Chapter 1
History & Hardware

History & Generations of Computing

Mechanical Machines

The first computers (some in the 17th century) were mechanical devices not electronic devices. While the technology was quite different than that of today's computers, much of the logic and basic design served as a model for modern computers.

Blaise Pascal-

Gottfried Leibnitz-

Joseph-Marie Jacquard-

Charles Babbage-

Herman Hollerith-

Early Electronic Computers (1930 - 1950)

Atanasoff Berry Computer (ABC)-

ZI-

Mark I-

Colossus-

Electronic Numerical Integrator and Calculator (ENIAC)-

The computers above stored only data in memory. The computer was programmed externally using wires and switches and could perform only one task at time then had to be reprogrammed. John von Neumann is credited with the stored program concept. He proposed that _____ and _____ should be stored in the computer's memory.

The development of modern computers may be traced by looking at the various generations of modern computing. We move from one generation to the next when there is a major change in the technology being used. As consumers, we will associate the change from one generation to the next with three elements – the computer becomes _____, _____, and _____.

First Generation (1950 - 1959)

Second Generation (1959 - 1965)

Third Generation (1965 - 1975)

Fourth Generation (1975 - 1985)

Fifth Generation (1985 - present)

A Brief History of Computing

The Internet is a great resource for researching the history of computing. Try the following web site to learn about the computers and people listed below. As web sites change regularly, you might need to perform a search to find sites covering the history of computers.

www.studyweb.com/computers/history.htm

ABACUS
Slide Rule
Difference engine
Analytical engine

Ada Byron Lovelace
George Boole
John von Neumann
Grace Hopper

Thinking Machines
The Creation of the Computer

1. Modern processor speed is measured in MIPS, _____ _____.

2. Random Access Memory on modern computers is so fast that every second it can send the equivalent of _____ type written pages to the CPU.

3. Modern hard drives can store the equivalent of _____ pages of type written material.

Early Computing Devices:

4. People in the early 19th century who made intricate computations by hand using tables were called _____.

5. The number of mistakes in the math tables used by the Royal Astronomical Society prompted _____ to propose a mechanical computer called the _____. In 1823 he received a government grant to produce the machine. By 1832 a small part of the proposed machine was working.

6. The government withdrew financial support when the inventor began work on a new project called the _____. This machine could solve any mathematical problem and contained all the essential components of a modern computer.

7. _____, daughter of Lord Byron, wrote a description of the machine and a set of instructions to demonstrate its use. She has been called the _____ although she never worked on a real computer.

8. By the late 1800's the population in the United States was increasing by _____ every decade. In 1887 the Census Bureau was still calculating the 1880 census. Desperate for a better method before 1890, they held a contest to see if a machine could be designed to perform the calculations. The winner of this contest was _____ with a machine that used _____. The Census Bureau leased 56 of his machines and the census of 1890 was tabulated in _____.

9. The use of the machines for the census was such a success that he formed a company called _____. He convinced the New York Central Railroad to try his machines but they were too slow for the volume of data used by the railroad. He spent a year working on the machine and the result was successful/unsuccessful. In 1911 he sold his shares of the company and it was merged with three other companies. This new company was run by a salesman named _____ and later became the company known as _____.

World War II:

10. The _____ was a German machine that produced what was thought to be an unbreakable code. The British developed a machine called the _____ that performed only one task, that of breaking the code. It could process _____ characters per second and used over _____ vacuum tubes.

11. In 1943 the United States was unable to produce the necessary artillery pieces due to the enormous number of calculations required to produce _____. A physicist from the Moore School of Engineering at the University of Pennsylvania named _____ proposed a machine that could figure a trajectory in 100 seconds. He was assisted in the project by a grad student named _____. The development would cost _____ and would take two years to complete. The war ended before the machine was completed. The machine was called the _____.

12. An advisor on this computer and a member of the Manhattan Project, _____ wrote a paper outlining the structure of a modern computer. The major difference in this machine would be the concept of _____.

13. Mauchley & Eckert formed a company and built the _____ computer for the Census Bureau. Due to financial problems they were forced to join with Remington Rand, a company that specialized in _____. Business remained slow as people saw no practical use for a computer. In 1952 they joined with CBS to predict _____. The two candidates were _____ and _____. In the end, the final results were within _____ of the results predicted by the computer. The public was hooked and computer companies began to appear.

