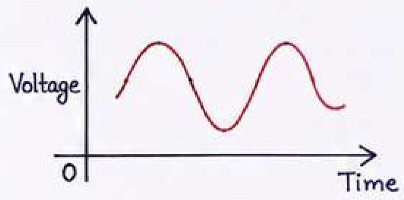
Number System and Codes

Difference between Analog and Digital Logic system, Positive and Negative Logic system

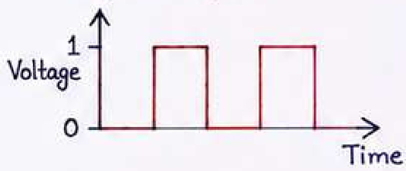
* 1. Difference between Analog and Digital Logic system

Analog Logic System	Digital Logic System
① Analog system works with continuous values. (Infinite number of values)	Digital system works with discrete values. (Only two values : 0 and 1)
② It can take any value within a range.	It can take only two values i.e., 0 or 1.
③ More susceptible to noise and interference.	Less susceptible to noise and interference.
④ Accuracy is lower as values change continuously.	Accuracy is higher as values are fixed (0 or 1).
⑤ Examples : Thermometer, Microphone, Volume Control etc.	Examples : Computer, Calculator, Digital Watch, Digital ICs etc.
⑥ Circuit design is complex.	Circuit design is simple and easy to implement.

Analog Signal



Digital Signal



In digital system, two states are used : 0 (Low) and 1 (High)

* 2. Positive and Negative Logic system

In digital electronics, two logic systems are used to represent binary data : Positive Logic and Negative Logic.

Positive Logic System

- In this system, higher voltage represents logic 1 (True) and lower voltage represents logic 0 (False).
- Logic 1 = High Voltage
  Logic 0 = Low Voltage
- This is the most commonly used logic system in digital circuits.

Voltage Representation (Positive Logic)

Logic State	Voltage Level
1 (High)	+5V (or High)
0 (Low)	0V (or Low)

- Example : TTL, CMOS (mostly used in positive logic)

Both systems perform the same logic operations, only the voltage levels are different.

Negative Logic System

- In this system, higher voltage represents logic 0 (False) and lower voltage represents logic 1 (True).
- Logic 0 = High Voltage
  Logic 1 = Low Voltage
- It is less common and used in some special applications.

Voltage Representation (Negative Logic)

Logic State	Voltage Level
0 (High)	+5V (or High)
1 (Low)	0V (or Low)

- Example : Some old systems, special purpose circuits

Key Points :

① Digital systems work with two discrete levels (0 and 1).
② Positive logic is more popular and standard.
③ Negative logic just reverses the meaning of 0 and 1.
④ Both are equally valid, choice depends on circuit design.

Summary

Positive Logic → 1 = High , 0 = Low
Negative Logic → 0 = High , 1 = Low

Number System and Codes

Introduction to different number systems

✱ 1. Introduction

In digital electronics, numbers are represented using different number systems. Each number system has a specific base (or radix) and uses a set of digits to represent values.

✱ 2. Different Number Systems

Number System	Radix (Base)	Digits Used	Description	Applications
(1) Binary Number System	2	0, 1	It is the fundamental number system used in digital electronics.	Used in all digital circuits, computers, microprocessors, etc.
(2) Octal Number System	8	0, 1, 2, 3, 4, 5, 6, 7	A shorthand representation of binary. Each octal digit represents 3 binary digits.	Used in old computers and digital systems for simplification.
(3) Decimal Number System	10	0, 1, 2, 3, 4, 5, 6, 7, 8, 9	The most common number system used in everyday life.	Used in counting, mathematics, general calculations, etc.
(4) Hexadecimal Number System	16	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F	A shorthand representation of binary. Each hexadecimal digit represents 4 binary digits.	Used in memory addresses, RGB color codes, microcontrollers, etc.

