

# School of Basic and Applied Sciences

Course Code : BSCP3005

Course Name: Digital System and Application

## Number System

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## Number System

System	Base	Symbols	Used by humans?	Used in computers?
Decimal	10	0, 1, ... 9	Yes	No
Binary	2	0, 1	No	Yes
Octal	8	0, 1, ... 7	No	No
Hexa-decimal	16	0, 1, ... 9, A, B, ... F	No	No

## POSITIONAL NUMBER SYSTEMS

In a **positional number system**, the position a symbol occupies in the number determines the value it represents. In this system, a number represented as:

$$\pm (S_{k-1} \dots S_2 S_1 S_0 \cdot S_{-1} S_{-2} \dots S_{-l})_b$$

has the value of:

$$n = \pm (S_{k-1} \times b^{k-1} + \dots + S_1 \times b^1 + S_0 \times b^0) + (S_{-1} \times b^{-1} + S_{-2} \times b^{-2} + \dots + S_{-l} \times b^{-l})$$

in which S is the set of symbols, b is the **base** (or **radix**).

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## The decimal system (base 10)

The word decimal is derived from the Latin root **decem** (ten). In this system the **base  $b = 10$**  and we use ten symbols

$$S = \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9\}$$

The symbols in this system are often referred to as **decimal digits** or just **digits**.

### Integers

$$N = \pm S_{k-1} \times 10^{k-1} + S_{k-2} \times 10^{k-2} + \dots + S_2 \times 10^2 + S_1 \times 10^1 + S_0 \times 10^0$$

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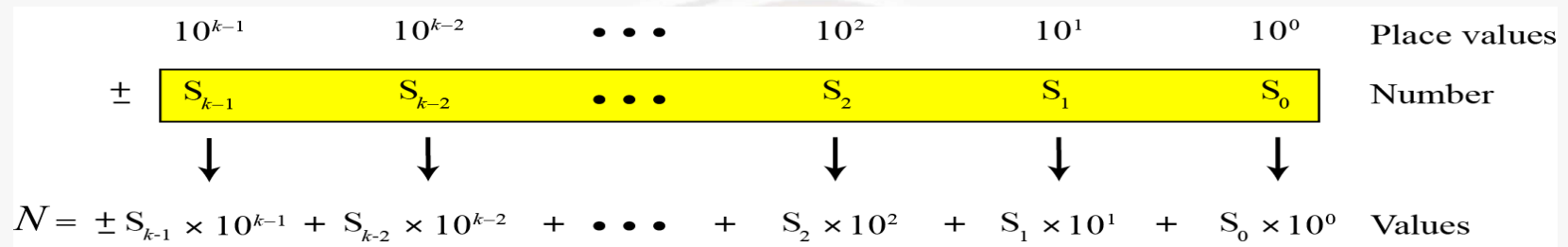
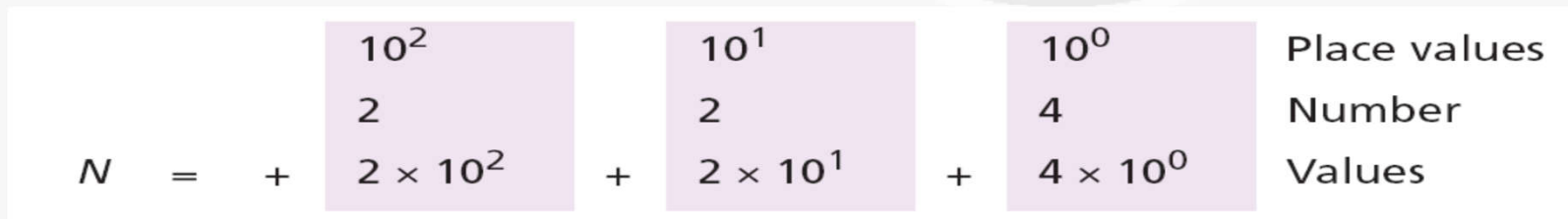


Fig: Place values for an integer in the decimal system

## Example

The following shows the place values for the integer +224 in the decimal system.



Note that the digit 2 in position 1 has the value 20, but the same digit in position 2 has the value 200. Also note that we normally drop the plus sign, but it is implicit.

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## Example

The following shows the place values for the decimal number -7508. We have used 1, 10, 100, and 1000 instead of powers of 10.

	1000	100	10	1	Place values
	7	5	0	8	Number
$N = -$	$( 7 \times 1000$	$+ 5 \times 100$	$+ 0 \times 10$	$+ 8 \times 1$	) Values

Note that the digit 2 in position 1 has the value 20, but the same digit in position 2 has the value 200. Also note that we normally drop the plus sign, but it is implicit.

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## Reals

Integral part

Fractional part

$$R = \pm \left( S_{k-1} \times 10^{k-1} + \dots + S_1 \times 10^1 + S_0 \times 10^0 \right) + \left( S_{-1} \times 10^{-1} + \dots + S_{-l} \times 10^{-l} \right)$$

## Example

The following shows the place values for the real number +24.13.

	$10^1$	$10^0$	$10^{-1}$	$10^{-2}$	Place values
	2	4	• 1	3	Number
$R = +$	$2 \times 10$	$+ 4 \times 1$	$+ 1 \times 0.1$	$+ 3 \times 0.01$	Values

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## The binary system (base 2)

The word binary is derived from the Latin root **bini** (or two by two). In this system the **base  $b = 2$**  and we use only two symbols,

$$S = \{0, 1\}$$

The symbols in this system are often referred to as **binary digits** or **bits** (binary digit).

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## Integers

$$N = \pm S_{k-1} \times 2^{k-1} + S_{k-2} \times 2^{k-2} + \dots + S_2 \times 2^2 + S_1 \times 2^1 + S_0 \times 2^0$$

	$2^{k-1}$	$2^{k-2}$	$\dots$	$2^2$	$2^1$	$2^0$	Place values
$\pm$	$S_{k-1}$	$S_{k-2}$	$\dots$	$S_2$	$S_1$	$S_0$	Number
	↓	↓		↓	↓	↓	
$N = \pm$	$S_{k-1} \times 2^{k-1}$	$+ S_{k-2} \times 2^{k-2}$	$+ \dots$	$+ S_2 \times 2^2$	$+ S_1 \times 2^1$	$+ S_0 \times 2^0$	Values

Figure : Place values for an integer in the binary system

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## Example

The following shows that the number  $(11001)_2$  in binary is the same as 25 in decimal. The subscript 2 shows that the base is 2.

	$2^4$	$2^3$	$2^2$	$2^1$	$2^0$	Place values
	1	1	0	0	1	Number
$N =$	$1 \times 2^4$	$+ 1 \times 2^3$	$+ 0 \times 2^2$	$+ 0 \times 2^1$	$+ 1 \times 2^0$	Decimal

The equivalent decimal number is  $N = 16 + 8 + 0 + 0 + 1 = 25$ .

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- Digital Fundamentals, Thomas L. Floyd, 11<sup>th</sup> Ed., 2015, Pearson Education Limited
- Modern Digital Electronics, R P Jain, 4<sup>th</sup> Ed., 2010, Tata McGraw Hill

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