14. In 1953 _____ unveils the _____.

15. In 1961 the United States trailed Russia in the space race. NASA realized the need for _____ computers. Each space craft required a computer as powerful as those that _____.

16. In 1947 _____ had been invented and replaced vacuum tubes as the dominant technology. Still not small enough, in 1959 the _____ was invented. It was expensive to produce but the space program was willing to fund its production.

17. The door was opened for personal computers in 1970 with the invention of the _____.

18. In the mid 1970's two young men working out of a garage formed a company called _____. Their names were _____ and _____. Personal computers were difficult to use because they operated with a command line interface. Instructions appeared as _____. For personal computers to be successful a GUI, _____ was necessary.

19. In 1968 _____ introduced a small pointing device called a _____. It was not adopted for popular use until a group of computer scientists at _____ developed a computer called the ALTO. The commercial version of the ALTO was called the _____ but it never sold well.

20. In 1979 _____ saw the ALTO computer and the _____ was born. It was a commercial success. The GUI relied on easy to use _____.

A Simple Computer

We are going to think of a computer as a group of switches. Each switch may be in one of two possible states, on or off. We will represent on with the digit 1 and off with the digit 0. The most basic computer could be described as a machine with one switch. This computer could understand only two instructions, on or off. Let's picture a house that has only one light switch.

1 switch	Instructions	
	0	(lights off)
	1	(lights on)

2 switches	Instructions	
	00	(front & back lights off)
	01	(front off and back on)
	10	(front on and back off)
	11	(front & back lights on)

3 switches	Instructions	
	000	(all lights off)
	001	(front & middle off, back on)
	010	(front off, middle on, back off)
	011	etc.
	100	
	101	
	110	
	111	

Based on the above, how many instructions would a computer with sixteen switches understand?

Typically, rather than look at a single binary digit, called a BIT, we will look at larger groups. A group of eight adjacent bits is called a BYTE and is used to represent a single character. The numeric representation for each character may be found on an ASCII chart. ASCII stands for American Standard Code for Information Interchange. This is a code that changes letters, numbers, and symbols into a 7-bit code with the eighth bit being used as a check bit (more about this in the class lecture on telecommunications). The extended version of the ASCII character set contains 256 characters. While this is sufficient for English, it is not large enough for international use. Because of this limitation, the Unicode character set is widely used.

Unicode uses 16 bits to represent a character. Therefore, 2^{16}, or 65,000 characters can be represented in Unicode. The first 256 characters of Unicode and the ASCII character set correspond exactly. Not all of the available codes have been assigned characters so expansion of the character set is still possible.

Numbers and The Machine

Since all computers are binary machines and the internal symbolic representation of the machine utilizes binary numbers, it is helpful to understand the binary number system. Because our world is a decimal world there is a need to transform numbers between these two systems. Also, because of the unwieldy nature of binary numbers and the difficulty humans have in distinguishing between large binary numbers, they are usually converted to either octal or hexadecimal equivalents. These forms are easier to work with than binary and easier to transform to/from binary than decimal.

The decimal numeration system is based on a method devised by Hindu mathematicians in India about 400 A.D. The Arabs began to use this system somewhere around 800 A.D. and it is usually referred to as the Arabic Number System. It was introduced to the Europeans around 1200. This method of representing numbers is very ingenious: it enables us to use carrying and borrowing in arithmetic and enables us to work with very large numbers as easily as small numbers. Can you imagine trying to do arithmetic in the Roman Numeral System?

The decimal system makes use of ten digits – 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9. These symbols, together with a placevalue or positional concept, enable us to represent any whole number. Fractional numbers can be represented also, but our discussion here deals only with whole numbers. The word "digit" is derived from the Latin "digitis", meaning finger or toe, and the fact that we have ten digits is commonly attributed to the ten fingers of man. If man had only eight fingers, the octal system would be a natural one.

The systems included in this discussion employ the principle of positional notation. For example, in the decimal system, 2563 means 2 thousands, 5 hundreds, 6 tens and 3 ones. The position of the 5 dictates that its value is 5 hundred. Each digit has a place value. The expanded form is

$$2563 = 2x1000 + 5x100 + 6x10 + 3x1$$

or

$$2563 = 2x10^3 + 5x10^2 + 6x10^1 + 3x10^0$$

The position of a digit determines the power of ten by which it is multiplied. This concept is familiar to anyone who has completed high school algebra.

