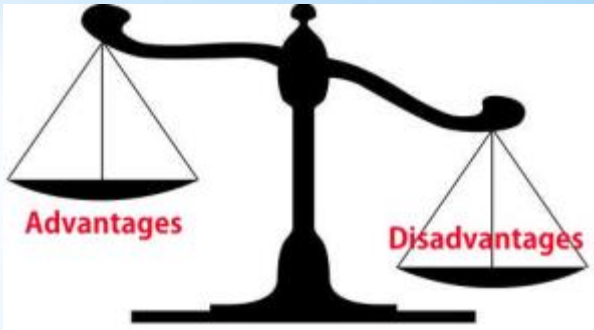
- Cost effective and good quality products
- High degree of flexibility to modify or redesig
- Very good performance characteristics
- Wide are of application
- Greater productivity in case of manufacturing organization
- Greater extend of machine utilization



Disadvantages of Mechatronics

High Initial cost

- Multi-disciplinary engineering background required to design and implementation
- Need of highly trained workers
- Complexity in identification an correction of problems in the system



Mechatronics Applications

- **Smart consumer products**: home security, camera, microwave oven, toaster, dish washer, laundry washer-dryer, climate control units, Automatic Digital Camera etc.
- Computer disk VCR/DVD drives, ATM, etc
- Medical: implant-devices, assisted surgery, haptic, etc.
- Defense: unmanned air, ground, and underwater vehicles, smart weapons, jet engines, etc.
- **Manufacturing**: NC & CNC machine tools, Rapid Prototyping, robotics, etc.
- **Automotive**: climate control, antilock brake, active suspension, cruise control, air bags, engine management, safety, etc.
- Network-centric, distributed systems: distributed robotics, telerobotics, intelligent highways, etc.

