# 3 Data Representation Methods in the Computer system

In this unit you will learn,

- computer data representation,
- Decimal, Binary, Octal and Hexadecimal number systems,
- most and least significant positional value of a number,
- converting decimal numbers to binary, octal numbers to hexadecimal numbers
- conversion among binary, octal, hexadecimal and decimal numbers,
- data storage capacity,
- coding systems in computers.

## 3.1 Computer Data Representation

Chanaka : Can you prepare this application using the computer Anjana?

Anjana : Sure, I'll do it. You read this. Let us type it. "Application…"

Chanaka : When "A" on the keyboard is pressed, how does the computer identify it Anjana?

Sameera : Let us ask our teacher.

Janitha : Teacher, how is letter "A" represented in the computer?

Teacher : look at this picture children. (Figure 3.1)

**Step 1**
Press “A” on the keyboard.


**Step 2**
The electronic symbol for letter “A” goes to the System Unit through the keyboard.

**Step 3**
Electronic signal of letter “A” 1000001 is converted to ASCII Binary Code and goes to the video memory via RAM

**1000001**

**Step 4**

“A” is displayed on the screen after processing.


Figure 3.1 – Letter “A” representation on the computer.

Teacher : According to the figure above (Figure 3.1), when you type “A” on the keyboard, this electronic symbol goes to the Central Processing Unit. Then this letter “A” is sent to the CPU it is converted to an electronic symbol and is stored in Memory to process this pattern. After the process, the letter “A” is displayed on the screen.

## 3.1.1 Number System

When typing letters or words using the computer, these words or letters are represented by the computer as numbers it can understand. While this group of numbers that the computer can understand is called a 'Number System' the limited number of numerals in the number system called digits. The value of these numbers (numerals) depends on the position they occupy within the number.

While the concept of number system was present in the 'Abacus ' considered as the first calculating machine of the world, it has progressed up to the computer of today.

The number system used for the representation of data in the computer is as follows;

Table 3.1 - Numbers and Alphabetic characters used in the Number System

| Number System | Base Value | Number and Alphabetic character used |
|---|---|---|
| 1. Binary | 2 | 0, 1 |
| 2. Octal | 8 | 0, 1, 2, 3, 4, 5, 6, 7 |
| 3. Decimal | 10 | 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 |
| 4. Hexa - decimal | 16 | 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F |

## 3.1.2 Use of Binary Numbers in Computer Data Representation

Computer represents data in two signal states. There are two Voltage levels for these two symbols. One is named as the high voltage level and the other is named as low voltage level. "0" and "1" digits respectively represent these low and high voltage levels in a circuit. Thus, "1" and "0" status are equal to the “On” and “Off” states of an electronic circuit. Any data in the world can be represented on the computer using these two digits.

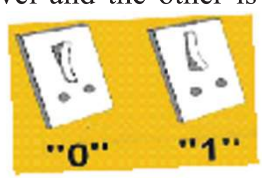


Figure 3.2 – A switch of an electronic circuit

According to the Figure 3.3 given below, when data stored in Secondary Storage is sent to the Main Memory and when it is sent to the Central Processing Unit from there, that data are converted to a binary code.

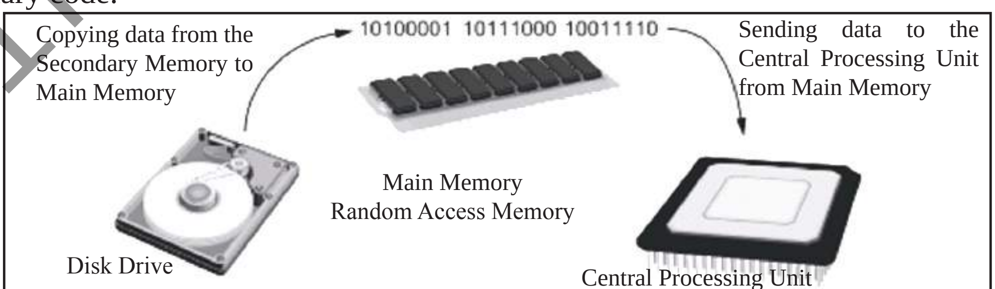


Figure 3.3 – How data is sent to the Central Processing Unit from the Secondary Storage

Let us consider the instance where Binary numbers are used for computer colours. Any colour can be made with the combination of different degrees of red, green and blue.

These can be represented as RGB (Red, Green, Blue) and the value of any colour ranges from 0 to 255.

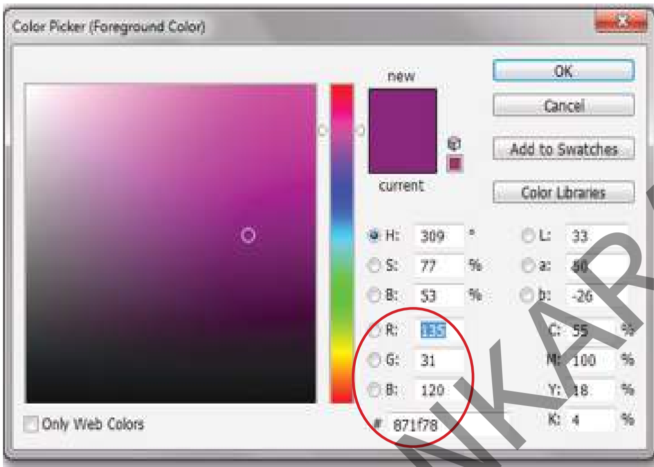



Figure 3.4 – Colour representation in computer

For instance, if you need to use dark purple for the background of a document, that colour can be represented in the computer as "135, 31, 120" (Figure 3.4). With these numbers, the colour combination for the above colour is represented in decimal numbers. Binary numbers for 135, 31 and 120 are $10000111_2$, $11111_2$, and $1111000_2$.

## 3.2 Decimal, Binary, Octal and Hexa-Decimal Number Systems

### 3.2.1 Decimal Number System

Each number system is made of a Unit, Number and Base / Radix.

**Unit**

Unit is a single object. For instance, a mango, a Rupee, and a day can be considered a unit.

**Number**

A number is a symbol which represents a unit or quantity.

**Base / Radix**

A number of symbols used in a number system is called the base/radix. The base of any number system is indicated in decimal numbers.

From our childhood, we have learnt to perform calculations using decimal Number System which consists of digits from 0 to 9.

Normally, the base value of decimal numbers are not mentioned, but for the other numbers the base value has to be mentioned. The digits that are used in the decimal number system are as follows;

Table 3.2 – Digits of Decimal Number System

| **Number System** | **Decimal Number System or base 10 number system** |
|---|---|
| Base / Radix | 10 |
| Digits used | 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 |

Let us study how a number included in the decimal number system is formed.

**Example**

Let us consider how the number 25 is formed.
25 is formed with the addition of 20 and 5.

$$\begin{aligned} 25 &= 20 + 5 \\ &= (2 \times 10) + (5 \times 1) \\ &= (2 \times 10^1) + (5 \times 10^0) \end{aligned}$$

These positional values such as $10^0$, $10^1$, $10^2$ are called Weighting Factors of decimal number system. This number can be shown on a counting frame (abacus). (Figure 3.5)

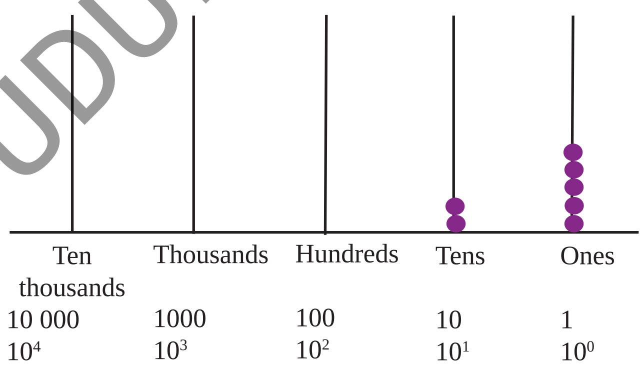



Figure 3.5 – Decimal number representation of 25

This can be shown as given below, as well.

2 5

$5 \times 10^0 = 5$

$2 \times 10^1 = 20$

$25$

**Example**

Next, let us consider how a decimal number is formed.

| 3 | 0 | 2. | 7 | 5 | - decimal number |
|---|---|---|---|---|---|
| ↓ | ↓ | ↓ | ↓ | ↓ | |
| $10^2$ | $10^1$ | $10^0$ | $10^{-1}$ | $10^{-2}$ | - weighting factor |

$= (3\times10^2) + (0\times10^1) + (2\times10^0) + (7\times10^{-1}) + (5\times 10^{-2})$

$= 300 + 0 + 2 + \frac{7}{10} + \frac{5}{100}$

$= 300 + 0 + 2 + 0.7 + 0.05$

$= 302.75$

302.75

$5 \times 10^{-2} = 0.05$

$7 \times 10^{-1} = 0.7$

$2 \times 10^0 = 2$

$0 \times 10^1 = 0$

$3 \times 10^2 = 300$

$302.75$

## 3.2.2 Binary Number System

Though we use the decimal number system when we input numbers as data or instructions, the computer represents these data as 0 and 1. The number system which consists of 0 and 1 is the binary number system.

