Chap. 1
History and Basics

Computing Technology For All

Online Reference

- zyBooks: chap.1
- https://www.worldsciencefestival.com/infographics/a_history_of_computer_science/
- https://en.wikipedia.org/wiki/History_of_computer_science
- https://medium.com/history-of-computer-science/brief-history-of-the-computer-science-a13c6fbe5873
- https://www.livescience.com/20718-computer-history.html
- http://www.myoddpc.com/other/history_of_computer.php
- http://www-03.ibm.com/ibm/history/history/history_intro.htm

Brief history

- Computers originated from telephone switches in the early 1900's.
- A switch is either on (1) or off (0).
- 1940's computers, with thousands of baseball-sized switches, occupied entire rooms.

  → single-chip computers.

  → By the 1970's, one coin-  computer chip (IC).

  → Today, that room-sized computer fits on a chip the size of a pinhead → Nanochip

- Moore's Law: A trend t engineers have reduced switch sizes by half about every 2 years.
- Agricultural age → Industrial age → Information age:
  - in the 1990's, with human activity shifting from traditional industry to creating/managing/using computerized information.
- Ref) World Population

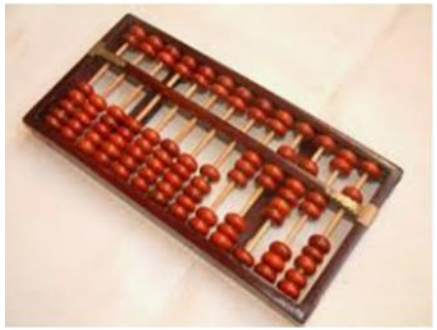
Brief history

- Information Technology, (I.T.):

  Anything related to computing technology, such as networking, hardware, software, the Internet, or the people that work with these technologies.

Early Computing

- The Abacus
  - First computing device, invented around 2400 BCE in ancient Babylon, 2000 years before Greek Methods of calculation.
  - The abacus generally features a table or tablet with beaded strings.
  - It was till 1980-1990's in East Asia, etc.



Early Computing: Analog Computer (AC)

- A form of computer that use electrical, mechanical, or hydraulic means to model the problem being solved (simulation) -- wikipedia.
- Any of a class of devices in which *continuously variable physical quantities*, such as electrical potential, fluid pressure, or mechanical motion, are represented in a way analogous to the corresponding quantities in the problem to be solved.

  The analog system is set up according to initial conditions and then allowed to *change freely* (i.e. variable).

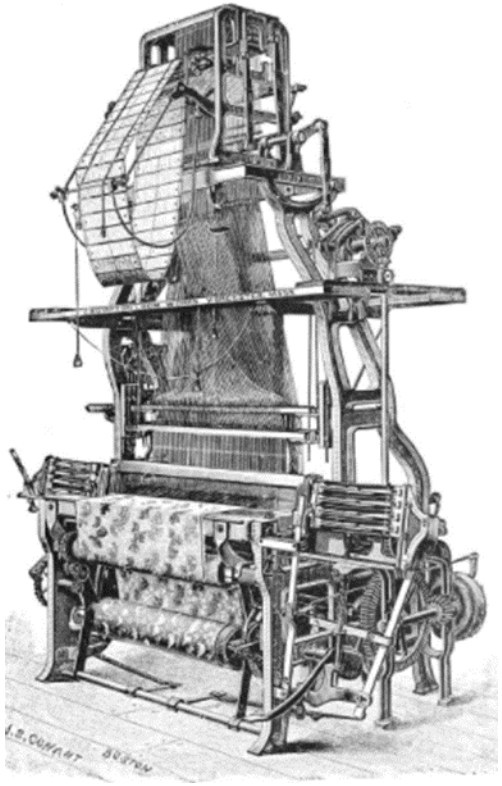
  Answers to the problem are obtained by measuring the variables in the analog model. - Britannica
- Cf) Digital Computer and Computer Science?