Mechatronics Applications




Robot examples



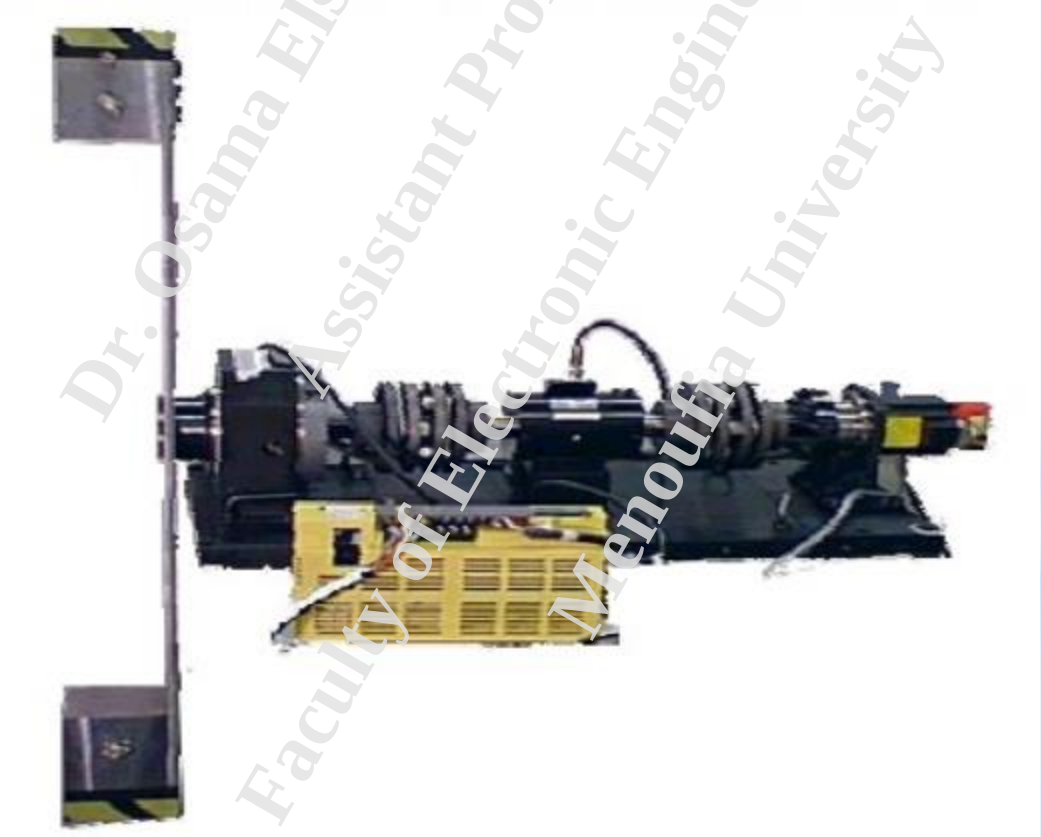




Robot sensors

Mechatronics Applications

Motion and Force control of an indirect drive robot



Mechatronics Applications

- **Programed to track a straight line.**
- **Programmed for collision avoidance in outside corridor**

Mechatronics Applications

Washing Machine

Simple Examples of Mechatronics

Photocopier machine

Modern Sewing machine

Disk Driver

Vending Machine

Automatic Sliding Door

Auto Garage Opener

Robot Platforms (1)

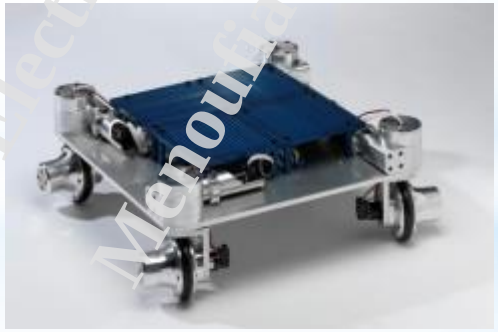
Indoor Robots

DLR Gripper

NASA Mars Rover

Asimo Humanoid

Outdoor Robots



Robot Base Station

KUKA Manipulator

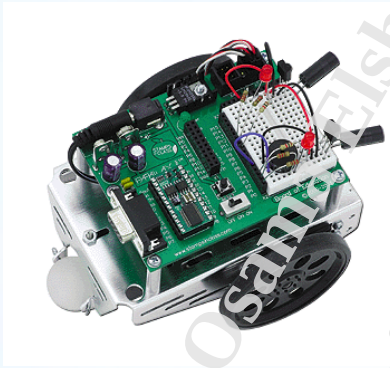
Robot Platforms (2)

Aibo 4 legged Robot

Qurio Humanoid

Robocup Team

Robot Platforms (3)

