Figure 1. Logical structure of a personal computer

A computer system has four types of components:
1. **Input devices** including a keyboard, mouse, scanner, joystick, barcode reader, etc.
2. **Output devices** including a printer, video display, speakers, etc.
3. **Processor.** Most personal computers contain a single processor. The processor executes programs that perform the functions requested.
4. **Memory.** Memory is divided into two classes, volatile and non-volatile. Registers, cache, and main store (RAM) are volatile. Fixed disk, CD ROM, and diskettes are non-volatile.

Memory Hierarchy.

Memory Type	Access Time	Comments
Cache	5×10^{-9} ($5ns$)	1. Cache stores a copy of the most frequently referenced instructions and data 2. Cache is volatile
Main store	20×10^{-9} ($20ns$)	1. Instructions must be present in main store to execute a program. 2. Main store contains a copy of programs and data. 3. Main store is volatile
Disk	10×10^{-3} ($10ms$) (Electromechanical)	1. Original copies of programs and data reside on disk. 2. Disk is non volatile

Notes:

1. The memory hierarchy includes those memory devices that can be accesses via a virtual address. The memory hierarchy includes cache, main store, and disk. The memory hierarchy does not include registers.

   1.1. Main store is a Random Access Memory (RAM).

   1.2. Random access means that any unit of storage can be accessed in about the same time as any other unit of storage. A tape is a sequential access memory. The first byte on the tape can be accessed much faster than the last byte on the tape.

   1.3. Disk, fixed disk and hard disk are synonymous. A disk is a direct access device. A direct access device has a three-part address, surface, cylinder, and sector. A disk consists of a stack of disk-shaped platters. Each platter has two surfaces, top and bottom. Concentric circles are drawn on each platter. The circles are aligned on all surfaces. A cylinder is a particular circle that is drawn on all the surfaces. Sectors are pie-shaped wedges that subdivide the cylinders.

   1.4. Memory devices that do not appear in the memory hierarchy are punched cards and their readers, tape drives and CD and DVD drives.

2. The speed of a computer is limited by the access speed of memory since all instructions and data are stored in memory.

3. Generally speaking, the CPU is many orders or magnitude faster than disk. A CPU can execute (at least) one million instructions in the time required to read a sector from disk.
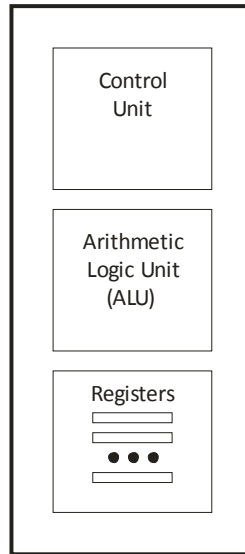
Figure 2. Anatomy of the Central Processing Unit

The central processor contains three basic components.

1. A control unit. The control unit directs the ALU to perform instructions defined in the processor.
2. An arithmetic logic unit. The arithmetic logic unit performs various operations on data in registers and stores the result either in another register on in main store.
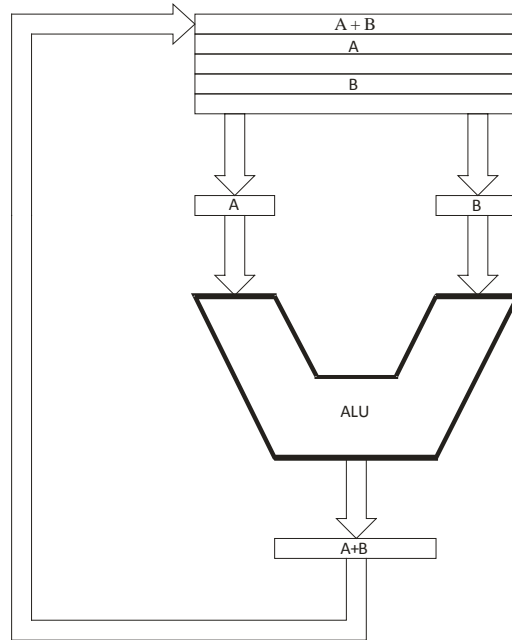3. Registers. Registers are used to store data.