Early Computing: Analog Computer

- Antikythera mechanism
  - Believed as the first analog computer, developed by the Greeks.
  - Used to predict astronomical position and eclipses decades in astronomy.
  - It was discovered 1901 in the shipwreck and was dated back to 100 BCE.
- ELWAT:
  - the Polish analog computer at Military Univ. of Technology in 1960's.
  - Used to solve differential equations, modeling and control processes.
- The Norden bombsight:
  - Used by the USAAF/USN/USAF during WWII, the Korean war and the Vietnam war.
  - Its usage includes the dropping of the atomic bombs on Japan.
  - Nomenclature and operation

Historical figures in computing

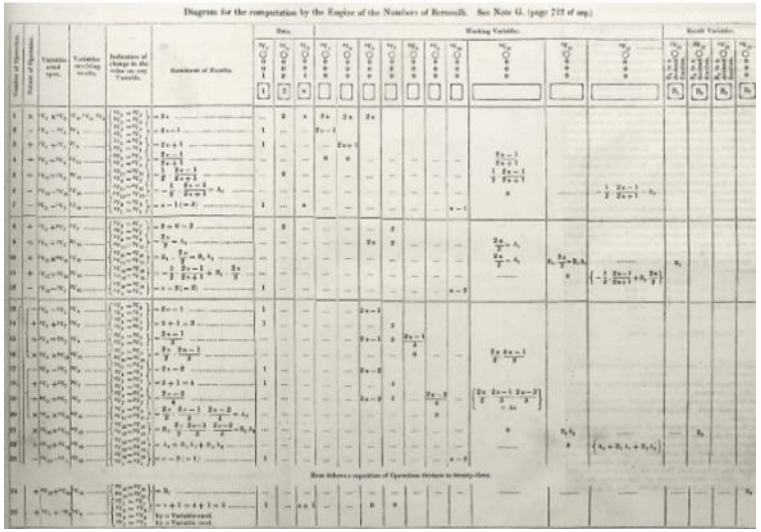
- Joseph Marie Jacquard (1752 - 1834)
  - a French silk weaver and inventor.
  - Jacquard Loom: 1804
    - a weaving device noted for simplifying the manufacturing of textiles.
    - The loom could be programmed to weave specific patterns using a chain of *punched cards*.
    - Using different cards allowed the woven patterns to change without modifying the mechanics of the loom.
    - The Jacquard Loom influenced modern *programmable devices*, such as the IBM digital compiler.



Historical figures (cont.)

- Charles Babbage (1791 – 1871, Fig. 1.2.2):
  - a British mathematician, philosopher, mechanical engineer, and inventor: a father of the computer.
  - Difference Engine:
    - the first automatic mechanical computer
    - used to calculate *polynomial functions*.
  - Analytical Engine:
    - the Difference Engine's successor, intended as a *programmable computing engine*.
  - Analytical Engine + more components = the modern computer
    - Arithmetic Logic Unit (ALU): used to perform arithmetic. Called a "mill".
    - Conditional Logic Unit: used to perform conditional branching and loops.
    - Memory: it could hold over 1,000 numbers containing 40 decimal digits.
    - Punched card reader: to input programs and data via *punched cards*.
    - Refer to slide-#26 for the von Neumann architecture of modern computer.

Historical figures (cont.)



- Ada Lovelace (1815 - 1852)
  - a British mathematician
  - the 1st computer programmer.
  - She translated a document about Babbage's Analytical Engine from French to English.
    - The document was augmented with her own notes, tripling the size of the original document.
    - In her note G, she detailed the *steps to compute* the Bernoulli numbers ➔ the first computer program.
  - She predict the use of Babbage's Engines beyond numerical calculations, far reaching applications in general computing.

Historical figures (cont.)

- Herman Hollerith (1860 - 1929):
  - an American inventor and the creator of the punched card tabulating machine and key punch machine.
  - The tabulating machine was an electromechanical computer used to summarize data stored on punched cards – used to compile statistics for the U.S. Census.
  - Tabulating Machin Company

  →Computing-Tabulating-Recording Company (CTR) → International Business Machines Corp. (IBM).
  - Ref) IBM Quantum processor

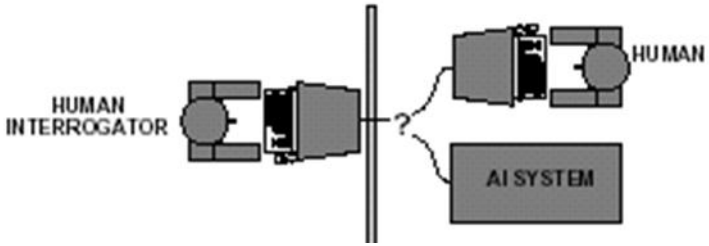
Historical figures (cont.)

