Embedded systems lab
Lab # 1
Introduction to microcontrollers

Objectives
- To be familiar with microcontrollers.

Theory
A microcontroller (or MCU) is a computer-on-a-chip. It is a type of microprocessor emphasizing self-sufficiency and cost-effectiveness, in contrast to a general-purpose microprocessor (the kind used in a PC).

A microcontroller is a single integrated circuit, commonly with the following features:
- Central processing unit - ranging from small and simple 4-bit processors to sophisticated 32- or 64-bit processors
- Input/output interfaces such as serial ports (UARTs)
- Other serial communications interfaces like PC, Serial Peripheral Interface and Controller Area Network for system interconnect
- Peripherals such as timers and watchdog
- RAM for data storage
- ROM, EPROM, EEPROM or Flash memory for program storage
- Clock generator - often an oscillator for a quartz timing crystal, resonator or RC circuit
- Many include analog-to-digital converters

Microcontroller versus Microprocessor
A microcontroller differs from a microprocessor in many ways. The first and most important difference is its functionality. In order that the microprocessor may be used, other components such as memory must be added to it. Even though the microprocessors are considered to be powerful computing machines, their weak point is that they are not adjusted to communicating to peripheral equipment.

On the other hand, the microcontroller is designed to be all of that in one. No other specialized external components are needed for its application because all necessary circuits which otherwise belong to peripherals are already built into it. It saves the time and space needed to design a device.

**Input/output Ports**

Each microcontroller has one or more registers (called a “port”) connected to the microcontroller pins. For example, suppose you want your device to turn three signal LEDs and simultaneously monitor the logic state of five sensors or push buttons. Some of ports need to be configured so that there are three outputs (connected to the LEDs) and five inputs (connected to sensors).

It is simply performed by software, which means that the pin’s function can be changed during operation. Usually, each I/O port is under control of another SFR, which means that each bit of that register determines the state of the corresponding microcontroller pin.

To program a pin to be an output or an input, we simply send a 0 or a 1 to the relevant bit in the TRISx register (0 for output and 1 for input)

To make one of the output pins high (+5v), we simply send a ‘1’ to the corresponding bit in PORTx register.

**Flash memory**

The contents of this memory can be written and cleared practically an unlimited number of times, the microcontrollers with Flash ROM are ideal for learning, experimentation and small-scale manufacture. Because of its popularity, the most microcontrollers are manufactured in flash versions today. So, if you are going to buy a microcontroller, the type to look for is definitely flash.

**Random Access Memory (RAM)**

Once the power supply is off the contents of RAM (Random Access Memory) is cleared. It is used for temporary storing data and intermediate results created and used during the operation of the microcontroller.

**Electrically Erasable Programmable ROM (EEPROM)**

The contents of the EEPROM may be changed during operation (similar to RAM), but remains permanently saved even upon the power supply goes off (similar to ROM).

Accordingly, an EEPROM is often used to store values, created during operation, which must be permanently saved. For example, if you design an electronic lock or an alarm, it would be great
to enable the user to create and enter a password, but useless if it is lost every time the power supply goes off. The ideal solution is the microcontroller with an embedded EEPROM.

**Central Processor Unit (CPU)**
As its name suggests, this is a unit which monitors and controls all processes inside the microcontroller. It consists of several smaller subunits like Instruction Decoder, Arithmetical Logical Unit (ALU) and Accumulator.

**PIC microcontrollers**
PIC microcontrollers designed by Microchip Technology are likely the right choice for you if you are the beginner. The real name of this microcontroller is PICmicro (Peripheral Interface Controller), but it is better known as PIC. Its first ancestor was designed in 1975 by General Instruments. This chip called PIC1650 was meant for totally different purposes. About ten years later, by adding EEPROM memory, this circuit was transformed into a real PIC microcontroller.

**PIC18F4550**
- High Performance RISC CPU
- Linear program memory addressing to 32 Kbytes
- Linear data memory addressing to 2 Kbytes
- External Clock up to 48 MHz
- Three external interrupt pins
- Four Timer modules (Timer0 to Timer3)
- 3-wire SPI™ (supports all 4 SPI modes)
- I2CTM Master and Slave mode
- Addressable USART module:
  - Supports RS-485 and RS-232
  - Compatible 10-bit Analog-to-Digital Converter
- USB V2.0 Compliant