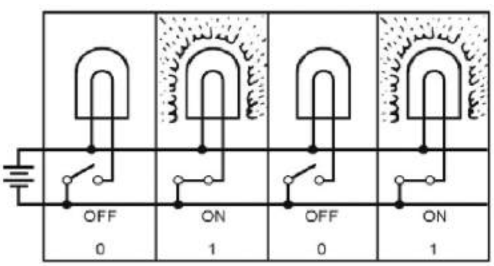



Figure 3.6 – Electronic circuit

The digits for the binary number system is given below. (Table 3.3)

Table 3.3 – Digits used in the Binary Number System

| Number System | Binary Number System |
|---|---|
| Base | 2 |
| Digits used | 0,1 |

For instance, let us consider $11101101_2$.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 0 | 1 | 1 | 0 | $1_2$ | - decimal number |
| ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | |
| $2^7$ | $2^6$ | $2^5$ | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ | - weighting factor |

The values such as $2^0$, $2^1$, $2^2$, $2^3$… are called the weighting factors of binary number system.

| $2^7$ | $2^6$ | $2^5$ | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 |

This number can be indicated in a binary base counting frame as given below. (Figure 3. 7)

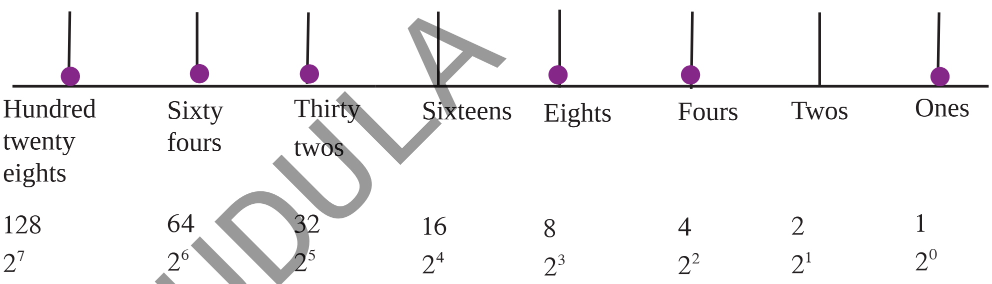



Figure 3.7 – Binary number representation.

The Binary number system is very important in computing and it contributes in the representation of a bit; the basic measuring unit of the computer. The smallest value and the highest value which can be seen in this number system is 0 or 1 respectively. This smallest value is called Bit (Binary Digit)

## 3.2.3 Octal Number System

The number system which uses eight digits: 0, 1, 2, 3, 4, 5, 6, 7 is called the octal number system.

Digits of the octal number system are given below. (Table 3.4)

Table 3.4 – Digits of Octal Number System

| **Number System** | **Octal Number System** |
|---|---|
| Base | 8 |
| Digits used | 0, 1, 2, 3, 4, 5, 6, 7 |

For instance, let us consider $236_8$.

| | | | |
|---|---|---|---|
| 2 | 3 | 6 | - octal number |
| ↓ | ↓ | ↓ | |
| $8^2$ | $8^1$ | $8^0$ | - weighting factor |

The values such as $8^0$, $8^1$, $8^2$, $8^3$ … are called the weighting factors of the octal number system. This number can be represented as given below in a base eight counting frame. (Figure 3.7)

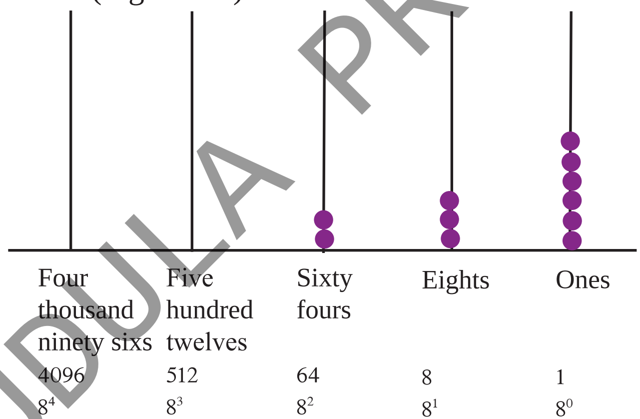



Figure 3.8 – Octal number representation

## 3.2.4 Hexa-Decimal Number System

The computer uses binary numbers and it is difficult for human beings to read them. Hence, the hexadecimal number system is used as it is easier for humans to use. Normally, calculations are performed using the ten fingers of the hands. Just imagine you have sixteen fingers on your hands. Then you can use sixteen numbers to count. In the hexadecimal number system, ten digits are used from 0 to 9 and for the other 6 digits, A, B, C, D, E and F symbols are used. Here, A, B, C, D, E and F are used to represent 10, 11, 12, 13, 14 and 15. (Table 3.5)

Table 3.5 – Comparison of Decimal and Hex-Decimal numbers

| **Decimal Number** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Hexa-Decimal Digit** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |

The Digits of the hexadecimal number system are given in the table below. (Table 3.6)

Table 3.6 - Digits of Hexadecimal Number System

| **Number System** | **Hexadecimal Number System** |
|---|---|
| Base | 16 |
| Digits Used | 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F |

When F the largest number of hexadecimal number system, is expressed in binary form, it can be indicated with 4 Bits. Thus, instead of using a binary number with 4 Bits, a single number in hexadecimal number system can be used. For example, Hexadecimal numbers are used to represent memory addresses of the computer.

You can see code "# 871F78" related to the dark purple colour shown in Figure 3.4. Here the value of the colour is started with "#" symbol. The colour value is indicated in the computer in hexa decimal numbers. Thus, the code for dark purple in the above example is "# 871F78". R,G,B values of this can be indicated from 0 to 255 in decimal numbers. If "#' or "&H" (ampersand) symbol is used in front of the value of any value, it is a hexa decimal number. Given below in Table 3.7 are the hexa decimal values and RGB values of dark purple colour.

Table 3.7 – Hexadecimal Value of Dark Purple Colour

| **Name of Colour** | **Colour** | **Hexadecimal Value** | **R** | **G** | **B** |
|---|---|---|---|---|---|
| Dark Purple | | # 871F78<br>&H 871F78 | 135 | 31 | 120 |

For instance, let us consider $15E_{16}$

1 → $16^2$

5 → $16^1$

$E_{16}$ - Hexa-decimal number → $16^0$ - Weighting factor

$16^2$ $16^1$ $16^0$ → $15E_{16}$

Here, $16^0$, $16^1$, $16^2$, $16^3$….. values are called Hexadecimal Weighting Factors. This number can be represented on a sixteen base counting frame as below. (Figure 3.9)

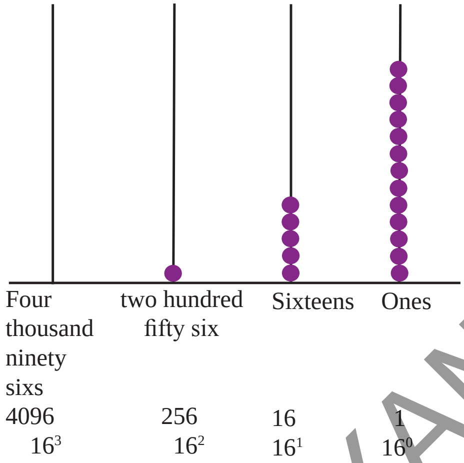



Figure 3.9 – Sixteen base number representation

## Relationship among Decimal, Binary, Octal and Hexadecimal

Figure 3.8 - Relationship among Decimal, Binary, Octal and Hexadecimal

| | Decimal | Binary | Octal | Hexadecimal | |
|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | |
| $2^0$ | 1 | 1 | 1 | 1 | $8^0$, $16^0$ |
| $2^1$ | 2 | 10 | 2 | 2 | |
| | 3 | 11 | 3 | 3 | |
| | 4 | 100 | 4 | 4 | |
| | 5 | 101 | 5 | 5 | |
| | 6 | 110 | 6 | 6 | |
| | 7 | 111 | 7 | 7 | |
| $2^3$ | 8 | 1000 | 10 | 8 | $8^1$ |
| | 9 | 1001 | 11 | 9 | |
| | 10 | 1010 | 12 | A | |
| | 11 | 1011 | 13 | B | |
| | 12 | 1100 | 14 | C | |
| | 13 | 1101 | 15 | D | |
| | 14 | 1110 | 16 | E | |
| | 15 | 1111 | 17 | F | |
| $2^4$ | 16 | 10000 | 20 | 10 | $16^1$ |
| | 17 | 10001 | 21 | 11 | |
| | 18 | 10010 | 22 | 12 | |
| | 19 | 10011 | 23 | 13 | |
| | 20 | 10100 | 24 | 14 | |
| | 21 | 10101 | 25 | 15 | |
| | 22 | 10110 | 26 | 16 | |
| | 23 | 10111 | 27 | 17 | |
| | 24 | 11000 | 30 | 18 | |

## 3.3 Most and Least Significant Positional Value of a Number

There are two seperate methods to find the most and least significant values of decimal numbers and whole numbers. When a whole number is read from left to right, the number in the right most end is the least significant positional value and the number in the left most end which is not 0 is the most significant positional value. (Figure 3.10)

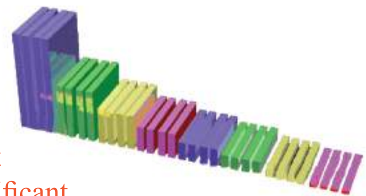



Figure 3.10 - Most and Least Significant Positional Values

In decimal numbers, the value in the right extreme after the decimal point which is not 0 becomes the least significant positional value and the number in the left extreme of the decimal point which is not 0 becomes the most significant positional value.