✱ 3. Explanation of Each Number System

(1) Binary Number System (Base-2)

- Uses only two digits : 0 and 1.
- Each position value is a power of 2.
- Example : $(1011)_2$
  ↳ (Binary number)

(2) Octal Number System (Base-8)

- Uses eight digits : 0 to 7.
- Each position value is a power of 8.
- Example : $(275)_8$
  ↳ (Octal number)

(3) Decimal Number System (Base-10)

- Uses ten digits : 0 to 9.
- Each position value is a power of 10.
- Example : $(347)_{10}$
  ↳ (Decimal number)

(4) Hexadecimal Number System (Base-16)

- Uses sixteen digits : 0 to 9 and A to F.
- Each position value is a power of 16.
- Example : $(24F)_{16}$
  ↳ (Hexadecimal number)

✱ 4. Summary Table

Number System	Radix (Base)	Digits Used	Example	Position Value
Binary	2	0, 1	$(1011)_2$	$2^0, 2^1, 2^2, 2^3 \ldots$
Octal	8	0 – 7	$(275)_8$	$8^0, 8^1, 8^2, 8^3 \ldots$
Decimal	10	0 – 9	$(347)_{10}$	$10^0, 10^1, 10^2, 10^3 \ldots$
Hexadecimal	16	0–9, A–F	$(2AF)_{16}$	$16^0, 16^1, 16^2, 16^3 \ldots$

Key Points :

① Binary is the base of all digital systems.
② Octal and Hexadecimal are shorthand forms of binary.
③ Decimal is used for general purpose calculations.
④ Understanding number systems is essential for digital electronics.

Summary

- Binary → Base-2 → Digits : 0, 1
- Octal → Base-8 → Digits : 0 – 7
- Decimal → Base-10 → Digits : 0 – 9
- Hexadecimal → Base-16 → Digits : 0–9, A–F

Number System and Codes

Decimal Number System

✱ 1. Introduction

The decimal number system has base 10.

It uses 10 digits : 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

Each position value is a power of 10.

✱ 2. Characteristics of Decimal Number System

- It is a base-10 number system.
- It uses ten digits from 0 to 9.
- Each position value is a power of 10.
- It is a weighted number system.
- It is widely used in everyday life.

✱ 3. Place Value in Decimal System

Position	4^{th}	3^{rd}	2^{nd}	1^{st}	0^{tst}	-2^{nd}
Place	Thousands	Hundreds	Tens	Ones	Tenths	Hundredths
Power of 10	10^3	10^2	10^1	10^0	10^{-1}	10^{-2}
Example	1000	100	10	1	0.1	0.01

Example : $237.64 = 2\times10^2 + 3\times10^1 + 7\times10^0 + 6\times10^{-1} + 4\times10^{-2}$

✱ 4. Conversion of Decimal Number

- Decimal to other number systems : By division method.
- Other number systems to Decimal : By expansion method.

✱ 5. Maths

Math 1 : Convert $(457.68)_{10}$ to expanded form.

Solution :

$(457.68)_{10}$

$= 4\times10^2 + 5\times10^1 + 7\times10^0 + 6\times10^{-1} + 8\times10^{-2}$

$= 4\times100 + 5\times10 + 7\times1 + 6\times0.1 + 8\times0.01$

$= 400 + 50 + 7 + 0.6 + 0.08$

$\therefore (457.68)_{10} = 400 + 50 + 7 + 0.6 + 0.08$

Math 2 : Convert $(209.375)_{10}$ to expanded form.

Solution :

$(209.375)_{10}$

$= 2\times10^2 + 0\times10^1 + 9\times10^0 + 3\times10^{-1} + 7\times10^{-2} + 5\times10^{-3}$

$= 2\times100 + 0\times10 + 9\times1 + 3\times0.1 + 7\times0.01 + 5\times0.001$

$= 200 + 0 + 9 + 0.3 + 0.07 + 0.005$

$\therefore (209.375)_{10} = 200 + 9 + 0.3 + 0.07 + 0.005$

✱ 6. Summary Table

Number System	Base (Radix)	Digits Used	Example	Position Value
Decimal	10	0 – 9	$(237.64)_{10}$	$\ldots, 10^2, 10^1, 10^0, 10^{-1}, 10^{-2}, \ldots$

Key Points :

① Decimal is a base-10 number system.
② It uses digits 0 to 9.
③ Each position value is a power of 10.
④ It is the most commonly used number system.