What is surprising to most people is that the numeral 10 represents ten ONLY because our system is base-ten. The base is also called the ***radix***.

If we had evolved a base-eight (octal) numeration system the above representation would be perfectly valid in every respect, but 10 would stand for eight instead of ten and the value would be correspondingly lower.

The following general rules apply in any positional notation system:

a) The number of digits (or distinct symbols) equals the base.
a) The largest digit (symbol) is one less than the base.
a) Each digit in a number is multiplied by the base raised to the appropriate power for the positional value of that digit.
a) The numeral 10 represents the base (radix)

The binary system is base two. The system has two digits, 0 and 1. This system is extremely useful in representing the internal workings of electronic digital computers because these machines are binary state machines, i.e. the devices utilized have two possible states.

The place values are powers of two. The following table provides the decimal equivalents for the first 17 binary numbers.

Binary	Decimal
0	0
1	1
10	2
11	3
100	4
101	5
110	6
111	7
1000	8
1001	9
1010	10
1011	11
1100	12
1101	13
1110	14
1111	15
10000	16

Note that although we commonly think of two as 2, in the binary system it is written as 10 (see rule d).

For the rest of this discussion, we will adopt the common practice of subscripting numerals to indicate their base whenever the system being used is not obvious. For example, 110_2 is binary and 110_{10} is decimal. The subscripts themselves are always in decimal.

Base Conversions

The actual conversion of a binary number to its decimal equivalent is quite simple. We simply add various powers of two.

Ex: Convert 11010111 to its decimal equivalent.

$$\begin{aligned} 11010111 &= 1x2^7 + 1x2^6 + 0x2^5 + 1x2^4 + 0x2^3 + 1x2^2 + 1x2^1 + 1x2^0 \\ &= 2^7 + 2^6 + 2^4 + 2^2 + 2^1 + 2^0 \\ &= 128 + 64 + 16 + 4 + 2 + 1 \\ &= 215_{10} \end{aligned}$$

The conversion from decimal to binary utilizes successive divisions by the base, it is called the "dibble-dabble" method.

Ex: Convert 23_{10} to its binary equivalent.

23 / 2 = 11 with remainder 1 (least significant bit)
11 / 2 = 5 with remainder 1
5 / 2 = 2 with remainder 1
2 / 2 = 1 with remainder 0
1 / 2 = 0 with remainder 1 (most significant bit)

Therefore $23_{10} = 10111_2$

The same methods may be used for conversion to/from octal and hexadecimal.

Ex: Convert 1253_8 to its decimal equivalent.

$$\begin{aligned} 1253_8 &= 1 * 8^3 + 2 * 8^2 + 5 * 8^1 + 3 * 8^0 \\ &= 1 * 512 + 2 * 64 + 5 * 8 + 3 * 1 \\ &= 512 + 128 + 40 + 3 \\ &= 683_{10} \end{aligned}$$

Use the "dibble-dabble" method above to convert 683 decimal to octal.

Name _____

Base Conversion Worksheet

Convert the following decimal numbers to their binary equivalents:

SHOW YOUR WORK TO RECEIVE CREDIT

1. 13_{10} = _____ (base 2 - binary)

2. 137_{10} = _____ (base 8 - octal)

3. 146_{10} = _____ (base 16 - hexadecimal)

Convert the following binary numbers to their decimal equivalents:

4. 10111_{2}= _____ (base 10)

5. 1327_{8} = _____ (base 10)

6. $1A3C_{16}$ = _____ (base 10)

Arithmetic

Addition and subtraction in base 2, 8 or 16 is exactly the same as in base 10 except we will be borrowing or carrying groups of 2, 8 or 16 rather than 10.

Addition

Sample addition of two base 8 numbers. Remember, we will be carrying groups of eight.

$$\begin{array}{r} 146_8 \\ +53_8 \\ \hline 221_8 \end{array}$$

Process: 6 + 3 = 9 (carry a group of eight and you have one left), 4 + 5 + the carry = 10 (carry a group of eight and you have two left), and finally 1 plus the carry = 2.

Sample addition of two base 2 numbers. This time we will carry every time we get a group of two.

$$\begin{array}{r} 10011_2 \\ +1011_2 \\ \hline 11110_2 \end{array}$$

Process: 1 + 1 = 2 (carry the two and none are left), 1 + 1 + the carry = 3 (carry the group of two and you have one left), 0 + 0 + the carry = 1, 0 + 1 = 1, and finally bring down the left most 1.

