Computer Programming Fundamentals

Handouts No. 1: Introduction to Computer Science

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Computer Science (CS)

Computer Science is the study of computers and computational systems. Unlike electrical and computer engineers, computer scientists deal mostly with software and software systems; this includes their theory, design, development, and application.

Computer Science is not just about computers. Rather it is the study of computation and information and is a subject which involves you in the very make-up of the world, and over the last 30 years it has transformed the way we run our everyday lives.

CS Career

Greg Law – a co-founder and chief technology officer at the Undo software company, which operates both in the U.K. and the U.S. – says computer science positions are plentiful, and that there are many interesting jobs available to computer science degree-holders.

"I'd recommend computer science to anyone who feels they have or may have an affinity with it," Law, who has a Ph.D. in computer science from City University London, wrote in an email. "Programming is a creative and fun endeavor – it's the act of creation and problem solving. And unlike most other creative roles, demand for good programmers far outstrips supply; the opportunities are diverse, and the financial rewards can be significant. The top tech firms in Silicon Valley routinely pay seven figures a year to new graduates, and even signing on bonuses that can immediately pay off all your student debt."

Constantine Coutras, a professor of computer science and chairperson of the computer science department at Montclair State University in New Jersey, says he would encourage people with an interest in and aptitude for math and science to consider pursuing a degree in computer science.

The following types of jobs are positions where a degree in computer science is a major asset:

- Data scientist
- Software tester
- Web developer
- Systems analyst
- Network architect
- Software engineer
- Software developer
- Full-stack developer
- User interface designer
- Database administrator
- Cloud computing engineer

- Information security analyst
- Computer science professor
- Chief information security officer
- Software quality assurance manager
- Information technology specialist
- Mobile application designer or developer
- Research and development (R&D) scientist
- Computer scientist or computer science researcher

"The most common path is to become a software developer, but there are many other paths open, including system administration and systems analyst," Law says. "The great thing about a (computer science) degree however is that today every company is becoming a software company, so a degree in computer science gives you access to a more diverse range of opportunities and industry than almost any other qualification."

Law says that a Ph.D. degree is typically necessary for research-intensive computer science positions, but many computer science careers are attainable with only a bachelor's or master's degree.

Computer

A computer is a programmable electronic device that accepts raw data as input and processes it with a set of instructions (a program) to produce the result as output. Computers consist of transistors that can be turn on or off to represent data. Therefore, computers use a number system called **Binary**.

There are 5 main computer components, which are:

- Input Devices
- CPU
- Output Devices
- Primary Memory
- Secondary Memory

Input device enables the user to send data, information, or control signals to a computer. The Central Processing Unit (CPU) of a computer receives the input and processes it to produce the output. Some of the popular input devices are:

- Keyboard
- Mouse
- Scanner
- Joystick
- Microphone

- Touch Pad
- Touch screen
- Webcam
- Biometric Devices

The output device displays the result of the processing of raw data that is entered in the computer through an input device. There are several output devices that display output in different ways such as text, images, hard copies, and audio or video. Some of the popular output devices are:

- Monitor
- Printer
- Projector

A Central Processing Unit is also called a processor, central processor, or microprocessor. It carries out all the important functions of a computer. It receives instructions from both the hardware and active software and produces output accordingly. It stores all important programs like operating systems and application software. CPU also helps Input and output devices to communicate with each other. Owing to these features of CPU, it is often referred to as the brain of the computer. Generally, a CPU has three components:

- ALU (Arithmetic Logic Unit)
- Control Unit
- Memory

The computer memory holds the data and instructions needed to process raw data and produce output. The computer memory is divided into large number of small parts known as cells. Each cell has a unique address which varies from 0 to memory size minus one. Computer memory is of two types: Volatile (RAM) and Non-volatile (ROM). The secondary memory (hard disk) is referred as storage not memory. But, if we categorize memory on behalf of space or location, it is of four types:

- Register memory
- Cache memory
- Primary memory
- Secondary memory

Hardware, which is abbreviated as **HW**, refers to all physical components of a computer system, including the devices connected to it. You cannot create a computer or use software without using hardware. The screen on which you are reading this information is also a hardware.

Software, which is abbreviated as SW or S/W, is a set of programs that enables the hardware to perform a specific task. All the programs that run the computer are software.

The software can be of three types: system software, application software, and programming software.

Platform

Platform defines a standard around which a system can be developed. Or, in another words a platform is any base of technologies on which other technologies or processes are built. Once the platform has been defined, software developers can produce appropriate software and managers can purchase appropriate hardware and applications.

The term cross-platform refers to applications, formats, or devices that work on different platforms. For example, a cross-platform programming environment (e.g. Java) enables a programmer to develop programs for many platforms at once.