Summary

- Base (Radix) = 10
- Digits = 0 to 9
- Position value = Power of 10
- Used in daily life and most calculations

Number System and Codes

Binary Number System

✳ 1. Introduction

- The binary number system has base 2.
- It uses only two digits : 0 and 1.
- Each position value is a power of 2.
- It is the fundamental number system used in digital electronics and computers.

✳ 2. Characteristics of Binary Number System

- It is a base-2 number system.
- It uses two digits : 0 and 1.
- Each position value is a power of 2.
- It is a weighted number system.
- It is widely used in digital circuits, computers, microprocessors, communication systems, etc.

✳ 3. Place Value in Binary Number System

Position	4th	3rd	2nd	1st	0th	−1st	−2nd	−3rd
Place	16's	8's	4's	2's	1's	½'s	¼'s	⅛'s
Power of 2	2^4	2^3	2^2	2^1	2^0	2^{-1}	2^{-2}	2^{-3}
Value	16	8	4	2	1	½	¼	⅛

Example : $(1011.01)_2 = 1\times2^3 + 0\times2^2 + 1\times2^1 + 1\times2^0 + 0\times2^{-1} + 1\times2^{-2}$
$= 8 + 0 + 2 + 1 + 0 + 0.25 = (11.25)_{10}$

✳ 4. Rules in Binary Number System

- Addition, Subtraction, Multiplication and Division are performed using only 0 and 1.
- Any number in binary is represented using 0s and 1s.
- Carry in addition is also in binary (0 or 1).
- Borrow in subtraction is also in binary.

✳ 5. Maths

Math 1 : Convert $(1011.10)_2$ to decimal form.

Solution :

$(1011.10)_2$
$= 1\times2^3 + 0\times2^2 + 1\times2^1 + 1\times2^0 + 1\times2^{-1} + 0\times2^{-2}$
$= 8 + 0 + 2 + 1 + 0.5 + 0$

$\boxed{\therefore (1011.10)_2 = (11.5)_{10}}$

Math 2 : Convert $(1101.011)_2$ to decimal form.

Solution :

$(1101.011)_2$
$= 1\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0 + 0\times2^{-1} + 1\times2^{-2} + 1\times2^{-3}$
$= 8 + 4 + 0 + 1 + 0 + 0.25 + 0.125$

$\boxed{\therefore (1101.011)_2 = (13.375)_{10}}$

Math 3 : Add $(1011)_2$ and $(1101)_2$.

Solution :

$$\begin{array}{r} 1011 \\ +\ 1101 \\ \hline 11000 \end{array}$$

$\boxed{\therefore (1011)_2 + (1101)_2 = (11000)_2}$

Math 4 : Subtract $(10110)_2$ from $(11001)_2$.

Solution :

$$\begin{array}{r} 11001 \\ -\ 10110 \\ \hline 00011 \end{array}$$

$\boxed{\therefore (11001)_2 - (10110)_2 = (00011)_2}$

✳ 6. Summary Table

Number System	Base (Radix)	Digits Used	Example	Position Value
Binary	2	0, 1	$(1011.01)_2$	$\ldots, 2^2, 2^1, 2^0, 2^{-1}, 2^{-2}, \ldots$

Key Points :

① Binary is a base-2 number system.
② It uses only two digits : 0 and 1.
③ Each position value is a power of 2.
④ It is the most essential number system in digital electronics and computing.

Summary

- Base (Radix) = 2
- Digits = 0, 1
- Position value = Power of 2
- Used in computers, digital circuits, communication, microprocessors, etc.

Number System and Codes

Octal Number System

* 1. Introduction

- The octal number system has base 8.
- It uses only eight digits : 0, 1, 2, 3, 4, 5, 6, 7.
- Each position value is a power of 8.
- It is a weighted number system.
- It is widely used in digital systems and computers.