### 3.3.1 Most Significant Digit (MSD) and Least Significant Digit (LSD)

Given below in Table 3.9 are the most and least significant digits of a round figure or a decimal number.

Table 3.9 – The Most and Least Significant Positional Value of a number

| Number | MSD | LSD |
|---|---|---|
| 329 | 3 | 9 |
| 1237.0 | 1 | 7 |
| 58.32 | 5 | 2 |
| 0.0975 | 9 | 5 |
| 0.4 | 4 | 4 |

You can use the same method used for the decimal number system to find the most and least significant positional digits of binary, octal and hexadecimal numbers.

**Activity**

Find the most significant digit and the least significant digit of the following numbers.

(i) $56870_{10}$ (ii) $154.01_{10}$ (iii) $23.080_{8}$ (iv) $AD\ 239_{16}$

(v) $0.00110_{2}$

## 3.3.2 Most Significant Bit (MSB) and Least Significant Bit (LSB)

Only the Binary Number System is used to find the most significant bit (MSB) and the least significant bit(LSB). There are two ways to find this using decimal numbers and whole numbers.

In a whole number, read from left to right, the value in the right extreme is the least significant bit and the value in the left extreme which is not 0 is the most significant bit. In binary decimal numbers, the value in the right extreme of the decimal point which is not 0 is the least significant bit and the value in the left extreme of the decimal point which is not 0 is the most significant bit.

Table 3.10 - The most significant bit and the least significant bit

| Binary Number | MSB | LSB |
|---|---|---|
| 1001 | $1 = (2^{3})$ | $1 = (2^{0})$ |
| 011.101 | $1 = (2^{1})$ | $1 = (2^{-3})$ |

**Activity**

Find the most significant bit and the least significant bit of the following numbers.

(i) $1000_{2}$ (ii) $011101_{2}$ (iii) $0.11001_{2}$ (iv) $1.0010_{2}$

(v) $0.00110_{2}$

# 3.4 Converting Decimal Numbers to Binary, Octal and Hexa-Decimal Numbers

## 3.4.1 Conversion of Decimal numbers to numbers of other bases

All the data we input to the computer is taken by it as digits of binary number system; 0 and 1. Hence, the knowledge to convert a base ten number to another base is important. Here in this chapter, conversion of a decimal number to a binary number, octal number and a hexadecimal number is discussed.

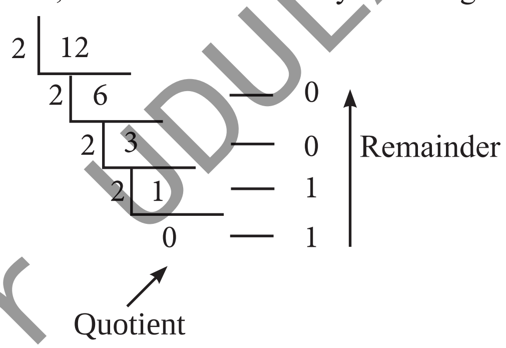
## 3.4.2 Conversion of Decimal Numbers to Binary Numbers

When a decimal number is converted to a binary number, the decimal number can be divided by two until the remainder is 0 and the remainder of the division can be written on the right side. After that, write all the remainders from the bottom to top to build the number.

**Example**

Converting number $12_{10}$ to a binary number.

- First, divide this number by 2 writing the remainders.




- Secondly, write down all the remainders from bottom to top.

$12_{10} = 1100_2$

**Example**

Converting $46_{10}$ to a binary number.

|---|---|
| 2 \| 46 | |
| 2 \| 23 | — 0 |
| 2 \| 11 | — 1 |
| 2 \| 5 | — 1 |
| 2 \| 2 | — 1 |
| 2 \| 1 | — 0 |
| 0 | — 1 |

$46_{10} = 101110_2$

**Activity**

Convert the following decimal numbers to binary numbers.

(i) $155_{10}$ (ii) $472_{10}$ (iii) $1163_{10}$

## 3.4.3 Converting Decimal Numbers to Octal Numbers

Here, divide the given number by 8 until the remainder is 0 and write the remainders from bottom to top.

**Example**

Converting $158_{10}$ to an octal number.

- Firstly, divide this number by 8 and write down the remainder.

| Division | Remainders ↑ |
|---|---|
| 8 \| 158 | |
| 8 \| 19 | — 6 |
| 8 \| 2 | — 3 |
| 0 (Quotient) | — 2 |

- Secondly, write down all the remainders from bottom to top.

$158_{10} = 236_8$

**Activity**

Convert the following decimal numbers to octal numbers.

(i) $155_{10}$ (ii) $472_{10}$ (iii) $1163_{10}$

## 3.4.4 Converting Decimal Numbers to Hexadecimal Numbers

Here, divide the number by 16 until the remainder is 0 and write down the remainders from bottom to top.

**Example**

Converting number $38_{10}$ to a hexadecimal number.

➢ Firstly, divide this number by 16 and write down the remainders.

```
16 | 38
   ------
   16 | 2    —  6  ↑
      -----       | remainders
         0   —  2 |
        ↗
  Quotient
```

➢ Secondly, write down all the remainders from bottom to top.

$38_{10} = 26_{16}$

**Example**

Converting number $47_{10}$ to a hexadecimal number.

```
16 | 47
   ------
   16 | 2    —  15 → F  ↑
      -----             |
         0   —  2  → 2  |
```

$47_{10} = 2F_{16}$

**Activity**

Convert the following decimal numbers to hexadecimal numbers.

(i) $256_{10}$ (ii) $478_{10}$ (iii) $1963_{10}$

## 3.5 Conversion among Binary, Octal, Hexadecimal and Decimal Numbers

We have converted decimal numbers (base ten) to binary, octal and hexadecimal numbers earlier. Now let us consider how to convert binary numbers to decimal numbers, octal numbers to decimal numbers and hexadecimal numbers to decimal numbers. (Figure 3.11)

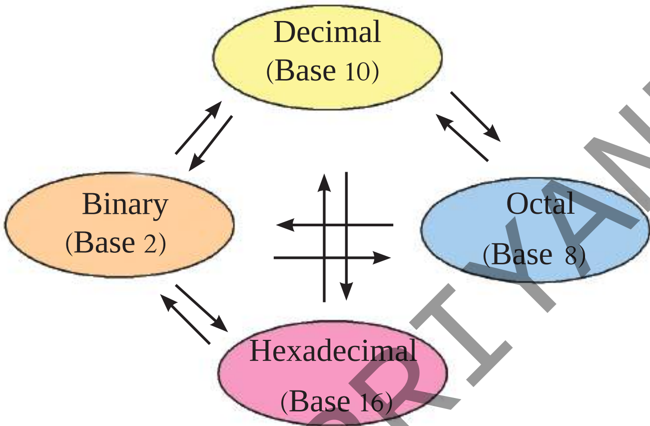



Figure 3.11 – Conversion between number systems

### 3.5.1 Converting Binary Numbers to Decimal Numbers

**Example**

Converting number $1101_2$ to a decimal number.

| 1 | 1 | 0 | 1 |
|---|---|---|---|
| ↓ | ↓ | ↓ | ↓ |
| $2^3$ | $2^2$ | $2^1$ | $2^0$ |

$$1101_2 = (1\times2^3) + (1\times2^2) + (0\times2^1) + (0\times2^0)$$
$$= (1\times8) + (1\times4) + (0\times2) + (1\times1)$$
$$= 8 + 4 + 0 + 1$$

$$1101_2 = 13_{10}$$

$1101_2$

$1\times2^0 = 1$
$0\times2^1 = 0$
$1\times2^2 = 4$
$1\times2^3 = 8$

13

$1101_2 = 13_{10}$

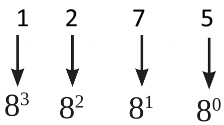
**Activity**

Convert the following binary numbers to decimal numbers.
(i)$101_2$ (ii) $111010110_2$ (iii)$1010010111_2$

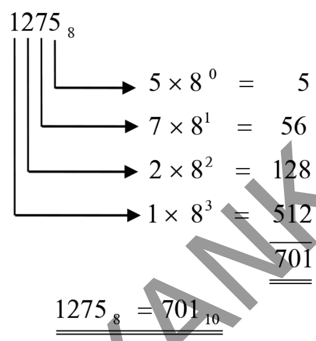
## 3.5.2 Converting Octal Numbers to Decimal Numbers

**Example**

Converting number $1275_8$ to a decimal number.




$$
\begin{aligned}
1275_8 &= (1\times8^3) + (2\times8^2) + (7\times8^1) + (5\times8^0) \\
&= (1\times512) + (2\times64) + (7\times8) + (5\times1) \\
&= 512 + 128 + 56 + 5 \\
1275_8 &= 701_{10}
\end{aligned}
$$




**Activity**

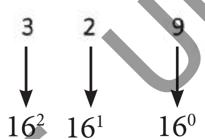
Convert the following octal numbers to decimal numbers.