- Alan Turing (1912 - 1954):
  - A father of the Computer Science & Artificial Intelligence
  - A British computer scientist and mathematician:
    - Well known for his cryptologic methods during WWII.
    - Bombe: the cryptanalytic machine developed by Turing to decipher the intercepted German messages of 'Enigma'. → Win the war.
  - The Turing Machine:
    - a basic abstract symbol manipulating device that can be used to simulate the logic of any computer that could possibly be constructed.
    - It was not actually constructed, but its theory yielded many insights.
  - Turing Test:
    - It evaluates if a computer is considered intelligent by posing a series of questions. A computer passes the test if the computer's response cannot be distinguished from a human's response.
  - The movie: The Imitation Game (2014)

Historical figures (cont.)

Turing Test: Computing machinery and intelligence

- The test was designed to provide an operational definition of intelligence.
  -- *"Can machines think?"* $\rightarrow$ *"Can machines behave intelligently?"*
- A test of an intelligent machine which is indistinguishable from human.
- Operational test for intelligent behavior: the Limitation Game



- Predicted by 2000, a machine might have a 30% chance of fooling a lay person for 5 minutes.
- Anticipated all major arguments against AI in following 50 years.
- Suggested major areas of AI: knowledge representation, automated reasoning, natural language processing, machine learning + computer vision, robotics

Historical figures (cont.)

- Grace Hopper (1906 - 1992)
  - an American computer scientist and mathematician credited with developing the first *compiler*.
  - She worked on the project to develop the UNIVAC I computer at Harvard Univ. → her suggestion to create a high-level programming language using English words made her invent the 1st programming language compiler.
  - Compiler? -- A program used to *convert* mathematical instructions, written in English words, into *machine code*.
  - A technical consultant to the committee that defined COBOL.
  - Contribution to removal of a moth (i.e. computer bug) from Harvard's Mark II computer.
- COBOL (COmmon Business-Oriented Language):
  - an English-based programming language designed for business use.

More History
in Computer Science

Computer Science: Beginnings

- Before the 1920's, the term "computer" denoted an occupation. Computers were people whose job it was to calculate various equations. Many thousands people were employed by the government and businesses.
- Analog computers and the very first digital computers were being developed by the 20's and 30's were known as "computing machines", but this phrase had passed out by the 40's. By that time "computer" meant a machine that performed calculations.
- Analog computers relied on physical substances to perform calculations, such as the turning of a shaft, while digital computers could *process information* and render a numeric value and store it as an individual digit.

Alan Turing

- Refer to slide-#12

The 1930's: Development of Mathematical Framework

- In the late 1800's, the 1st programmable computers appeared using punch card technology. To be programmable, a machine had to be able to simulate the computations of any other machine by altering its computational process.
- 1931: Gödel's Incompleteness Theorem
- 1936: Church-Turing Thesis:
  - Formalizing what can and cannot be computed.
- 1937: First formal logic for circuit analysis (Shannon)

The 1940's: Practical Applications

- Development mainly focused around the War effort.
- Machines for encrypting and decrypting.
- Most famous of the machines was the German "Enigma" Cipher Machine (WWII).
- Much of the work took place in Britain at Bletchley Park which is considered the birthplace of the modern computer.
  - Alan Turing worked for the Government Code and Cypher School at Bletchley Park, cracking the intercepted coded messages of the Nazis.

Computers: The transition from Analog to Digital

- The advent of World War II prompted the transition from analog computers to digital.
- Electronic circuits, relays, capacitors, and vacuum tubes replaced mechanical gears and analog calculations became digital ones.
- Examples of new digital computers:
  - Atanasoff-Berry Computer, the Z3, the Colossus and ENIAC (which was 1000 times faster than its contemporaries).
  - They were hand built and relied on *vacuum tube* technology.
  - For input assimilation, they relied on punched cards or punched paper tape.

The 1950's and 1960's

- 1953: Ada Lovelace's work is republished including the first algorithm specifically tailored for a computer.
- 1960's: Symbolic computation progresses to the point where a computer can do well in a first-year university calculus class.
- 1964: First computer *mouse* is developed.
- 1968: First tablet PC (Dynabook) conceptualized by Alan Kay.
- 1969: Unix First written.
  - Unix is a multitasking, multiuser operating system that was developed at the Bell Labs, AT & T, by Ken Thompson, Dennis Ritchie, et.al in 1970s.
  - Written in C and assembly language.