Subtraction

Sample subtraction of two base 8 numbers. Remember, when we borrow we are borrowing one group of 8.

$$\begin{array}{r} 426_8 \\ -57_8 \\ \hline 347_8 \end{array}$$

Process: We need to borrow a group of 8 from the middle column, 6 + the borrowed 8 = 14 – 7 = 7. Now we need to borrow from the far left column. 1 + the borrowed 8 = 9 – 5 = 4. Bring down the 3 from the far left column.

Sample subtraction of two base 2 numbers. This time we will borrowing one group of 2.

$$\begin{array}{r} 1101_2 \\ -110_2 \\ \hline 111_2 \end{array}$$

Process: 1 – 0 = 1, next we need to borrow a group of two, 0 + the borrow = 2 – 1 = 1, we need to borrow again and 0 + the borrow = 2 – 1 = 1.

The process is exactly the same as in base 10. If you get confused, simply add or subtract two base 10 numbers and review the process you do so naturally in this familiar base.

Name _____

Arithmetic Worksheet
SHOW YOUR WORK TO RECEIVE CREDIT

1. 246_8
   $+65_8$

2. 10111_2
   $+1011_2$

3. 3256_8
   -347_8

4. 110001_2
   -11011_2

5. $9A48_{16}$
   $+ \ 175C_{16}$

6. $E34B_{16}$
   $- 7AF_{16}$

Computer Hardware Lab

Go to the website called **howstuffworks.com**
Select **Computer Stuff**
Select **Microprocessors**
Scroll to the bottom of the page and select **Inside a Microprocessor**

_____ is the native language of a microprocessor.

A microprocessor does three basic things – list them below.

Information is moved along an electronic pathway called a bus. The address bus _____ _____ to memory. The data bus _____. The information on whether the data is to be read from memory or written to memory is transmitted along _____ and _____ lines.

Scroll to the bottom of the page and select **RAM and ROM**.

ROM stands for _____. On a PC, the ROM is called the _____ which stands for _____ _____. Describe what happens when the microprocessor starts (when you turn your computer on).

This "boot" process is used to load the _____.

RAM stands for _____. This is the "user portion" of memory. All programs and data must be in RAM to be executed. One problem with RAM is that it is volatile which mean anything stored there is _____ when the computer is turned off.

Click on the link to **BIOS**. Select **What BIOS Does**.

The most important role is to _____. It performs other tasks as well. The POST _____ checks to make sure _____ _____. BIOS provides a set of low-level routines used by the _____ to interface with basic hardware components such as the _____ , _____, and the _____ and _____ ports. Basically, serial ports provide a standard connector that allows you to attach devices such as modems, printers, and digital cameras. Parallel ports also provide a connection for devices such as printers. A serial port "serializes" data – it transmits data one byte at a time. A serial port requires only one wire to transmit the byte. A parallel port is more efficient and faster. It has one wire for each bit (8 wires). A serial port lowers the cable cost and makes cables smaller but a parallel port is 8 times faster.

The BIOS is special software that interfaces the major hardware components of your computer with the operating system software. It is usually stored on a _____ _____ chip on the _____ but sometimes it is another type of ROM.

One of the first things the BIOS does is check the information stored on a _____ _____ (CMOS) chip. The CMOS Setup provides _____ _____.

Return to the **Computer Stuff** main page and select **Microprocessors** again. Select **Inside a Microprocessor**. Scroll to the bottom of the page and select **How Bytes and Bits Work**. Read the section on **Decimal Numbers** as a review basic number systems then continue on to the section called **Bits**.

Computers operate using the base-2 or _____. The word bit stands for _____. It may contain the value ____ or ____. When you examine a number in the binary system you will see that the place values increase by powers of _____.

Select the section on **Bytes**. A byte is a collection of _____ bits. Using one byte you can represent numbers ranging from _____ to _____.

Bytes are used to hold characters in a text document. In the _____ _____ decimal values 0 to 127 are used to represent specific _____. Most systems make use of the full range of 256 characters using the upper 128 characters to handle things like _____ _____. Text is stored in _____ and on _____ using these numeric codes.

The decimal value for the character 'A' is 65, 'B' 66, 'C' 67 and so on. Show the binary representation for the character 'G' _____.