2. Characteristics of Octal Number System

- It is a base-8 number system.
- It uses eight digits : 0 to 7.
- Each position value is a power of 8.
- It is a weighted number system.
- It is used in computer systems, digital electronics, and microprocessors.

* 3. Place Value in Octal Number System

Position	4^{th}	3^{rd}	2^{nd}	1^{st}	0^{th}	-1^{st}	-2^{nd}
Place	512's	64's	8's	8's	1's	$\frac{1}{8}$'s	$\frac{1}{64}$'s
Power of 8	8^4	8^3	8^2	8^1	8^0	8^{-1}	8^{-2}
Value	4096	512	64	8	1	$\frac{1}{8}$	$\frac{1}{64}$

Example : $(725.36)_8$

$$= 7\times8^2 + 2\times8^1 + 5\times8^0 + 3\times8^{-1} + 6\times8^{-2}$$
$$= 7\times64 + 2\times8 + 5\times1 + 3\times\frac{1}{8} + 6\times\frac{1}{64}$$
$$= 448 + 16 + 5 + 0.375 + 0.09375 = (469.46875)_{10}$$

* 4. Rules in Octal Number System

- Addition, Subtraction, Multiplication and Division are performed using digits 0 to 7.
- Any octal number is represented using digits 0 to 7 only.
- Carry in addition is also in octal (0 to 7).
- Borrow in subtraction is also in octal.

* 5. Maths

Math 1 : Convert $(725.36)_8$ to decimal form.

Solution :

$(725.36)_8$

$$= 7\times8^2 + 2\times8^1 + 5\times8^0 + 3\times8^{-1} + 6\times8^{-2}$$
$$= 7\times64 + 2\times8 + 5\times1 + 3\times\frac{1}{8} + 6\times\frac{1}{64}$$
$$= 448 + 16 + 5 + 0.375 + 0.09375$$

$$\therefore (725.36)_2 = (469.46875)_{10}$$

Math 2 : Convert $(537.4)_8$ to decimal form.

Solution :

$(537.4)_8$

$$= 5\times8^2 + 3\times8^1 + 7\times8^0 + 4\times8^{-1}$$
$$= 5\times64 + 3\times8 + 7\times1 + 4\times\frac{1}{8}$$
$$= 320 + 24 + 7 + 0.5$$

$$\therefore (537.4)_8 = (351.5)_{10}$$

Math 3 : Add $(325.7)_8$ and $(142.5)_2$.

Solution :

```
   325.7
 + 142.5
 -------
   510.4
```

$$\therefore (325.7)_8 + (142.5)_2 = (510.4)_8$$

Math 4 : Subtract $(672.3)_8$ from $(745.6)_8$.

Solution :

```
   745.6
 - 672.3
 -------
   073.3  =  73.3
```

$$\therefore (745.6)_8 - (672.3)_8 = (73.3)_8$$

* 6. Summary Table

Number System	Base (Radix)	Digits Used	Example	Position Value
Octal	8	0 – 7	$(725.36)_8$	$\ldots, 8^2, 8^1, 8^0, 8^{-1}, 8^{-2}, \ldots$

Key Points :

① Octal is a base-8 number system.
② It uses digits 0 to 7.
③ Each position value is a power of 8.
④ It is used in computers, digital circuits and microprocessors.

Summary

- Base (Radix) = 8
- Digits = 0 to 7
- Position value = Power of 8
- Used in computers, digital electronics, microprocessors, etc.

Number System and Codes

BCD (Binary Coded Decimal)

* 1. Introduction

- BCD stands for Binary Coded Decimal.
- It is a code in which each decimal digit (0 to 9) is represented by its 4-bit binary equivalent.
- It is widely used in digital systems, calculators, display units, counters, and data communication.
- Since each decimal digit is represented by 4 bits, BCD is a weighted code.

