1. Make a list of 10 products containing microprocessors that we use everyday.
   - Personal computer
   - Television
   - Calculator
   - Elevator
   - Mobile phones
   - MP3 players
   - Microwave ovens
   - DVD players
   - Engine Control Unit (ECU) – inside automobiles.
   - Air conditioners.
   - Digital Camera/Video Camera.

2. Describe the circumstances that would prompt you to use a microprocessor-based design solution instead of a hard-wired IC logic design.

   The choice between microprocessor-based or hard-wired design depends on the desired circuit functionality and cost. If a simple digital system needs to be built, it is probably better to use several ICs to design them as they would be cheaper compared to microprocessor systems. However, if the system is very complicated (it has to perform many types of functions), then it is probably better to use a microprocessor-based system. This is because such complex systems may require a lot of ICs, making the circuit very large, complex and expensive. Using microprocessor-based systems, all the ICs can be replaced with only one microprocessor that performs the similar task, thus reducing the cost, as well as the overall size of the circuit.
3. In an 8-bit microprocessor system, how many lines are in the data bus? The address bus? What about 16-bit microprocessor systems?

In a microprocessor, the lines in the data bus are indicated by the microprocessor bit. For example, a 32-bit microprocessor can transfer 32-bits at one read/write. Therefore, the microprocessor contains 32 data lines. In an 8-bit microprocessor, the microprocessor can process 8-bits at a time; therefore it has 8 data lines. Following the same rule, a 16-bit microprocessor has 16 data lines.

There are no set rules that define the size of the address bus. The number of address lines depends on the required application of the microprocessor and the development of memory chip technology. During the 1970’s, 16-line address buses were used for 8-bit microprocessors (64 kB max). Due to improvements in memory technology and increase in PC program requirements, (from 1980’s to now), 32-bit address bus is the most common for 16-bit to 32-bit microprocessors (4 GB max).

4. How many different addresses can be accessed using the 16-bit address bus?

The maximum memory that can be addressed (\(y\)) can be calculated using \(y = 2^x\), where \(x\) is the number of address lines. Therefore, for a 16-bit address bus, the maximum memory that can be addressed is 65,536 bytes (64kB).
5. Draw a block diagram for a computerized cash register. The hardware should include a numerical display, a keyboard, and a compact printer.

![Block diagram of computerized cash register.]

6. Explain the meaning of software, hardware and firmware.

Hardware is a physical electronic circuit that is attached to the microprocessor to perform specific tasks. Hardware is created by physically wiring different electronic components. When properly connected to a power supply, it performs its function when activated by the microprocessor. To remove the hardware, it must be physically disconnected from the microprocessor system.

Software is a collection of binary codes (instructions) that tell the microprocessor to perform specific tasks. Software is created by programming, where programs are typed into a computer, and converted to machine code using an assembler or compiler. It is then loaded into memory (RAM) and executed by the microprocessor. To stop the software from executing, the binary codes have to be cleared from memory.

Firmware is a cross between software and hardware. Like software, instructions are encoded in binary format. But, unlike software, these
instructions are not loaded into RAM, but burned into Read-Only Memory (ROM) chips. These chips are physically embedded into a microprocessor system, similar to hardware. To remove the firmware, the ROM must be removed from its slot, and replaced with ROM containing new instructions.

7. Name the major components in a microcomputer system and describe the functions of each.

The microcomputer system (PC) consists of several components:

- **Microprocessor (CPU):** performs all arithmetic and logical operations inside the computer. It loads the instructions from memory and executes them. Also controls data transfer inside the system bus.
- **Memory:** stores instructions and data for the CPU. Consists of RAM (Random Access Memory) and ROM (Read Only Memory).
- **I/O:** Input/output devices that interact with the user. Examples: keyboard, mouse, video display.
- **System bus:** a set of electrical connections that connects all components in the microcomputer.
- **Supporting circuitry:** circuitry to activate/deactivate components, access memory, and perform error checking.

8. What is system bus? Discuss the signals that must be available for an effective bus operation.

The system bus is a set of electrical connections that connects all components in the microcomputer. The system bus consists of three types of lines: data lines, address lines, and control lines. The data lines carry data between components and the CPU. The address lines are used to carry the memory address that the CPU wants to access. The control lines carry information that controls data transfer, device interfacing and error checking tasks. All these signals are required for an effective bus operation.
9. Describe the microprocessor execution cycle.

The microprocessor execution cycle is a series of steps performed by the microprocessor during its run-time. It consists of three steps (fetch, decode and execute), which are repeated in an endless loop. The first step is the fetch cycle. The fetch cycle is responsible to get information from the memory and load it into the microprocessor. The second step is the decode cycle. The decode cycle analyzes the instructions and locates any other necessary data to perform the operation. Finally, in the execute cycle, the necessary data is loaded into the microprocessor, and the instruction is executed. After the instruction is executed, the cycle repeats with another fetch cycle to load the next instruction.

10. Describe the difference between a microcomputer and a microprocessor.

The major difference between the microprocessor and microcomputer is that the microprocessor is a single device that processes data, while the microprocessor is the system built around the microprocessor to support its data-processing abilities. A microprocessor is an electronic device made from a silicon wafer, where tiny transistors are etched onto its surface. The microprocessor has an instruction set, which allows it to perform arithmetic, logical and control operations. However, the microprocessor cannot process data by itself. A microcomputer is a complete computing system built around such a microprocessor. Since it is a complete system, other than the microprocessor, the microcomputer must also include memory, I/O system, power supply and supporting circuitry for proper operation.