Robot educational kits

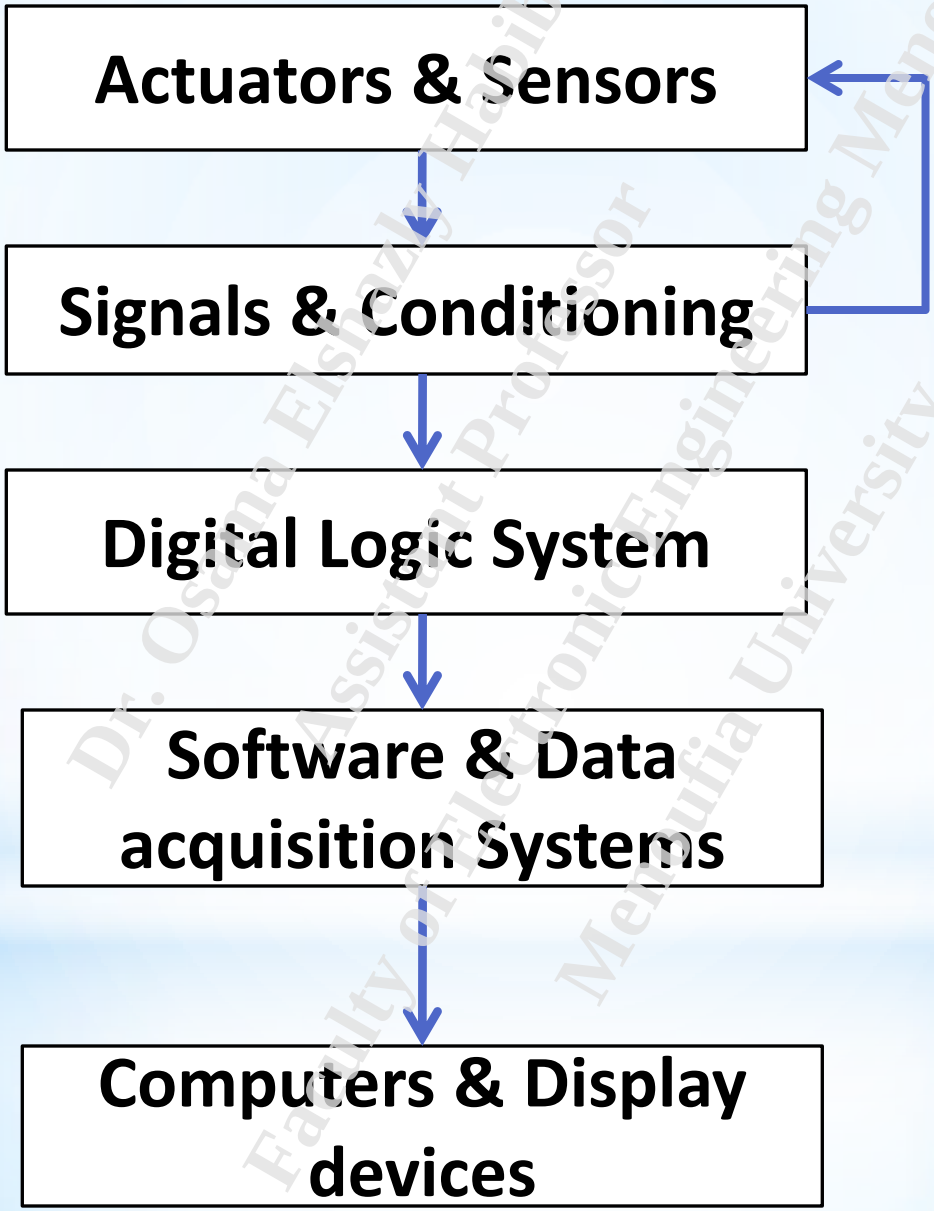




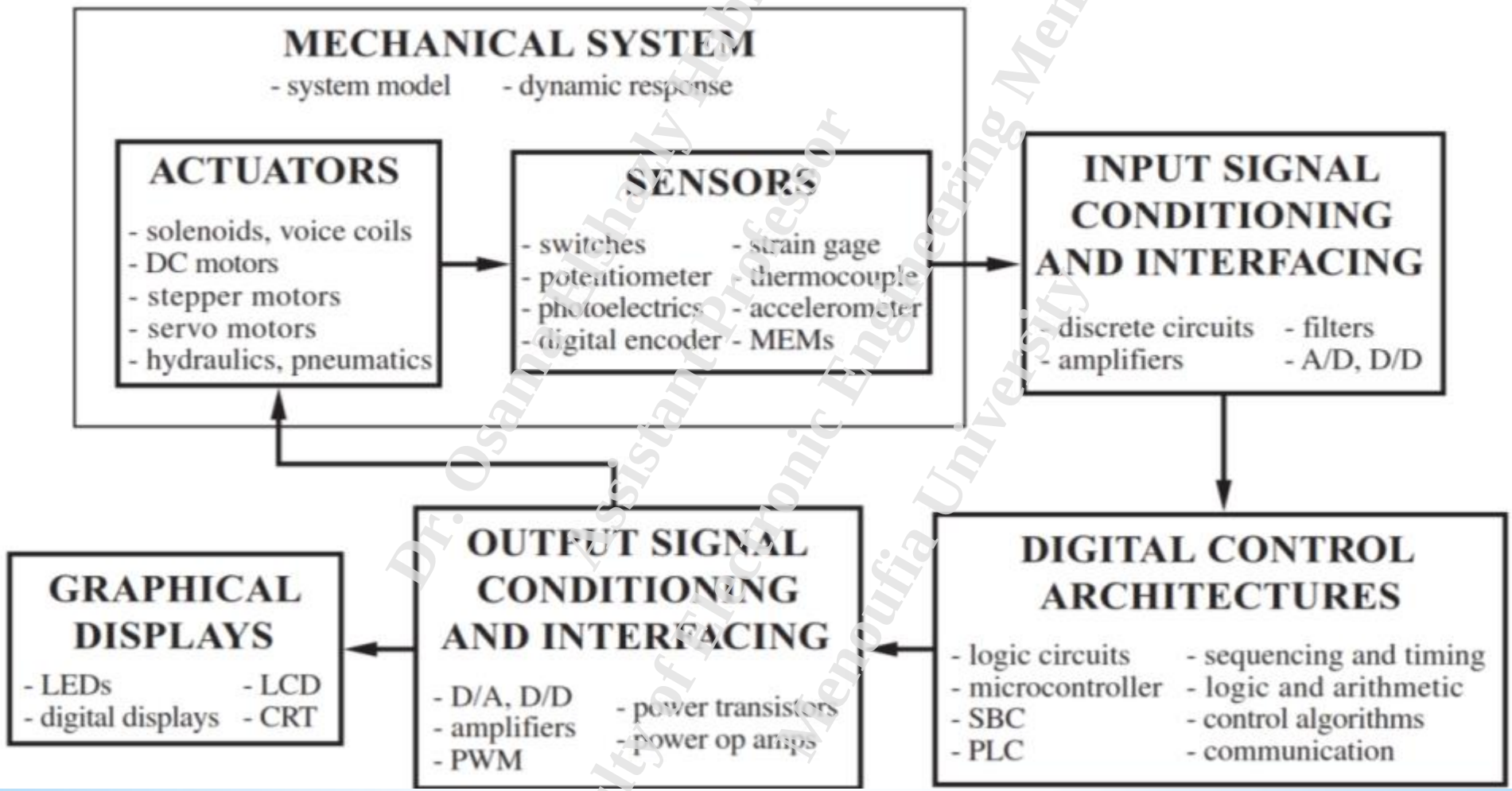


Robot sensors

Elements of Mechatronics System

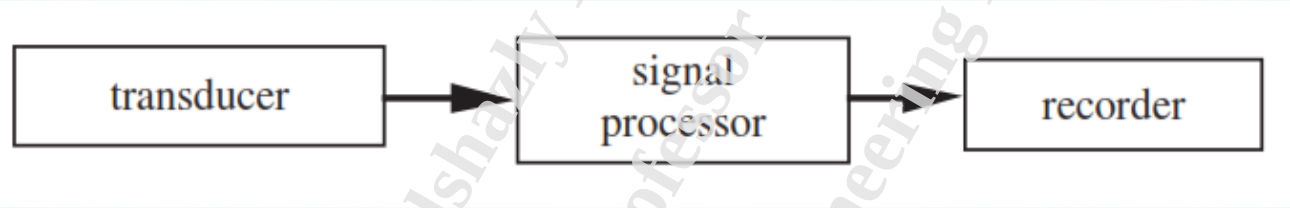


Elements of Mechatronics System



Measurement System