(i) $230_8$ (ii) $745_8$ (iii) $2065_8$

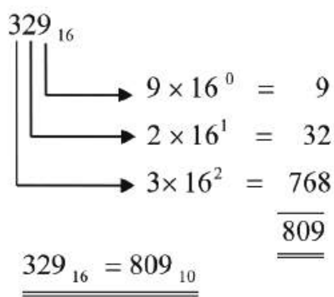
## 3.5.3 Converting Hexadecimal Numbers to Decimal Numbers

**Example**

Converting number $329_{16}$ to a decimal number.




$$
\begin{aligned}
329_{16} &= (3\times16^2) + (2\times16^1) + (9\times16^0) \\
&= (3\times256) + (2\times16) + (9\times1) \\
&= 768 + 32 + 9 \\
329_{16} &= 809_{10}
\end{aligned}
$$



**Example**

Converting number $AB2_{16}$ to a decimal number.

| A | B | 2 |
|---|---|---|
| ↓ | ↓ | ↓ |
| $16^2$ | $16^1$ | $16^0$ |

$$AB2_{16} = (A \times 16^2) + (B \times 16^1) + (2 \times 16^0)$$
$$= (10 \times 256) + (11 \times 16) + (2 \times 1)$$
$$= 2560 + 176 + 2$$
$$AB2_{16} = 2738_{10}$$

$AB2_{16}$

$$2 \times 16^0 = 2$$
$$11 \times 16^1 = 176$$
$$10 \times 16^2 = 2560$$
$$2738$$

$$AB2_{16} = 2738_{10}$$

**Activity**

Convert the following hexadecimal numbers to decimal numbers

(i) $1A_{16}$ (ii) $7EF_{16}$ (iii) $A49_{16}$

## 3.5.4 Converting Binary Numbers to Octal Numbers

From the digits used in the octal number system; 0, 1, 2, 3, 4, 5, 6, and 7, the largest digit is 7. We can indicate digit 7 as $111_2$ in binary form. Thus 7; the largest digit in the octal number system, can be indicated in a binary form with 3 digits. Likewise all the digits in the octal number system can be indicated in the three digit binary form. Given below in Table 3.11 are the binary forms of the digits used in eight base (octal) number system.

Table 3.11 – Indicating octal digits in decimal and binary numbers.

| Decimal Number | Octal Number | Binary Number |
|---|---|---|
| 0 | 0 | 000 |
| 1 | 1 | 001 |
| 2 | 2 | 010 |
| 3 | 3 | 011 |
| 4 | 4 | 100 |
| 5 | 5 | 101 |
| 6 | 6 | 110 |
| 7 | 7 | 111 |

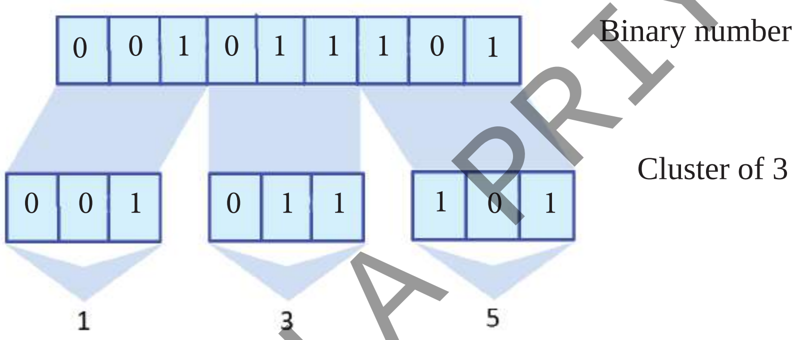
As per the above table, three bits are used when indicating an octal number in binary form. ($8 = 2^3$)

Let us consider how a binary number is converted to an octal number.

**Example**

Converting $1011101_2$ to an octal number.

- First, divide the number into three bits from the right corner to the left corner. If the last cluster in the left corner does not consist of 3 bits, add 0s to complete.
- Write each octal number separately for each cluster.
- Then write these clusters in octal digits.
- Write these digits in order from the left corner to the right corner.




$$1011101_2 = 135_8$$

**Activity**

Convert the following binary numbers to octal numbers.

(i) $10011001_2$ (ii) $111100111_2$ (iii) $10101010110_2$

## 3.5.5 Converting Binary Numbers to Hexadecimal Numbers

From the symbols used in the hexadecimal number system, the value represented by "F" possesses the largest numerical value. This can be indicated as a four-bit binary number; $1111_2$. Thus, all the digits in the hexadecimal number system can be indicated as four-bit binary numbers. Given below in Table 3.12 are the binary numbers for the digits used in the hexadecimal number system.

Table 3.12 – Indicating hexadecimal digits in decimal and binary numbers.

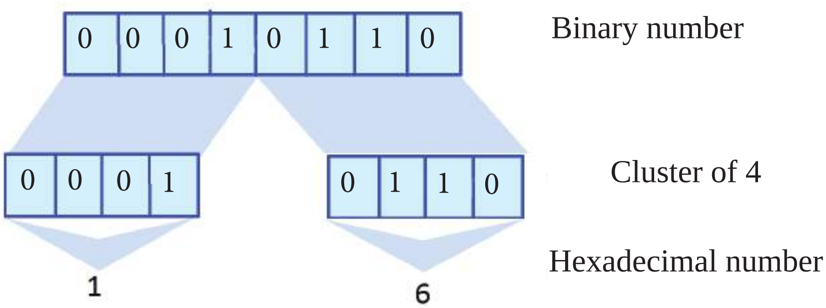
| Decimal Number | Hexadecimal Number | Binary Number |
|---|---|---|
| 0 | 0 | 0000 |
| 1 | 1 | 0001 |
| 2 | 2 | 0010 |
| 3 | 3 | 0011 |
| 4 | 4 | 0100 |
| 5 | 5 | 0101 |
| 6 | 6 | 0110 |
| 7 | 7 | 0111 |
| 8 | 8 | 1000 |
| 9 | 9 | 1001 |
| 10 | A | 1010 |
| 11 | B | 1011 |
| 12 | C | 1100 |
| 13 |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

As shown in the table above (Table 3.12), four bits are used to indicate a hexadecimal number in binary form. ($16 = 2^4$)

**Example**

Converting number $10110_2$ to a hexadecimal number.

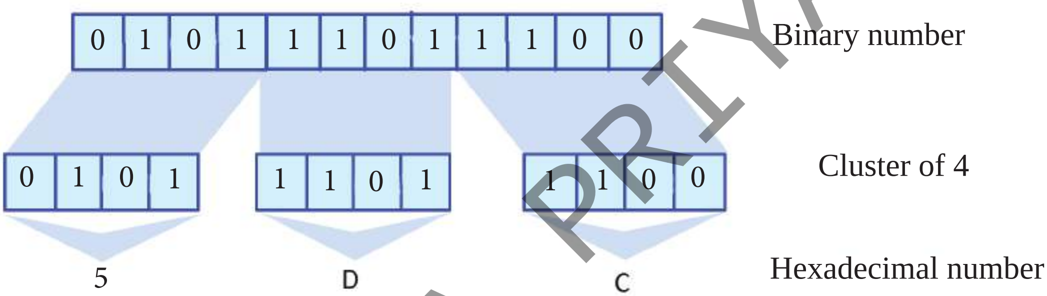
- First, divide the number into four-bit clusters from the right corner to the left corner.
- Write hexadecimal numbers separately for each cluster.
- Write these numbers in order from the left corner to the right corner and write down the base.




$$\underline{\underline{10110_2 = 16_{16}}}$$

**Example**

Converting number $10111011100_2$ to a hexadecimal number.




$$\underline{\underline{10111011100_2 = 5DC_{16}}}$$

**Activity**

Convert the following binary numbers to hexadecimal numbers.

(i) $11011010_2$ (ii) $11111001101_2$ (iii) $10011100011_2$

## 3.5.6 Converting Octal numbers to Binary Numbers

We have learned above that an octal number can be indicated in three digits when it is converted to a binary number.

Thus, each digit in octal numbers should be written in three digits when it is converted to base two.

**Example**

Converting number $457_8$ to a binary number.

- Firstly, write each digit in octal number in three bits.
- Secondly, write down all the bits together to get the binary number for the octal number.

| | | |
|---|---|---|
| 4 | 5 | 7 |
| 100 | 101 | 111 |

$457_8 = 100101111_2$

**Activity**

Convert the following octal numbers to binary numbers.

(i) $10_8$ (ii) $245_8$ (iii) $706_8$

## 3.5.7 Converting Octal numbers to Hexadecimal Numbers

**Example**

Converting number $1057_8$ to a hexadecimal number.

