# Data Representation

- Computers are electronic devices powered by electricity which have only two states: on and off.
- The two digits, 0 and 1 can easily represent these two states.

| Binary Digit (Bit) | Electronic Charge | Electronic System |
|---|---|---|
| 1 |  | ON |
| 0 |  | OFF |

# Number System

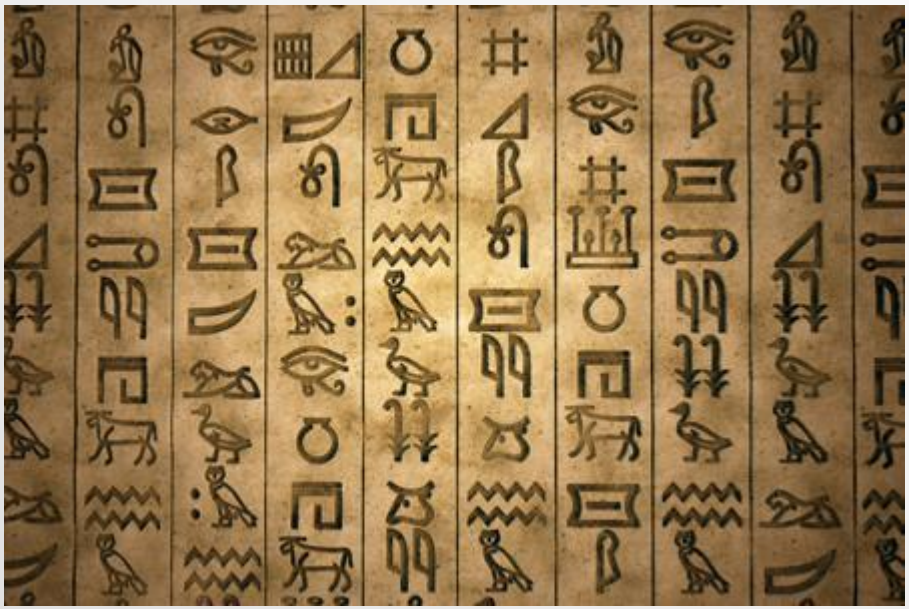
- A number system is defined as a set of values to represent ‘quantity’.
- For example, a number of students in a class, no. Of assignments, no. Of marks obtained, etc.
- The number system is divided into two categories:
  - Non-positional number system
  - Positional number system

# Non-positional Number System

- In early days of human civilisation people used to do counting with things like stones, fingers, sticks, pebble etc.
- This method of counting is called non-positional number system.
- It was very difficult to perform arithmetic operations using this number system as it uses symbols.
- Like I for 1, II for 2, III for 3, etc. But there was no symbol for 0.
- Non-positional number systems are not used in computers.
- A non-positional number system still uses a limited number of symbols in which each symbol has a value.

# Non-positional Number System

- Every system varies by country and it depends on symbols and values set by the people of that country.
- For example, the Egyptians use Hieroglyphics, and the Greeks use a numeral system.



**Roman Numeral Table**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | I | 14 | XIV | 27 | XXVII | 150 | CL |
| 2 | II | 15 | XV | 28 | XXVIII | 200 | CC |
| 3 | III | 16 | XVI | 29 | XXIX | 300 | CCC |
| 4 | IV | 17 | XVII | 30 | XXX | 400 | CD |
| 5 | V | 18 | XVIII | 31 | XXXI | 500 | D |
| 6 | VI | 19 | XIX | 40 | XL | 600 | DC |
| 7 | VII | 20 | XX | 50 | L | 700 | DCC |
| 8 | VIII | 21 | XXI | 60 | LX | 800 | DCCC |
| 9 | IX | 22 | XXII | 70 | LXX | 900 | CM |
| 10 | X | 23 | XXIII | 80 | LXXX | 1000 | M |
| 11 | XI | 24 | XXIV | 90 | XC | 1600 | MDC |
| 12 | XII | 25 | XXV | 100 | C | 1700 | MDCC |
| 13 | XIII | 26 | XXVI | 101 | CI | 1900 | MCM |

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# Positional Number System

- A positional number system is a system consisting of a finite number of symbols / digits used to represent large numbers.
- The value of each digit in such a number is determined by
  - Digit
  - Position
  - Radix (or Base)
- Digit: the digit itself
- Position: the position of the digit in the numbers. It starts from right hand side.
- Radix:  the total number of digits available in that number system

# Positional Number System

- Following are the various types of positional number system
  - Decimal number system
  - Binary number system
  - Octal number system
  - Hexadecimal number system
- A number in a particular base is written as $(number)_{base}$

| Numbering Systems | | |
|---|---|---|
| System | Base | Digits |
| Binary | 2 | 0 1 |
| Octal | 8 | 0 1 2 3 4 5 6 7 |
| Decimal | 10 | 0 1 2 3 4 5 6 7 8 9 |
| Hexadecimal | 16 | 0 1 2 3 4 5 6 7 8 9 A B C D E F |

# Positional Number System

- For example,
  - $(121)_{10}$ means the number 121 is a decimal number.
  - $(345)_{8}$ is an octal number
- The rightmost digit has the position of 0, the next digit on its left has the position 1 and so on.