Figure 3. ALU data path schematic

The instruction cycle:
1. **Fetch**: Read an instruction from main store. A value stored in memory is copied to a special register within the CPU. Increment the instruction address to the next instruction.
2. **Decode**: Separate the instruction into its component parts. Instructions contain an operation code (opcode) and operands. Operands could be immediate values, a reference to a register, or a reference to a location in main store.
3. **Execute**: Perform the operation specified by the opcode.
4. **Process interrupts**: Poll interrupt lines. If any interrupts are asserted, transfer control to the interrupt handler. Make the next instruction the first instruction of the interrupt handler.

Assignment : Read Chapter 1, Introduction, *Big C++*. Do exercises R1.2, R1.3, R1.5, R1.7, R1.9, R1.10, R1.14, R1.16, R1.18, and the exercises at the end of this lecture note.

Instructions for completing homework assignments:
1. Record all homework in Microsoft Word ® documents. Learn how to use the Equation Editor. If the Equation Editor is not available request the laboratory assistant install it.
2. Type the question first.
3. Below the question, type your answer.
4. Prove your answer correct.
5. Check your answer against the answers found by your colleagues in this class.
6. If you cannot resolve differences between your answer and the answer found by your colleagues found, ask your instructor to solve the problem in class.
7. Do not fail to find the correct answer.
8. Carefully organize all the work you do in this class.
   8.1. Print and save the source for all your programming assignments.
   8.2. Save all the source and executables for your programming assignments on a CD.
   8.3. Print and save all the lectures presented in this class.
   8.4. Print and save all the homework assignments you complete in this class.
   8.5. Save all your homework assignments on a CD.
   8.6. Save all your tests.
   8.7. Find correct answers for every question that you missed.
   8.8. Store your printed material in a notebook.
9. When your notebook is complete, it will serve as valuable reference for other computer science classes.

Exercises:

1. A certain antiquated computer can access main store (RAM) up to 20 million times per second. What is the minimum time of a single main store access? Express your answer in engineering units.

2. A certain antiquated computer can access main store (RAM) up to 50 million times per second. Cache is five (5) times faster than main store. What is the minimum time of a single cache access? Express your answer in engineering units.

3. A certain antiquated computer has a CPU clock that cycles once every five (5) nanoseconds (*ns*). How many single cycle instructions can the CPU execute while waiting for an average fixed (hard) disk access to complete?

4. List five (5) input devices.

5. List five (5) output devices.

6. Identify the memory hierarchy. Order the components by their access time.

7. A certain antiquated computer has a memory hierarchy that consists of a fixed disk and main store. The fixed disk has an access time of 10 milliseconds (*ms*). The main store has an access time of 20 nanoseconds (*ns*). The probability that the virtual address produced by the CPU is actually in main store is 0.9. What is the effective access time of the memory hierarchy?

8. Complete the table of units given below. Please find information to complete the table at URL http://www.ex.ac.uk/cimt/dictunit/dictunit.htm.

Power of ten	Engineering Unit	Abbreviation
10^{12}	tera	T
10^{9}		
10^{6}		
10^{3}		
10^{2}		
10		
10^{-1}		
10^{-2}		
10^{-3}		
10^{-6}		
10^{-9}		
10^{-12}		

9. Engineering units are expressed in units whose exponents are evenly divisible by three (3). For example 1 centisecond (1 cs) is properly expressed as 10 ms (ten milliseconds) in standard engineering units. Express the following times in proper engineering form.

   9.1. One-tenth of a second.

   9.2. Five hundred seconds.

   9.3. One hundred million seconds.

   9.4. One ten-thousandth of a second.

   9.5. One ten-millionth of a second.

   9.6. 1×10^{-2} seconds

   9.7. 1×10^{-4} seconds

   9.8. 1000×10^{-7} seconds

   9.9. 10×10^{4} seconds

   9.10. 100×10^{8} seconds