- First, write each digit in octal number in three bits.
- Divide the binary number you get into four-bit clusters from the right corner to the left corner.
- Write the related hexadecimal number for each cluster.

| | | | |
|---|---|---|---|
| 1 | 0 | 5 | 7 |
| 001 | 000 | 101 | 111 |

| | | |
|---|---|---|
| 00 1 0 | 0 0 1 0 | 1111 |
| 2 | 2 | 15 |
| 2 | 2 | F |

$1057_8 = 22F_{16}$

**Activity**

Convert the following octal numbers to hexadecimal numbers

(i) $320_8$ (ii) $475_8$ (iii) $1673_8$

## 3.5.8 Converting Hexadecimal Numbers to Binary Numbers

You have learnt earlier that any symbol in a hexadecimal number can be written in a four-bit binary number. Thus, when a hexadecimal number is converted to a binary number, each digit in that number should be indicated in a four-bit binary number.

**Example**

Converting number $74_{16}$ to a binary number.

| 7 | 4 |
|---|---|
| 0111 | 0100 |

$$74_{16} = 1110100_2$$

Converting number $2AE_{16}$ to a binary number.

| 2 | *A* | *E* |
|---|---|---|
| 0010 | 1 010 | 1110 |

$$2AE_{16} = 1010101110_2$$

**Activity**

Convert the following hexadecimal numbers to binary numbers.

(i) $78_{16}$ (ii) $B2C_{16}$ (iii) $4DEF_{16}$

## 3.5.9 Converting Hexadecimal Numbers to Octal Numbers

First, the hexadecimal number should be converted to a binary number and then it should be converted to an octal number.

**Example**

Converting number $23A_{16}$ to an octal number.

| 2 | 3 | *A* |
|---|---|---|
| 0010 | 0011 | 1010 |

| 001 | 0 0 0 | 1 1 1 | 010 |
|---|---|---|---|
| 1 | 0 | 7 | 2 |

$23A_{16} = 1072_8$

### Activity

Convert the following hexadecimal numbers to octal numbers.

(i) $320_{16}$ (ii) $A7B_{16}$ (iii) $10ED_{16}$

### Activity

1. Consider number "$23_y$". Here, 'y' is the base of the number system. From the number systems you have learned, as to which number system "23y" belongs.
2. Convert the decimal number $83_{10}$ to a binary number. Show steps.
3. Convert the binary number $10110111_2$ to an octal number. Show steps.
4. Convert the hexadecimal number $23D_{16}$ to a binary number.

5. Fill in the blanks in the table given below.

Table 3.13 – Several colours and their RGB values and the hexadecimal values

| Name of the Colour | Colour | Hexadecimal Value | R | G | B |
|---|---|---|---|---|---|
| Dark purple | | # 871F78 | 135 | 31 | 120 |
| Light pink | | | 255 | 182 | 193 |
| Sky blue | | | 50 | 153 | 204 |
| Green | | | 0 | 255 | 0 |
| Yellow | | | 255 | 238 | 0 |

## 3.6 Data Storage Capacity

A certain space is needed to store data in the computer. Data storage capacity is measured by units such as bits, bytes, kilobytes, Megabytes, Gigabytes, Terabytes and Petabytes. Let us understand how to arrange these different data storage capacities in order from the small unit to the big unit and to define the relationships between these as well.

### 3.6.1 Units to Measure Data Storage

**Bit**

This is the smallest unit used in the computer to store data. This word is coined from the words B inary Dig it A bit is the two binary digits; 0 and 1.

**Byte**

1 byte is 8 bits.

**Nibble**

A nibble is half of a byte or 4 bits. This unit is not commonly used like bits and bytes.

**kilobyte**

This consists of 1024 bytes. ($1024 = 2^{10}$) Kilobyte is written as KB or kbyte.

**Megabyte**

This consists of 1024 kilobytes (1024 = 210) or 1048576 bytes. Megabyte is written as MB or mbyte.

**Gigabyte**

One Gigabyte is made of 1024 Megabytes. (1024 MB) Gigabyte is written as GB or gbyte. It is wrong to write ‘Gb’ as it indicates gigabit.

**Terabyte**

One Terabyte is made of 1024 Gigabytes (1024 GB). This is written as TB.

**Petabyte**

One Petabyte is made of 1024 Terabytes (1024 TB).

**Observation**

Following are the relationships between units which measure data storage capacity.

8 bits = 1 byte
4 bits = 1 nibble
1024 bytes = 1 kilobyte (KB)
1024 kilobytes = 1 Megabyte (MB)
1024 Megabytes = 1 Gigabyte(GB)
1024 Gigabytes = 1 Terabyte(TB)
1024 Terabytes = 1 Petabyte(PB)

Consider the examples given below to get an idea about the units above.

Table 3.14 – Approximate data storage capacity as text pages.

| Name | Abbreviation | Approximate Bytes | Exact Bytes | Approximate Text pages |
|---|---|---|---|---|
| Byte | B | One | 1 | One text |
| Kilobyte | KB (or K) | Thousand | 1024 | ½ page |
| Megabyte | MB | One million | 1,048,576 | 500 pages |
| Gigabyte | GB | One billion | 1,073,741,824 | 500,000 pages |
| Terabyte | TB | One trillion | 1,099,511,627,776 | 500,000,000 pages |

## 3.6.2 Capacities of Data Storage Devices

Different storage devices possess different storage capacities. The tasks fulfilled by these devices are also different. Let us study these different storage devices. (Figure 3.12)

| |
|---|
| Register Memory |
| 1 KB |
| Cache memory |
| 3 MB – 32 MB |
| Compact Disk (CD) |
| 650 – 900 MB |
| Digital Versatile Disc |
| 4.7 – 9 GB |
| Random Access Memory |
| 01 – 64 GB |
| Read Only Memory (ROM) |
| Flash Memory |
| 1 – 64 GB |
| Hard Disk |
| 100 GB – 6 TB |
| Magnetic Tape |
| 1 TB – 185 TB |

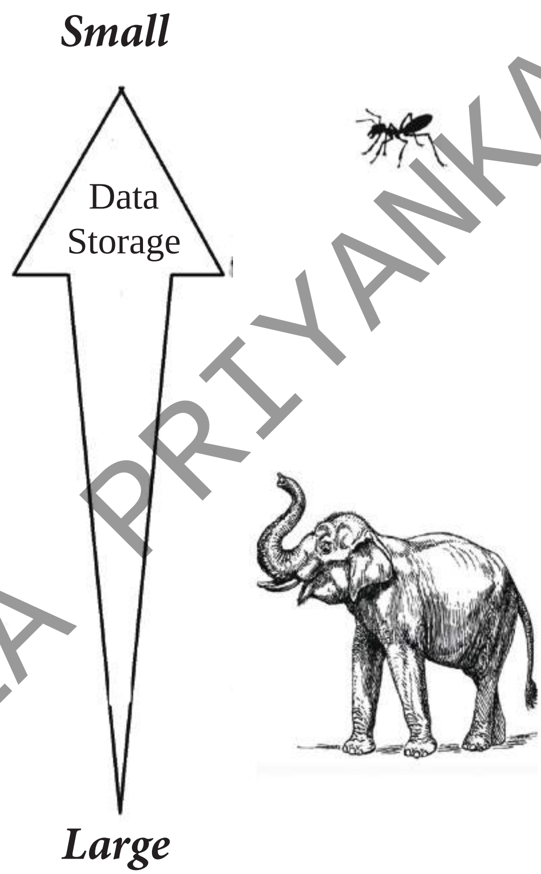



Figure 3.12 – Capacities of storage devices

When reading and writing data, the time spent to access the devices (access speed) is different. Consider the figure given below. (Figure 3.13)

## 3.6.3 Data Access Speed

| |
|---|
| Register Memory |
| Cache Memory |
| Random Access Memory |
| Read Only Memory |
| Flash Memory |
| Hard Disk |
| Digital Versatile Disc – DVD |
| Compact Disc (CD) |
| Magnetic Tape |

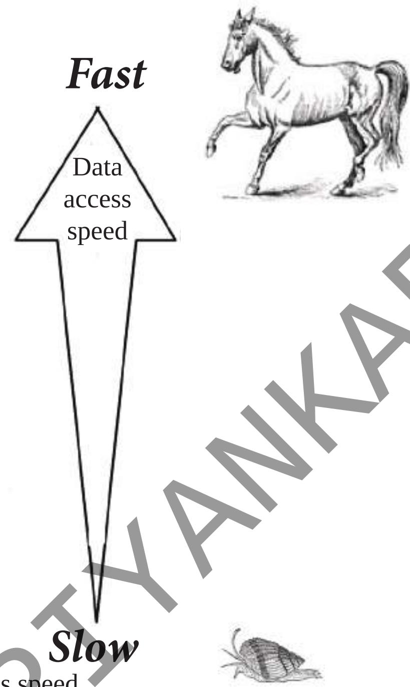



Figure 3.13 – Data access speed

## 3.6.4 Cost per unit Storage

For different storage devices, cost per a bit to store data is different. For instance, the cost is more for Register Memory and Cache Memory. The comparison is shown in the figure given below. (Figure 3.14)

| |
|---|
| Register Memory |
| Cache Memory |
| Random Access Memory |
| Read Only Memory |
| Magnetic Tape |
| Flash Memory |
| Hard Disk |
| Digital Versatile Disc – DVD |