2. Basic Concept

- Each decimal digit is encoded separately.
- 4 bits are used to represent one decimal digit.
- Total 10 valid codes (for 0 to 9).
- 4-bit combinations 1010 to 1111 are not used in BCD (invalid BCD codes).
- Example : Decimal 59 in BCD

  5 → 0101 , 9 → 1001

  So, 59 (BCD) = 0101 1001

* 3. BCD Code Table (8421 Code)

Decimal Digit	BCD Code				8421 Code
	8	4	2	1	
0	0	0	0	0	0000
1	0	0	0	1	0001
2	0	0	1	0	0010
3	0	0	1	1	0011
4	0	1	0	0	0100
5	0	1	0	1	0101
6	0	1	1	0	0110
7	0	1	1	1	0111
8	1	0	0	0	1000
9	1	0	0	1	1001

* 4. Important Points

- BCD uses 4 bits for each decimal digit.
- It is a weighted code (8-4-2-1).
- Easy conversion between decimal and binary.
- Invalid BCD Codes : 1010, 1011, 1100, 1101, 1110, 1111
- Used in calculators, digital clocks, computers, decimal displays, and communication systems.
- Arithmetic operations in BCD require correction (e.g., in addition if sum > 9 or carry occurs).

* 5. Examples

Example 1 : Convert Decimal $(275)_{10}$ to BCD.

Solution :

2 → 0010 7 → 0111 5 → 0101

So, $(275)_{10}$ in BCD = $\boxed{0010\ 0111\ 0101}$

Example 2 : Convert Decimal $(4890)_{10}$ to BCD.

Solution :

4 → 0100 8 → 1000 9 → 1001 0 → 0000

So, $(4890)_{10}$ in BCD = $\boxed{0100\ 1000\ 1001\ 0000}$

Example 3 : Convert BCD (0011 1000 0101) to Decimal.

Solution :

0011 → 3 1000 → 8 0101 → 5

So, $\boxed{(0011\ 1000\ 0101)_{BCD} = (385)_{10}}$

Example 4 : Convert BCD (0110 0001 1001 0000) to Decimal.

Solution :

0110 → 6 0001 → 1 1001 → 9 0000 → 0

So, $\boxed{(0110\ 0001\ 1001\ 0000)_{BCD} = (6190)_{10}}$

* 6. Summary Table

Code	Full Form	Bits Used per Digit	Valid Digits	Base (Radix)	Weight	Used In
BCD	Binary Coded Decimal	4	0 - 9	10	8 - 4 - 2 - 1	Calculators, Displays, Digital Clocks, Computers, Communication Systems

Key Points :

① BCD is a weighted code.
② It uses 4 bits to represent one decimal digit.
③ Total 10 valid codes (0 to 9).
④ 6 combinations (1010 to 1111) are invalid in BCD.
⑤ Used in digital systems, calculators, and displays.

Summary

- Each decimal digit is represented by its 4-bit binary code.
- BCD is easy to convert and understand.
- BCD simplifies decimal data handling in digital systems.
- It is essential in practical digital electronics.

Number System and Codes

Hexadecimal Number System

1. Introduction

- The hexadecimal number system has base 16.
- It uses sixteen digits : 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F.
- Each position value is a power of 16.
- It is a weighted number system.
- It is widely used in digital systems, memory addressing, microprocessors and computers.

2. Characteristics of Hexadecimal Number System

- It is a base-16 number system.
- It uses sixteen digits : 0 to 9 and A to F.
- Each position value is a power of 16.
- It is a weighted number system.
- It is widely used in digital circuits, computers, microprocessors and communication systems.

Note : A = 10, B = 11, C = 12, D = 13, E = 14, F = 15

3. Place Value in Hexadecimal Number System

Position	4th	3rd	2nd	1st	0th	-1st	-2nd
Place	4096's	256's	16's	1's	1's	1/16's	1/256's
Power of 16	16^4	16^3	16^2	16^1	16^0	16^{-1}	16^{-2}
Value	65536	4096	256	16	1	1/16	1/256

Example : $(1A3.F)_{16}$

$= 1 \times 16^2 + A \times 16^1 + 3 \times 16^0 + F \times 16^{-1}$

$= 1 \times 256 + 10 \times 16 + 3 \times 1 + 15 \times 1/16$

$= 256 + 160 + 3 + 0.9375 = (419.9375)_{10}$

4. Rules in Hexadecimal Number System

- Addition, Subtraction, Multiplication and Division are performed using digits 0 to F.
- Any hexadecimal number is represented using 0 to 9 and A to F only.
- Carry in addition is also in hexadecimal (0 to F).
- Borrow in subtraction is also in hexadecimal.