A platform is a crucial element in software development. A platform might be simply defined as a place to launch software. The platform provider offers the software developer an undertaking that logic code (a general term for bytecode, source code and machine code) will run consistently as long as the platform is in place.

Operating System (OS)

Operating System is a program that allows you to interact with the computer - all of the software and hardware on your computer, by one of the following **User Interfaces (UI)**:

- **Command Line Interface (CLI):** you type a text command and the computer responds according to that command.
- **Graphical User Interface (GUI):** you interact with the computer through a GUI with pictures and buttons by using the mouse, keyboard or touch screen. See list of operating systems.

Followings are well-known operating systems:

Windows: provides a GUI, virtual memory management, multitasking, and support for many peripheral devices.

Mac OS: The official name of the Macintosh operating system, before it was System x.x.

Unix: a popular multi-user, multitasking operating system developed at Bell Labs.

Linux: (Unix-like) An open source operating system that runs on a number of hardware platforms.

Disk Operating Systems (DOS): can refer to any operating system. Originally developed by Microsoft for IBM. MS-DOS was the standard operating system for IBM-compatible personal computers. Today, Windows OS continue to support DOS (or a DOS-like user interface) for special purposes by emulating the operating system.

Binary

Binary is a base-2 number system that is made up of only two numbers: 0 and 1. This number system is the basis for all binary code. The 0s and 1s in binary represent OFF or ON, respectively. In a transistor, an "0" represents no flow of electricity, and "1" represents electricity being allowed to flow.

When we first learned to count, we might have used one finger to represent one thing. That system is called unary. When we learned to write numbers with the digits 0 through 9, we learned to use decimal.

For example, we know the following represents one hundred and twenty-three.

١٢٣

The 3 is in the one’s column, the 2 is in the ten’s column, and the 1 is in the hundred’s column.

100		**10**		**1**	
1		**2**		**3**	
1x100	**+**	**2x10**	**+**	**3x1**	

So, 123 is 100×1 + 10×2 + 1×3 = 100 + 20 + 3 = 123. Each place for a digit represents a power of ten since there are ten possible digits for each place (0,1,2,3,4,5,6,7,8,9).

10^2	10^1	10^0
100	**10**	**1**

In binary, with just two digits (0,1), we have powers of two for each place value:

2^2	2^1	2^0
4	**2**	**1**

For example:

4		**2**		**1**	
1		**0**		**1**	
1x4	**+**	**0x2**	**+**	**1x1**	

Now, the binary number 101 represents the decimal value of 5.

IF we change the binary value to, 0 1 1, the decimal value would be 3.

4		2		1
0		1		1
0x4	+	1x2	+	1x1

If we wanted to represent 8, we would need another digit (2^3=8):

8		4		2		1
1		0		0		1
1x8	+	0x4	+	0x2		0x1

And binary makes sense for computers because we power them with electricity, which can be either on or off, so each bit only needs to be on or off. In a computer, there are millions, or billions of switches called transistors that can store electricity and represent a bit by being "on" or "off". With enough bits, or binary digits, computers can count to any number.

- one digit is called **bit**.
- 8 digits are called **byte**.
- 2^{10} bytes are called **Kilobyte (KB)**. 1KB = 1024 byte.
- 2^{10} KB is called **Megabyte (MB)**. 1MB = 1024 KB = 2^{100} bytes.
- 2^{10} MB is called **Gigabyte (GB)**. 1GB = 1024 MB = 2^{100} KB = 2^{1000} bytes.
- 2^{10} GB is called **Terabyte (TB)**.

Data Representation

To represent letters, all we need to do is decide how numbers map to letters. Some humans, many years ago, collectively decided on a standard mapping called **ASCII**. The letter "A", for example, is the number 65, "B" is 66, "C" is 67 and so on. The mapping also includes punctuation and other symbols. Other characters, like letters with accent marks, and emoji, are part of a standard called **Unicode** that use more bits than ASCII to accommodate all these characters.

When we receive an emoji, our computer is just receiving a decimal number like 128514 (11111011000000010 in binary) that it then maps to the image of the emoji.

An image, too, is comprised of many smaller square dots, or pixels, each of which can be represented in binary with a system called RGB, with values for red, green, and blue

light in each pixel. By mixing different amounts of each color, we can represent millions of colors:

The red, green, and blue values are combined to get a light-yellow color:

If we look at this image as example:

We can see the pixels of that image if we zoom in far enough.

Computer programs know, based on the context of its code, whether the binary numbers should be interpreted as numbers, or letters, or pixels.

Videos are just many, many images displayed one after another, at some number of frames per second. Music, too, can be represented by the notes being played, their duration, and their volume.

Sound needs to be converted into binary for computers to be able to process it. To do this, sound is captured - usually by a microphone - and then converted into a digital signal. An analogue to digital converter will sample a sound wave at regular time intervals.