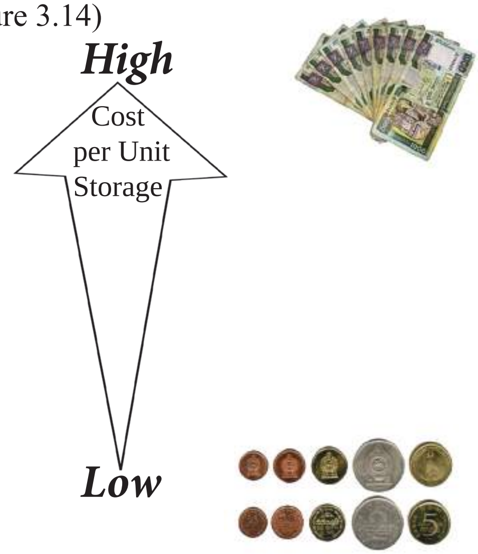



Figure 3.14 – Cost per unit storage

## 3.7 Coding Systems

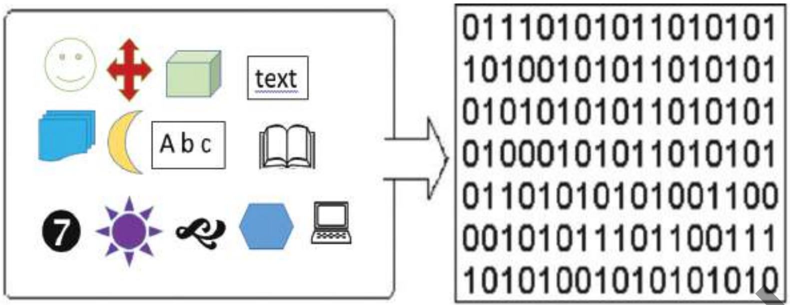



Figure 3.15 – Data you enter to the computer and computer data representation

According to the above figure (Figure 3.15), when you enter a data to the computer, it converts the data to different patterns made of 0 and 1. Thus, binary codes are used when storing numeric, alphabetic, special character, images and sounds in internal storage devices of computers.

In the beginning of the lesson, when you type 'A' on the keyboard, the code you get for 'A' is the bits pattern 1000001 (the binary code of letter 'A'). The number of bits used is 7. Thus, a combination made of a bit pattern is used to represent each data and the bits used for each code is different. Following are different coding systems used.

1. BCD Binary Coded Decimal
2. ASCII American Standards Code for Information Interchange
3. EBCDIC Extended Binary Coded Decimal Interchange Code
4. Unicode

### 3.7.1 BCD - Binary Coded Decimal

This coding system was used in the early stages of computing. In this system one digit is represented by 4 bits. This is used only to represent decimal numbers. Sixteen symbols ($2^4 = 16$) can be represented in this system. The table 3.15 shows the BCD codes for the 10 digits from 0 to 9.

Table 3.15 – Decimal Numbers and BCD Values

| Decimal Value | BCD Value |
|---|---|
| 0 | 0000 |
| 1 | 0001 |
| 2 | 0010 |
| 3 | 0011 |
| 4 | 0100 |
| 5 | 0101 |
| 6 | 0110 |
| 7 | 0111 |
| 8 | 1000 |
| 9 | 1001 |

**Example**

Indicating number $37_{10}$ in BCD codes.

3 $\quad$ $7_{10}$

0011 $\quad$ 0111

$37_{10} = 00110111$

**Activity**

Write the BCD values for the decimal values given below.

(i) 302 (ii) 2136 (iii) 17295

## 3.7.2 ASCII – American Standard Code for Information Interchange

Initially ASCII coding system used 7-bit binary digit. 128 characters can be represented using this coding system. ASCII is used to represent text. (Appendix - Table 3.17)

ASCII system is designed and approved by ANSI (American National Standard Institute).

**Example**

- **Text**

When the word 'School' is entered into the computer through the keyboard, write down how it is understood by the computer. (Use Appendix Table 3.7)

- First, write the decimal numbers for the symbols.

  S - 83 c - 99 h - 104 o - 111 l - 108

- Write binary numbers for each value.

  S - 1010011 c – 1100011 h - 1101000 o - 1101111
  l - 1101100

- Write the associated code

  S c h o o l
  1010011110001111010001101111110111111101100

**Activity**

Write down the ASCII code of "ICT" in binary numbers.

## 3.7.3 EBCDIC – Extended Binary Coded Decimal Interchange Code

We can write only 128 characters using ASCII system, but the EBCDIC code system allows the use of 256 characters. Here, one symbol can be written with a binary number which consists of 8 bits. Hence, 256 characters can be represented using this system. This system was used in IBM main frame computers. The table below shows that there are different EBCDIC codes for the 26 different capital letters and 26 different EBCDIC codes for the 26 simple letters in this system.

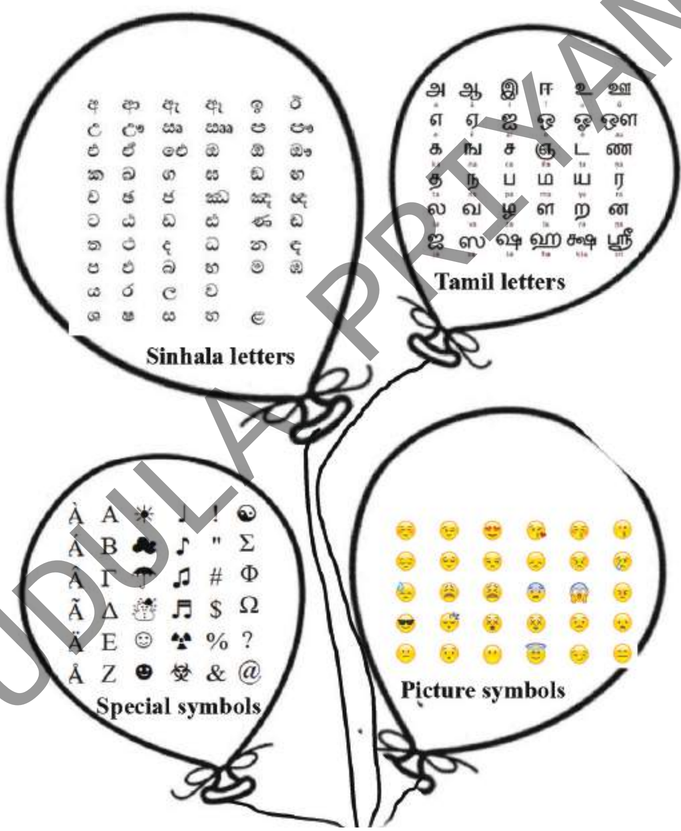
Table 3.16 – EBCDIC values for English capital and simple letters

| Uppercase | | | Lowercase | | |
|---|---|---|---|---|---|
| | EBCDIC | | | EBCDIC | |
| Character | In Binary | In Hexa Decimal | Character | In Binary | In Hexa Decimal |
| A | 1100 0001 | C1 | a | 1000 0001 | 81 |
| B | 1100 0010 | C2 | b | 1000 0010 | 82 |
| C | 1100 0100 | C3 | c | 1000 0011 | 83 |
| D | 1100 0101 | C4 | d | 1000 0100 | 84 |

## 3.7.4 Unicode System

Though 128 characters can be used in the ASCII system and 256 characters can be used in the EBCDIC system for data representation. For example, these systems cannot be used for Sinhala, Japanese, Chinese and Tamil languages as there are more than 256 characters. Hence Unicode system was designed according to a standard to represent 65536 different symbols of 16 bits ($2^{16} = 65536$).

As per the figure given below (Figure 3.16), shows the Unicode system can be used to represent Sinhala and Tamil letters, and special symbols and picture symbols.




Unicodes

Figure 3.16 – Occasions Unicode are used

Unicode system uses unique number for each number, text or symbol in any or Operating System.

**Example**

- **Picture and Graphic Data**

Given below (Figure 3.17) is a close up or a highly enlarged image of photograph. A photograph consists of pixels (dots) made of different colours in big grid. Computer graphic data such as pictures, frames of a movie or frames of an animation consist of various colours. The picture given below consists of a number of different colours.

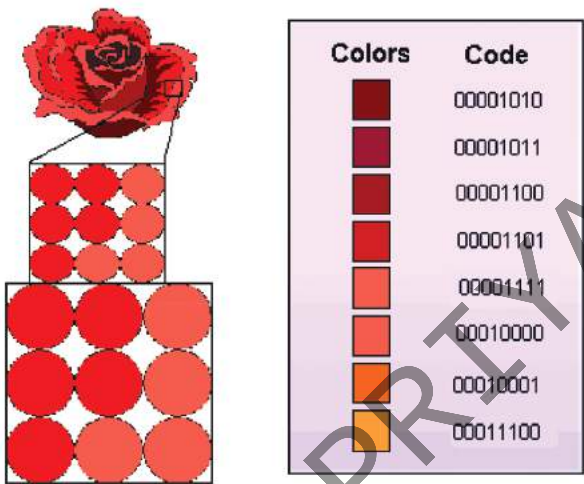



Figure 3.17 – Colours in a picture and their binary values.