5. Maths

Math 1 : Convert $(2AF.3)_{16}$ to decimal form.

Solution :

$(2AF.3)_{16}$

$= 2 \times 16^2 + A \times 16^1 + F \times 16^0 + 3 \times 16^{-1}$

$= 2 \times 256 + 10 \times 16 + 15 \times 1 + 3 \times 1/16$

$= 512 + 160 + 15 + 0.1875$

$\boxed{\therefore (2AF.3)_{16} = (687.1875)_{10}}$

Math 2 : Convert $(3B7.A)_{16}$ to decimal form.

Solution :

$(3B7.A)_{16}$

$= 3 \times 16^2 + B \times 16^1 + 7 \times 16^0 + A \times 16^{-1}$

$= 3 \times 256 + 11 \times 16 + 7 \times 1 + 10 \times 1/16$

$= 768 + 176 + 7 + 0.625$

$\boxed{\therefore (3B7.A)_{16} = (951.625)_{10}}$

Math 3 : Add $(1A3)_{16}$ and $(2F7)_{16}$.

Solution :

$$\begin{array}{r} 1\ A\ 3 \\ +\ 2\ F\ 7 \\ \hline 4\ 9\ A \end{array}$$

$\boxed{\therefore (1A3)_{16} + (2F7)_{16} = (49A)_{16}}$

Math 4 : Subtract $(2B6)_{16}$ from $(5A3)_{16}$.

Solution :

$$\begin{array}{r} 5\ A\ 3 \\ -\ 2\ B\ 6 \\ \hline 2\ E\ D \end{array}$$

$\boxed{\therefore (5A3)_{16} - (2B6)_{16} = (2ED)_{16}}$

6. Summary Table

Number System	Base (Radix)	Digits Used	Example	Position Value
Hexadecimal	16	0 – 9, A – F	$(1A3.F)_{16}$	..., 16^2, 16^1, 16^0, 16^{-1}, 16^{-2}, ...

Key Points :

1. Hexadecimal is a base-16 number system.
2. It uses digits 0 to 9 and letters A to F.
3. Each position value is a power of 16.
4. It is widely used in digital electronics, computers, microprocessors and memory addressing.

Summary

- Base (Radix) = 16
- Digits = 0 to 9, A to F
- Position value = Power of 16
- Used in digital circuits, computers, microprocessors, memory addressing, communication systems, etc.

Number System and Codes

Conversion from One Number System to Another

1. Decimal to Binary

<u>Method</u> : Repeatedly divide the decimal number by 2 and write the remainders in reverse order.

<u>Example</u> : $(45)_{10} = (?)_2$

Division by 2	Quotient	Remainder
45 ÷ 2 =	22	1
22 ÷ 2 =	11	0
11 ÷ 2 =	5	1
5 ÷ 2 =	2	1
2 ÷ 2 =	1	0
1 ÷ 2 =	0	1

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So, $(45)_{10} = (101101)_2$

2. Binary to Decimal

<u>Method</u> : Multiply each bit with its corresponding power of 2 and add the results.

<u>Example</u> : $(101101)_2 = (?)_{10}$

Binary Number	1	0	1	1	0	1
Position	2^5	2^4	2^3	2^2	2^1	2^0
Value	32	16	8	4	2	1
Multiplication	1×32	0×16	1×8	1×4	0×2	1×1

So, $(101101)_2 = 32 + 0 + 8 + 4 + 0 + 1$

$= (45)_{10}$

3. Decimal to Octal

<u>Method</u> : Repeatedly divide the decimal number by 8 and write the remainders in reverse order.