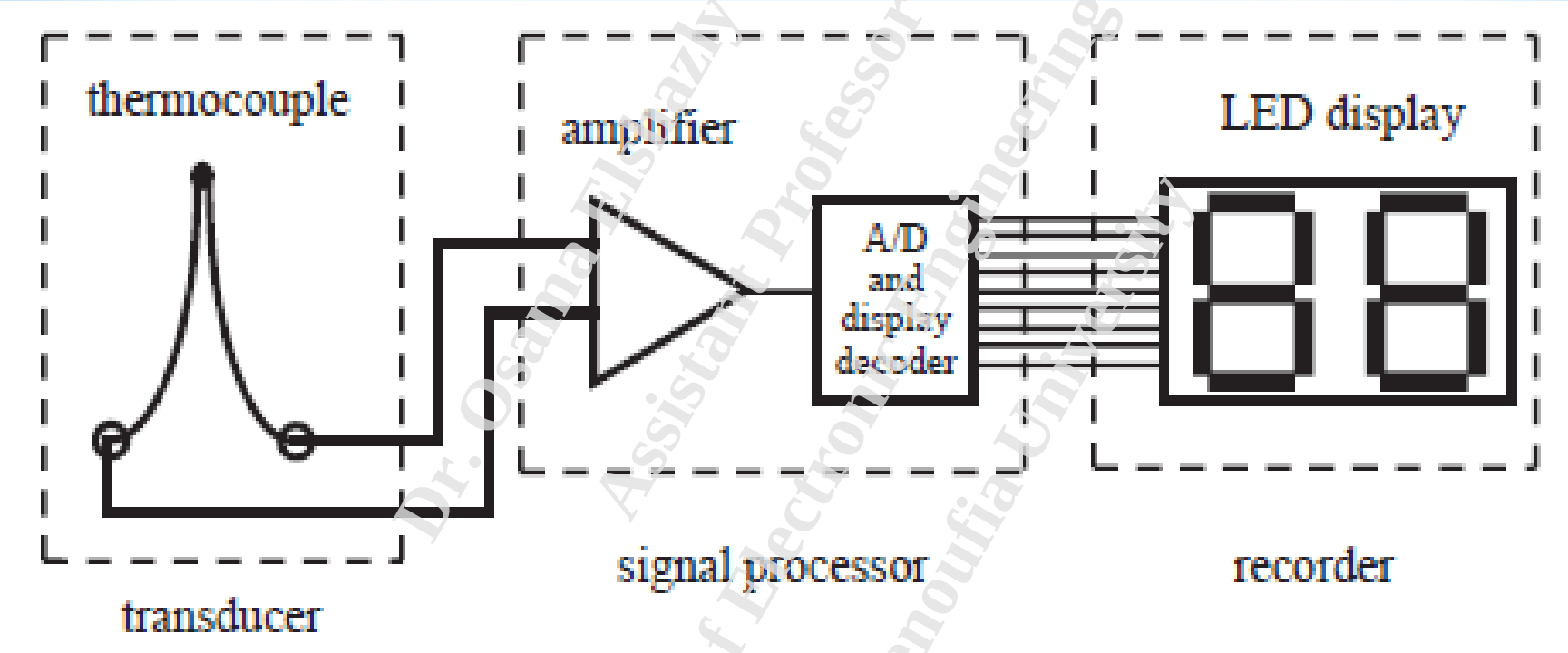
- It is a fundamental part of many mechatronic system



- **Transducer** converts a physical input into an output, usually a voltage.
- **The signal processor** performs filtering, amplification, or other signal conditioning on the transducer output.
  - **Sensor** = **transducer**
  - **Sensor** = transducer + signal processor.
- The **recorder** is an instrument, a computer, a hard-copy device, or simply a display that maintains the sensor data for online monitoring or subsequent processing.