- **Sound**

As shown in the figure below (Figure 3.17) is the sound emitted from a speaker is normally represented as analog waves. However, all data in computer are digital data and those are made of bytes. Hence, sound which comes as a analog data is converted to a digital data. Thus, a sound is also represented in a bits pattern made of 0s and 1s in a computer.

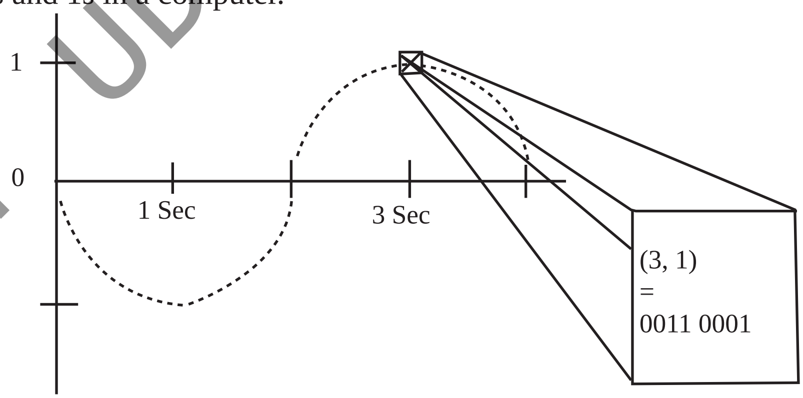



Figure 3.18 – Conversion of analog data of a sound to digital data

By this coding system, codes are classified to represent characters of all the international languages. The institution which initiated is the International Standard Institution and Unicode Consortium. Unicode is largely used in designing websites and newspapers. (Appendix - Table 3.18)

### Activity

1. If ‘A’ character is represented as 1000001 in ASCII system, what is the ASCII code for letter ‘F’?

2. What is the largest number presented in BCD (Binary Coded Decimal)?

3. What is the minimum number of bits required to present a hexadecimal number?

4. If $1000010_2$ represents “B” in ASCII code, what is the ASCII code for letter “L”?

5. What are the coding systems used in computers? Explain the need to use such coding systems.

### Summary

Number systems used for data representation

| Number Systems | | |
|---|---|---|
| **Number Systems** | **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 |

❖ Code systems used in computers

| Code System | Number of Bits Used |
|---|---|
| BCD - Binary Coded Decimal | 4 |
| ASCII - American Standard Code for Information Interchange Code | 7 |
| EBCDIC- Extended Binary Coded Decimal Interchange Code | 8 |
| Unicode | 16 |

## Appendix

ASCII and EBCDIC codes for characters and related decimal, octal and hexadecimal numbers

Table 3.17 - ASCII and EBCDIC codes for characters and related decimal, octal and hexadecimal numbers

| Decimal | Hex | Octal | EBCDIC Character | ASCII Character | | Decimal | Hex | Octal | EBCDIC Character | ASCII Character |
|---|---|---|---|---|---|---|---|---|---|---|
| 00 | 00 | 000 | NUL | NUL | | 128 | 80 | 200 | | |
| 001 | 01 | 001 | SOH | SOH | | 129 | 81 | 201 | a | |
| 002 | 02 | 002 | STX | STX | | 130 | 82 | 202 | b | |
| 003 | 03 | 003 | ETX | ETX | | 131 | 83 | 203 | c | |
| 004 | 04 | 004 | PF | EOT | | 132 | 84 | 204 | d | |
| 005 | 05 | 005 | HT | ENQ | | 133 | 85 | 205 | e | |
| 006 | 06 | 006 | LC | ACK | | 134 | 86 | 206 | f | |
| 007 | 07 | 007 | DEL | BEL | | 135 | 87 | 207 | g | |
| 008 | 08 | 010 | | BS | | 136 | 88 | 210 | h | |
| 009 | 09 | 011 | | HT | | 137 | 89 | 211 | i | |
| 010 | 0A | 012 | SMM | LF | | 138 | 8A | 212 | | |
| 011 | 0B | 013 | VT | VT | | 139 | 8B | 213 | | |
| 012 | 0C | 014 | FF | FF | | 140 | 8C | 214 | | |
| 013 | 0D | 015 | CR | CR | | 141 | 8D | 215 | | |
| 014 | 0E | 016 | SO | SO | | 142 | 8E | 216 | | |
| 015 | 0F | 017 | SI | SI | | 143 | 8F | 217 | | |
| 016 | 10 | 020 | DLE | DLE | | 144 | 90 | 220 | | |
| 017 | 11 | 021 | DC1 | DCI | | 145 | 91 | 221 | j | |
| 018 | 12 | 022 | DC2 | DC2 | | 146 | 92 | 222 | k | |
| 019 | 13 | 023 | TM | DC3 | | 147 | 93 | 223 | l | |
| 020 | 14 | 024 | RES | DC4 | | 148 | 94 | 224 | m | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 021 | 15 | 025 | NL | NAK | | 149 | 95 | 225 | n | |
| 022 | 16 | 026 | BS | SYN | | 150 | 96 | 226 | o | |
| 023 | 17 | 027 | IL | ETB | | 151 | 97 | 227 | p | |
| 024 | 18 | 030 | CAN | CAN | | 152 | 98 | 230 | q | |
| 025 | 19 | 031 | EM | EM | | 153 | 99 | 231 | r | |
| 026 | 1A | 032 | CC | SUB | | 154 | 9A | 232 | | |
| 027 | 1B | 033 | CU1 | ESC | | 155 | 9B | 233 | | |
| 028 | 1C | 034 | IFS | FS | | 156 | 9C | 234 | | |
| 029 | 1D | 035 | IGS | GS | | 157 | 9D | 235 | | |
| 030 | 1E | 036 | IRS | RS | | 158 | 9E | 236 | | |
| 031 | 1F | 037 | IUS | US | | 159 | 9F | 237 | | |
| 032 | 20 | 040 | DS | Space | | 160 | A0 | 240 | | |
| 033 | 21 | 041 | SOS | ! | | 161 | A1 | 241 | | |
| 034 | 22 | 042 | FS | " | | 162 | A2 | 242 | s | |
| 035 | 23 | 043 | | # | | 163 | A3 | 243 | t | |
| 036 | 24 | 044 | BYP | $ | | 164 | A4 | 244 | u | |
| 037 | 25 | 045 | LF | % | | 165 | A5 | 245 | v | |
| 038 | 26 | 046 | ETB | & | | 166 | A6 | 246 | w | |
| 039 | 27 | 047 | ESC | ' | | 167 | A7 | 247 | x | |
| 040 | 28 | 050 | | ( | | 168 | A8 | 250 | y | |
| 041 | 29 | 051 | | ) | | 169 | A9 | 251 | z | |
| 042 | 2A | 052 | SM | * | | 170 | AA | 252 | | |
| 043 | 2B | 053 | CU2 | + | | 171 | AB | 253 | | |
| 044 | 2C | 054 | | , | | 172 | AC | 254 | | |
| 045 | 2D | 055 | ENQ | - | | 173 | AD | 255 | [ | |
| 046 | 2E | 056 | ACK | . | | 174 | AE | 256 | | |
| 047 | 2F | 057 | BEL | / | | 175 | AF | 257 | | |
| 048 | 30 | 060 | | 0 | | 176 | B0 | 260 | | |
| 049 | 31 | 061 | | 1 | | 177 | B1 | 261 | | |
| 050 | 32 | 062 | SYN | 2 | | 178 | B2 | 262 | | |
| 051 | 33 | 063 | | 3 | | 179 | B3 | 263 | | |
| 052 | 34 | 064 | PN | 4 | | 180 | B4 | 264 | | |
| 053 | 35 | 065 | RS | 5 | | 181 | B5 | 265 | | |
| 054 | 36 | 066 | UC | 6 | | 182 | B6 | 266 | | |
| 055 | 37 | 067 | EOT | 7 | | 183 | B7 | 267 | | |
| 056 | 38 | 070 | | 8 | | 184 | B8 | 270 | | |
| 057 | 39 | 071 | | 9 | | 185 | B9 | 271 | | |
| 058 | 3A | 072 | | : | | 186 | BA | 272 | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 059 | 3B | 073 | CU3 | ; | | 187 | BB | 273 | | |
| 060 | 3C | 074 | DC4 | < | | 188 | BC | 274 | | |
| 061 | 3D | 075 | NAK | = | | 189 | BD | 275 | ] | |
| 062 | 3E | 076 | | > | | 190 | BE | 276 | | |
| 063 | 3F | 077 | SUB | ? | | 191 | BF | 277 | | |
| 064 | 40 | 100 | Space | @ | | 192 | CO | 300 | { | |
| 065 | 41 | 101 | | A | | 193 | C1 | 301 | A | |
| 066 | 42 | 102 | | B | | 194 | C2 | 302 | B | |
| 067 | 43 | 103 | | C | | 195 | C3 | 303 | C | |
| 068 | 44 | 104 | | D | | 196 | C4 | 304 | D | |
| 069 | 45 | 105 | | E | | 197 | C5 | 305 | E | |
| 070 | 46 | 106 | | F | | 198 | C6 | 306 | F | |
| 071 | 47 | 107 | | G | | 199 | C7 | 307 | G | |
| 072 | 48 | 110 | | H | | 200 | C8 | 310 | H | |
| 073 | 49 | 111 | | I | | 201 | C9 | 311 | I | |
| 074 | 4A | 112 | CENT | J | | 202 | CA | 312 | | |
| 075 | 4B | 113 | . | K | | 203 | CB | 313 | | |
| 076 | 4C | 114 | < | L | | 204 | CC | 314 | | |
| 077 | 4D | 115 | ( | M | | 205 | CD | 315 | | |
| 078 | 4E | 116 | + | N | | 206 | CE | 316 | | |
| 079 | 4F | 117 | \| | O | | 207 | CF | 317 | | |
| 080 | 50 | 120 | & | P | | 208 | D0 | 320 | } | |
| 081 | 51 | 121 | | Q | | 209 | D1 | 321 | J | |
| 082 | 52 | 122 | | R | | 210 | D2 | 322 | K | |
| 083 | 53 | 123 | | S | | 211 | D3 | 323 | L | |
| 084 | 54 | 124 | | T | | 212 | D4 | 324 | M | |
| 085 | 55 | 125 | | U | | 213 | D5 | 325 | N | |
| 086 | 56 | 126 | | V | | 214 | D6 | 326 | O | |
| 087 | 57 | 127 | | W | | 215 | D7 | 327 | P | |
| 088 | 58 | 130 | | X | | 216 | D8 | 330 | Q | |
| 089 | 59 | 131 | | Y | | 217 | D9 | 331 | R | |
| 090 | 5A | 132 | ! | Z | | 218 | DA | 332 | | |
| 091 | 5B | 133 | $ | [ | | 219 | DB | 333 | | |
| 092 | 5C | 134 | * | \ | | 220 | DC | 334 | | |
| 093 | 5D | 135 | ) | ] | | 221 | DD | 335 | | |
| 094 | 5E | 136 | ; | ^ | | 222 | DE | 336 | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 095 | 5F | 137 | | _ | | 223 | DF | 337 | | |
| 096 | 60 | 140 | - | ` | | 224 | E0 | 340 | | |
| 097 | 61 | 141 | / | a | | 225 | E1 | 341 | | |
| 098 | 62 | 142 | | b | | 226 | E2 | 342 | S | |
| 099 | 63 | 143 | | c | | 227 | E3 | 343 | T | |
| 100 | 64 | 144 | | d | | 228 | E4 | 344 | U | |
| 101 | 65 | 145 | | e | | 229 | E5 | 345 | V | |
| 102 | 66 | 146 | | f | | 230 | E6 | 346 | W | |
| 103 | 67 | 147 | | g | | 231 | E7 | 347 | X | |
| 104 | 68 | 150 | | h | | 232 | E8 | 350 | Y | |
| 105 | 69 | 151 | | i | | 233 | E9 | 351 | Z | |
| 106 | 6A | 152 | | j | | 234 | EA | 352 | | |
| 107 | 6B | 153 | , | k | | 235 | EB | 353 | | |
| 108 | 6C | 154 | % | l | | 236 | EC | 354 | | |
| 109 | 6D | 155 | _ | m | | 237 | ED | 355 | | |
| 110 | 6E | 156 | > | n | | 238 | EE | 356 | | |
| 111 | 6F | 157 | ? | o | | 239 | EF | 357 | | |
| 112 | 70 | 160 | | p | | 240 | F0 | 360 | 0 | |
| 113 | 71 | 161 | | q | | 241 | F1 | 361 | 1 | |
| 114 | 72 | 162 | | r | | 242 | F2 | 362 | 2 | |
| 115 | 73 | 163 | | s | | 243 | F3 | 363 | 3 | |
| 116 | 74 | 164 | | t | | 244 | F4 | 364 | 4 | |
| 117 | 75 | 165 | | u | | 245 | F5 | 365 | 5 | |
| 118 | 76 | 166 | | v | | 246 | F6 | 366 | 6 | |
| 119 | 77 | 167 | | w | | 247 | F7 | 367 | 7 | |
| 120 | 78 | 170 | | x | | 248 | F8 | 370 | 8 | |
| 121 | 79 | 171 | | y | | 249 | F9 | 371 | 9 | |
| 122 | 7A | 172 | : | z | | 250 | FA | 372 | | |
| 123 | 7B | 173 | # | { | | 251 | FB | 373 | | |
| 124 | 7C | 174 | @ | \| | | 252 | FC | 374 | | |
| 125 | 7D | 175 | ` | } | | 253 | FD | 375 | | |
| 126 | 7E | 176 | = | ~ | | 254 | FE | 376 | | |
| 127 | 7F | 177 | " | DEL | | 255 | FF | 377 | | |