The 1960's

- Several developments in the course of modern computing.
- The transition from vacuum tube to *transistor*:
  - The transistor was developed in the 1940's and 50's, and applied to computers in the 60's.
  - By the 1970's transistors had almost completely supplanted vacuum tubes as the main active components of computers.
- Several advantages of Transistor over vacuum tubes:
  - Their *small size* and *small price*. With transistor technology, electronic equipment gradually became smaller and smaller.

    --- Moore's law.
  - It also made possible by the invention of the microprocessor, developed in the 1960's.

The 1960's

- The microprocessor + the integrated circuit, led to *microcomputers*.
  - A microprocessor is a computer processor wherein the data processing logic and control is included on a single *integrated circuit*, or a small number of integrated circuits.

→ A huge step towards making computers more available to the general public.

- Moore's Law:
  - In general, the number of transistors on a integrated circuit has doubled every 2 years since the 1970's, in accordance with Moore's Law.
- The speed and quality of computers advances very quickly.

The 1970's

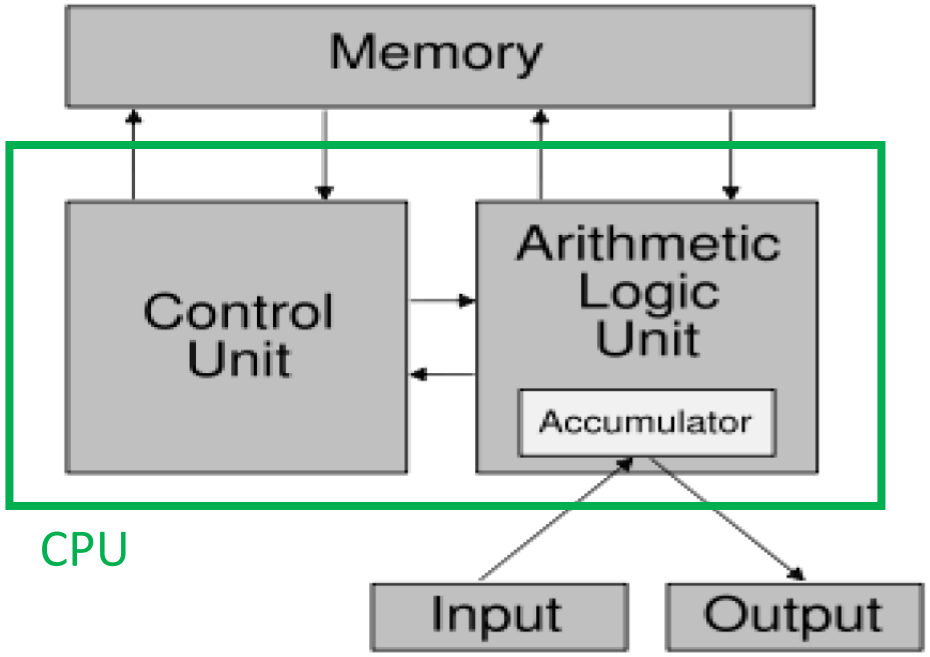
- 1973: Unix translated almost entirely into C (from assembly code)
- 1969-1973: C programming language developed at Bell Labs (still popular today, easily the most influential programming language of all time)
- C is complicated and confusing for beginners due to manual memory declaration

The 1980's to *Present*

- The invention of the *Internet*: most interesting and life-altering development.
- How fast does information travel in the modern era? News makes it around the world in minutes. At the beginning of computer science it took hundreds of years for ideas to spread.
- Nano-technology developed during the 1980's and 90's and allowed for even faster and smaller computers.
- Currently the smallest transistor chips in the world are about 2 nm (2021):
  - cf) standard is chips with 7-nm transistors
  - IBM's new 2-nm chips have transistors smaller than a strand of DNA.
  - https://newatlas.com/computers/ibm-2-nm-chips-transistors/
  - 1 nanometer (nm) = 10^{-9} meters.
- Big Data

The Von Neumann Machine

- John von Neumann
- The modern computer has five basic components: memory, control unit, arithmetic logic unit, input and output.
- Designed by noted mathematician John von Neumann in the 1940's.
- It has been very influential in the design, evolution, and continued architectural setup of the modern computer.