When you start talking about memory and auxiliary storage (hard disk drives etc.) you are talking about lots of bytes. For example kilo is a prefix used to represent 2^{10} or 1024. Because we are more comfortable with decimal numbers we use kilo to mean roughly 1000. So a device with 40K (40 kilobytes) of storage could store roughly _____ bytes. A 20M device could store roughly _____ bytes.

Continue on to the **Binary Ma**th section. Study the sample problem and perform the binary addition problem below.

```
    101101
+   110101
```

Scroll to the bottom of the page and select **Lots More Information**. Scroll down and select **The Binary System**. Read the section **Basic Concepts Behind the Binary System** as a review of the class lecture. Convert the following binary number into decimal.

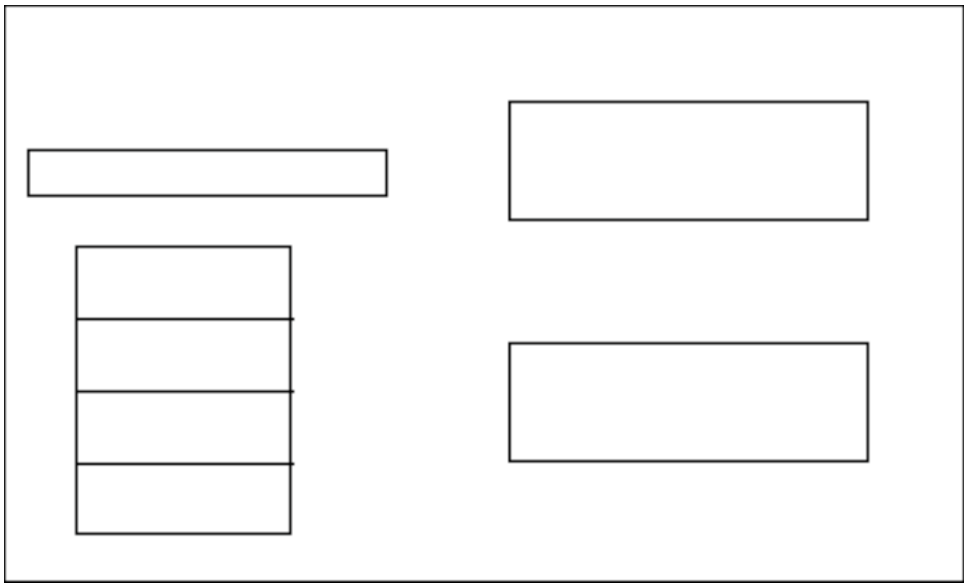
111011

Read the section called **Conversion from Decimal to Binary**. Use the algorithm provided and convert the decimal value 54 into binary. SHOW YOUR WORK.

Basic Elements of Computer Hardware

Computer Hardware – the physical components of the machine

The CPU (Central Processing Unit) is the _____ of the computer and is divided into three parts. The _____, the _____, and the _____.



Control Unit:

Arithmetic Logic Unit:

Program Counter:

Data Registers:

Instruction Register:

Main Memory

Main memory is a collection of storage locations each with its own address (a bit pattern of 1's and 0's). There are some basic units of storage.

bit -

byte -

word -

Unit	Number of Bytes	Decimal Approximation
kilobyte	2^{10} (1024) bytes	10^{3} bytes
megabyte	2^{20} (1,048,576) bytes	10^{6} bytes
gigabyte	2^{30} (1,073,741,824) bytes	10^{9} bytes
terabyte	2^{40} bytes	10^{12} bytes
petabyte	2^{50} bytes	10^{15} bytes
exabyte	2^{60} bytes	10^{18} bytes

There are three types of main memory RAM _____,
ROM _____, and cache.

RAM:

ROM:

cache:

Input/Output and Auxiliary Storage Devices

The input/output system provides a means of communication with things outside the computer as well as storage for programs and data when the computer is turned off.

Non-storage Devices:

Storage Devices:

Because the CPU is the brain of the computer, all of the components must be connected to it. This is done using a group of wires (an electrical pathway) called a _____. The CPU needs to have a way to transfer data, access various address locations in memory, and pass along instructions.

Data Bus:

Address Bus:

Control Bus:

Input and output devices such as keyboards, monitors, printers, and disk drives are not connected directly to the buses that are used for the CPU to communicate with memory. Input/output devices are connected using controllers.