Table 3.18 – ASCII and EBCDIC values related to letters

Unicode for Sinhala and Tamil letters

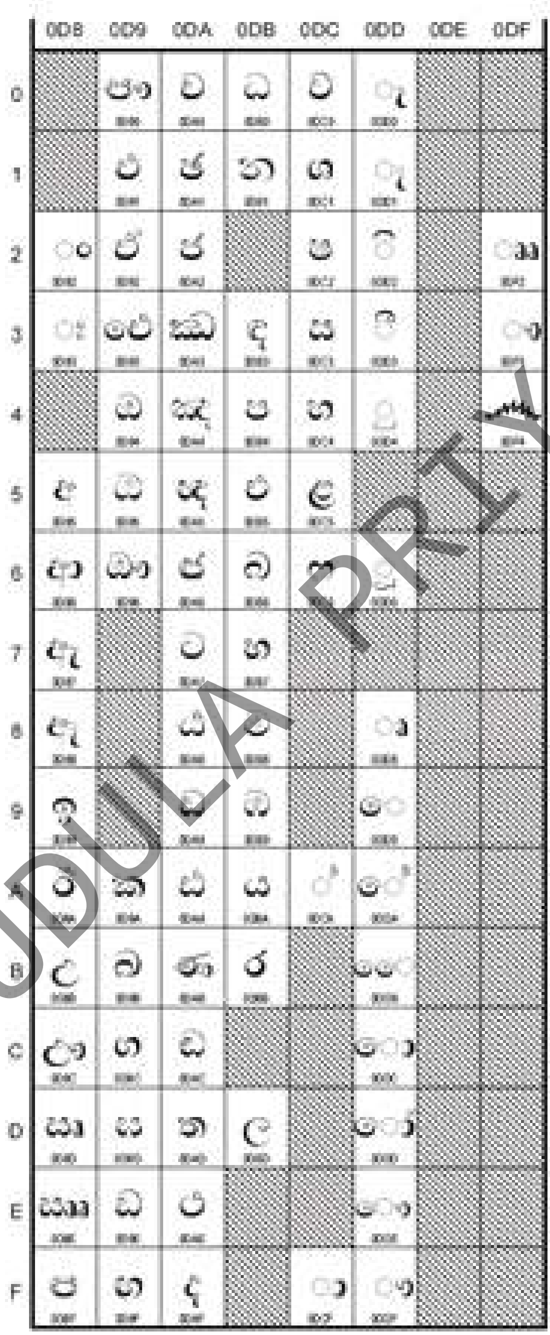



Table 3.18 – Sinhala Unicode

| | 0B8 | 0B9 | 0BA | 0BB | 0BC | 0BD | 0BE | 0BF |
|---|---|---|---|---|---|---|---|---|
| 0 | | ஐ | | ர | ◌ீ | ௐ | | ௰ |
| 1 | | | | ற | ◌ு | | | ௱ |
| 2 | ◌ஂ | ஒ | | ல | ◌ூ | | | ௲ |
| 3 | ஃ | ஓ | ண | ள | | | | ௳ |
| 4 | | ஔ | த | ழ | | | | ௴ |
| 5 | அ | க | | வ | | | | ௵ |
| 6 | ஆ | | | ஶ | ெ◌ | | ௦ | ௶ |
| 7 | இ | | | ஷ | ே◌ | ◌ௗ | ௧ | ௷ |
| 8 | ஈ | | ந | ஸ | ை◌ | | ௨ | ௸ |
| 9 | உ | ங | ன | ஹ | | | ௩ | ௹ |
| A | ஊ | ச | ப | | ொ | | ௪ | ௺ |
| B | | | | | ோ | | ௫ | |
| C | | ஜ | | | ௌ | | ௬ | |
| D | | | | | ◌் | | ௭ | |
| E | எ | ஞ | ம | ◌ா | | | ௮ | |
| F | ஏ | ட | ய | ◌ி | | | ௯ | |

Table 3.19 – Tamil Unicode