The Advent of the Home Computer

- In 1975, the first commercially successful home computer, the MITS Altair 8800 (the same computer that Microsoft was founded to provide programming for), was released.
- Shortly thereafter, the Apple I, Apple II, Commodore PET, and TRS-80 were released. Among them, the Apple II was by far the most successful.
- Seeing Apple's success, IBM released the original IBM PC model. Soon afterwards a number of "IBM PC" clones were released, such as computers from Compaq.
- Microsoft successfully negotiated a deal to provide the operating system of all IBM's and *IBM compatible machines*. This, coupled with later blunders by Apple, led to Microsoft's assumption of a near monopoly in the computer market.

Implications

- 3 ½ decades later, the revolution of home computer is still occurring.
  - Microsoft, Apple - iMac, iBook, iPod, etc.
  - independent free source operating systems like Linux and Solaris.
- The computer industry itself generates billions upon billions of dollars in revenue annually between software, hardware, games, etc.
- Modern militaries and nearly every other commercial industry in the world now relies upon computers.
- Can you imagine your daily life without a computer?

Programming

Programming

- Computer program basics
  - A computer program consists of instructions executing one at a time.

  Basic instruction types:
  - Input: A program gets data from a file, keyboard, touchscreen, network, etc.
  - Process (Algorithm): A program performs computations on the data, such as adding two values like x + y.
  - Output: A program puts that processed data somewhere, such as to a file, screen, network, etc.
- Variables (PA 1.3.1 & 3):
  - A location in memory that stores a value which varies as a program assigns a variable with a new value.
  - E.g.) x ← 2, y ← 3 ➔ z ←5 ; x ← 4, y ← 3 ➔ 7

Programming (cont.)

- Computational Thinking
  - In the information age, many people believe computational thinking, or creating a sequence of instructions to solve a problem, will become increasingly important for work and everyday life as mathematical thinking was important throughout the industrial age to enable people to successfully live and work.
- Algorithm
  - A sequence of instructions that solves a problem.

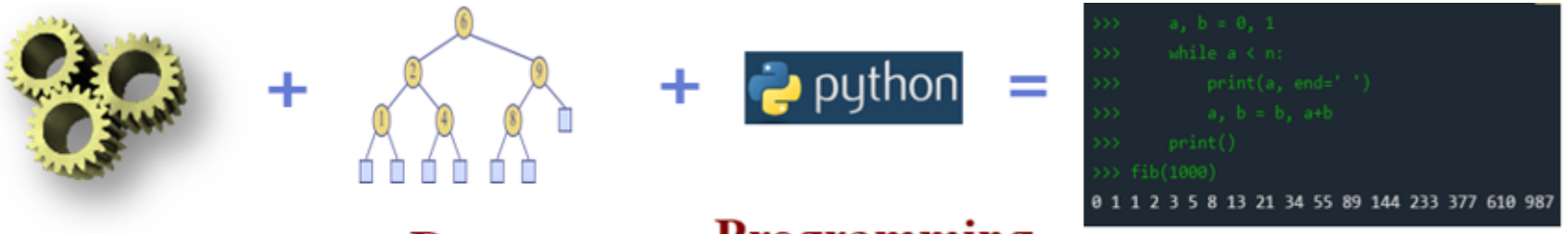
Programming (cont.)

- Algorithm:

Input (Data, Instance of a problem)

Algorithm

Output (a Solution to the problem)



Algorithm + **Data Structure** + **Programming Language** = **Program**

Computers all around us (Fig. 1.4.1 - 4)

- Commonly-Used Computers:
  - Desktops, laptops, tablets, smartphones, etc.
- Embedded Computers:
  - a computer inside another electrical device like inside a TV, car, printer, thermostat, satellite, etc.