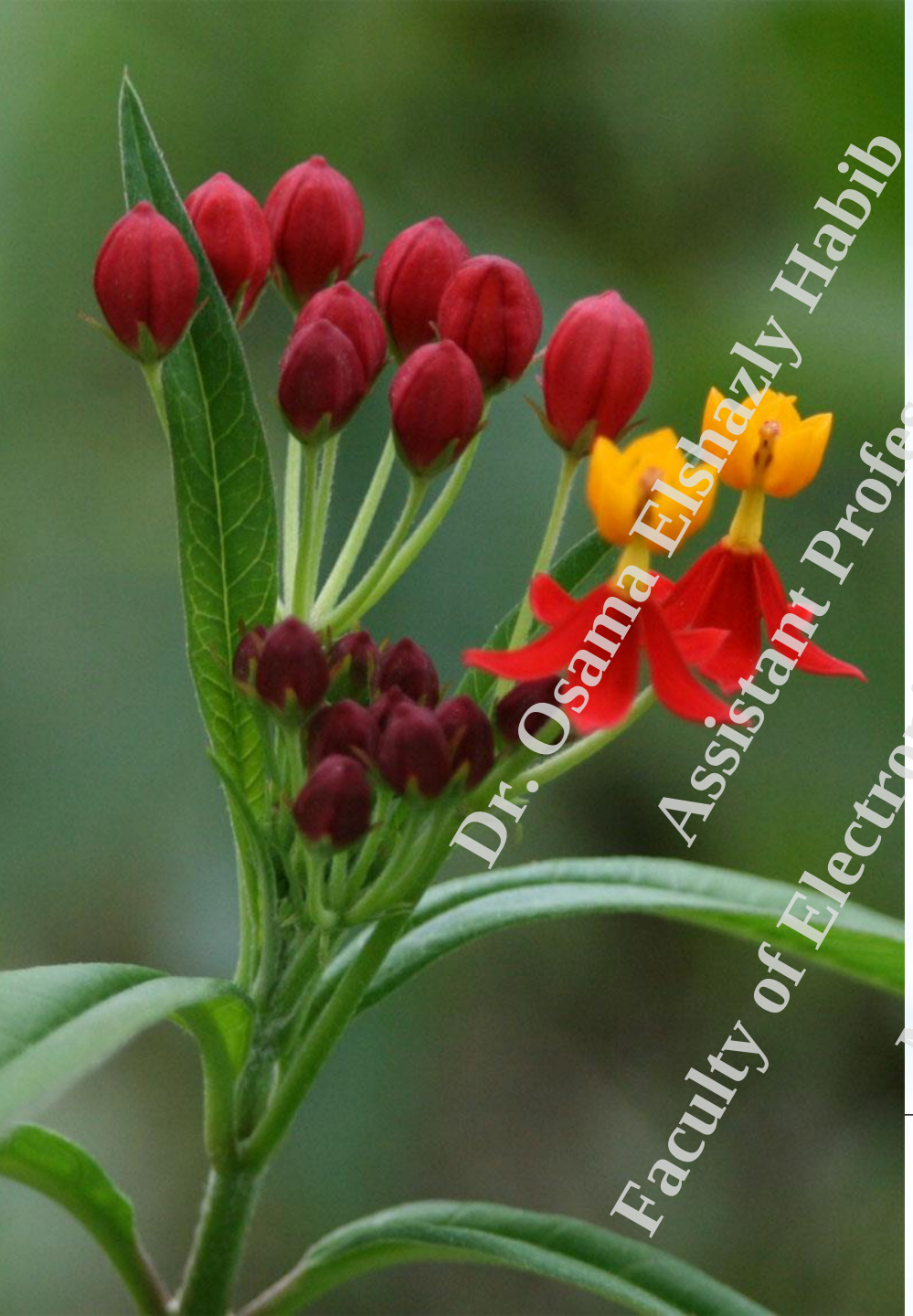
Measurement System Example

Digital Thermometer



The thermocouple is a transducer that converts temperature to a small voltage; the amplifier increases the magnitude of the voltage; the A/D (analog-to-digital) converter is a device that changes the analog signal to a coded digital signal; and the LEDs (light emitting diodes) display the value of the temperature.

Chapter2: Sensors



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