# Decimal Number System

- The name is derived from the Latin word Decan, which means ten.
- It is also known as base 10 number system.
- The Decimal Number System consists of ten digits from 0 to 9.
- These digits can be used to represent any numeric value.
- It is the most widely used number system.
- The value represented by individual digit depends on weight and position of the digit.

# Decimal Number System

- Each number in this system consists of digits which are located at different positions.
- The position of first digit towards left side of the decimal point is 0.
- The position of second digit towards left side of the decimal point is 1.
- Similarly, the position of first digit towards right side of decimal point is -1.
- The position of second digit towards right side of decimal point is -2 and so on.
- The value that comes before the decimal point, is called integer value and the value that comes after decimal point is called fraction value.

| Power | 2 | 1 | 0 | . | -1 | -2 |
|---|---|---|---|---|---|---|
| Power value | $10^2$ | $10^1$ | $10^0$ | | $10^{-1}$ | $10^{-2}$ |
| Quantity | 100 | 10 | 1 | | 1/10 | 1/100 |

# Binary Number System

- Digital computer represents all kinds of data and information in the binary system.
- Binary Number System consists of two digits 0 and 1.
- Its base is 2.
- It is also known as base 2 number system.
- So, each digit or bit in binary number system can be 0 or 1.
- A combination of binary numbers may be used like 1001, 11001.111, 100011.101,etc.

# Binary Number System

- The word ‘bit’ came from **bi**nary digi**t**.
- Some terminologies in binary system

| | |
|---|---|
| Bit | 0 or 1 |
| Nibble | 4 bits |
| Byte | 8 bits |
| word | 16 bits or 2 bytes |
| 1 Kilobyte | 1024 bytes |
| 1 Megabyte | 1024 KB |
| 1 Gigabyte | 1024 MB |
| 1 Terabyte | 1024 GB |
| 1 Petabyte | 1024 TB |
| 1 Zetabyte | 1024 PB |

| Power | 2 | 1 | 0 | . | -1 | -2 |
|---|---|---|---|---|---|---|
| Power value | $2^2$ | $2^1$ | $2^0$ | | $2^{-1}$ | $2^{-2}$ |
| Quantity | 4 | 2 | 1 | | 1/2 | 1/4 |

# Binary Number System

| DECIMAL | BINARY | DECIMAL | BINARY |
|---|---|---|---|
| 0 | 0 | 10 | 1010 |
| 1 | 1 | 11 | 1011 |
| 2 | 10 | 12 | 1100 |
| 3 | 11 | 13 | 1101 |
| 4 | 100 | 14 | 1110 |
| 5 | 101 | 15 | 1111 |
| 6 | 110 | 16 | 10000 |
| 7 | 111 | 17 | 10001 |
| 8 | 1000 | 18 | 10010 |
| 9 | 1001 | 19 | 10011 |

# Octal Number System

- In octal number system, the base 8 is used.
- So it is called as base 8 number system.
- There are only 8 digits available to represent the values in the system.
- A binary number is divided up into groups of only 3 bits, with each group or set of bits having a distinct value of between 000 (0) and 111 ( 4+2+1 = 7 ).

# Hexadecimal Number System

- In hexa-decimal number system, the base 16 is used.
- So it is called as base 16 number system.
- There are 16 digits available to represent the values in the system.
- i.e (0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F)

# Number System

| Binary | Octal | Decimal | Hexadecimal |
|---|---|---|---|
| 0000 | 0 | 0 | 0 |
| 0001 | 1 | 1 | 1 |
| 0010 | 2 | 2 | 2 |
| 0011 | 3 | 3 | 3 |
| 0100 | 4 | 4 | 4 |
| 0101 | 5 | 5 | 5 |
| 0110 | 6 | 6 | 6 |
| 0111 | 7 | 7 | 7 |
| 1000 | 10 | 8 | 8 |
| 1001 | 11 | 9 | 9 |
| 1010 | 12 | 10 | A |
| 1011 | 13 | 11 | B |
| 1100 | 14 | 12 | C |
| 1101 | 15 | 13 | D |
| 1110 | 16 | 14 | E |
| 1111 | 17 | 15 | F |
| *Base-2* | *Base-8* | *Base-10* | *Base-16* |