Representing Information as Bits

- Bit
  - Computers are built from connected switches that, are either on or off: 1 or 0,
  - Bit: a basic unit of computer or information that is *either single 0 or 1*.
  - Byte: a sequence of bits: ***8 bits = 1 byte***.
  - All data stored in a computer is represented using bits including numbers, letters, symbols, and multimedia
  - 64-bit processor vs. 32-bit processor
- ASCII (American Standard Code for Information Interchange)
  - Character encoding standard
  - Character: a letter (a, b, ..., z, A, B, ..., Z), symbol (!, @, #, ...), or single-digit number (0, 1, ..., 9).
  - Each character can be given a *unique bit* code.
  - 7 bit per code (2^7 = 126 symbols)
  - E.g.) a = 97 = 110 0001, A = 65 = 100 0000 - Table 1.5.1 in zyBooks.
  - Binary number: base = 2
  - Table 1.5.1

  - https://www.pcmag.com/encyclopedia

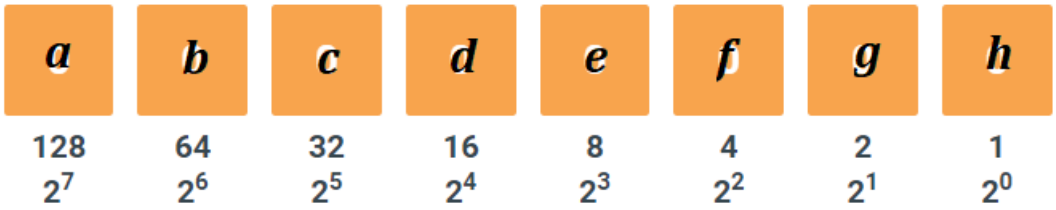
Representing Information as Bits (cont.)

- Unicode
  - Another character encoding standard, published in 1991.
  - More bits than ASCII
  - Thus, it can represent over 100,000 items, such as symbols and non-English characters, and emoji, etc.
  - an information technology (IT) standard for the consistent encoding, representation, and handling of text expressed in most of the world's writing systems.
  - As of March, 2020, there is a repertoire of 143,859 characters, with Unicode 13.0 (143,696 graphic characters + 163 format characters) covering 154 modern and historic scripts, as well as multiple symbol sets and emoji.
  - https://unicode.org/charts/
  - Different character encoding: UTF-8, UTF-16, UTF-32

    Refer to https://en.wikipedia.org/wiki/Unicode

Representing Information as Bits (cont.)

- Binary Numbers:
  - Computers can only represent two values (0 or 1), so use base two numbers, known as binary numbers ("bi" refers to 2).
- Decimal Numbers:
  - Because early humans represented values using ten fingers, humans developed base ten numbers, known as decimal numbers ("dec" refers to 10).
- Conversion of binary number to decimal number?
  - Binary number, $abcdefgh_2$ where $a, b, .., h \in \{0, 1\}$



→ $a \cdot 2^7 + b \cdot 2^6 + c \cdot 2^5 + d \cdot 2^4 + e \cdot 2^3 + f \cdot 2^2 + g \cdot 2^1 + h \cdot 2^0$

where *a* is at the highest order and *h* is at the lowest order.

- *E.g.)* $101011 = 1 \cdot 2^5 + 0 \cdot 2^4 + 1 \cdot 2^3 + 0 \cdot 2^2 + 1 \cdot 2^1 + 1 \cdot 2^0 = 43$

Naming Numerous Bits

- IEC prefixes: International Electrotechnical Commission, 1998
- Metric system vs. IEC prefix.

Power of 2	**Value**	**Metric prefix**	**IEC prefix**
10	$2^{10} = 1024 \approx 10^3$	Kilo (K): 1 kilobit = 1 Kb	Kibi (Ki): 1 kibibit = 1 Kib
16	$2^{16} = 65536$	64 Kb (= 1 Kb * 2^6)	64 Kib
20	$2^{20} = 1048576 \approx 10^6$	Mega (M): 1 megabit = 1 Mb	Mebi (Mi): 1 mebibit = 1 Meb
30	$2^{30} = 1073741824 \approx 10^9$	Giga (G): 1 gigabit = 1 Gb	Gibi (Gi): 1 gibibit = 1 Gib
32	$2^{32} = 4294967296 \approx 4 * 10^9$	4 Gb (= 1 Kb * 2^2)	4 Gib
40	$2^{40} \approx 1.0995 \times 10^{12}$	Tera (T): 1 terabit = 1Tb	
more	2^{50}, 2^{60}, 2^{70}, etc.	Peta(10^{15}), Exa(10^{18}), Zetta (10^{21}), Yotta (10^{24}), etc.	

- E.g.) 1 TeraByte HD, 32 GB RAM,