<u>Example</u> : $(345)_{10} = (?)_8$

Division by 8	Quotient	Remainder
345 ÷ 8 =	43	1
43 ÷ 8 =	5	3
5 ÷ 8 =	0	5

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So, $(345)_{10} = (531)_8$

4. Octal to Decimal

<u>Method</u> : Multiply each digit with its corresponding power of 8 and add the results.

<u>Example</u> : $(531)_8 = (?)_{10}$

Octal Number	5	3	1
Position	8^2	8^1	8^0
Value	64	8	1
Multiplication	5×64	3×8	1×1

So, $(531)_8 = 5\times64 + 3\times8 + 1\times1$

$= (345)_{10}$

5. Decimal to Hexadecimal

<u>Method</u> : Repeatedly divide the decimal number by 16 and write the remainders in reverse order.

<u>Example</u> : $(305)_{10} = (?)_{16}$

Division by 16	Quotient	Remainder
305 ÷ 16 =	19	1
19 ÷ 16 =	1	3
1 ÷ 16 =	0	1

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So, $(305)_{10} = (131)_{16}$

<u>Note</u> : Remainders 10 to 15 are written as A, B, C, D, E, F (10 = A, 11 = B, 12 = C, 13 = D, 14 = E, 15 = F)

6. Hexadecimal to Decimal

<u>Method</u> : Multiply each digit with its corresponding power of 16 and add the results.

<u>Example</u> : $(2AF)_{16} = (?)_{10}$

Hex Number	2	A	F
Position	16^2	16^1	16^0
Value	256	16	1
Multiplication	2×256	10×16	15×1

So, $(2AF)_{16} = 2\times256 + 10\times16 + 15\times1$

$= 512 + 160 + 15$

$= (687)_{10}$

Hex Symbols

A = 10
B = 11
C = 12
D = 13
E = 14
F = 15

7. Conversion Summary Table

From	To	Method	Example	Result
Decimal (Base 10)	Binary (Base 2)	Repeated division by 2	$(45)_{10}$ →	$(101101)_2$
	Octal (Base 8)	Repeated division by 8	$(345)_{10}$ →	$(531)_8$
	Hexadecimal (Base 16)	Repeated division by 16	$(305)_{10}$ →	$(131)_{16}$
Binary (Base 2)	Decimal (Base 10)	Multiply by powers of 2	$(101101)_2$ →	$(45)_{10}$
	Octal (Base 8)	Convert to decimal or use grouping	$(110101)_2$ →	$(65)_8$
	Hexadecimal (Base 16)	Convert to decimal or use grouping	$(10101111)_2$ →	$(AF)_{16}$
Octal (Base 8)	Decimal (Base 10)	Multiply by powers of 8	$(531)_8$ →	$(345)_{10}$
	Binary (Base 2)	Replace each octal digit by 3-bit binary	$(65)_8$ →	$(110101)_2$
	Hexadecimal (Base 16)	Convert to decimal or via binary	$(37)_8$ →	$(1F)_{16}$
Hexadecimal (Base 16)	Decimal (Base 10)	Multiply by powers of 16	$(2AF)_{16}$ →	$(687)_{10}$
	Binary (Base 2)	Replace each hex digit by 4-bit binary	$(2AF)_{16}$ →	$(0010\ 1010\ 1111)_2$
	Octal (Base 8)	Convert to binary then to octal	$(1A3)_{16}$ →	$(643)_8$

Quick Reference Powers

Powers of 2

$2^0 = 1$
$2^1 = 2$
$2^2 = 4$
$2^3 = 8$
$2^4 = 16$
$2^5 = 32$
...

Powers of 8

$8^0 = 1$
$8^1 = 8$
$8^2 = 64$
$8^3 = 512$
...

Powers of 16

$16^0 = 1$
$16^1 = 16$
$16^2 = 256$
$16^3 = 4096$
...

Number System and Codes

Exercise - Number System Conversion

Note : Convert the following numbers from one number system to another.

1. Convert Decimal to Other Number Systems

	Decimal	Binary (Base 2)	Octal (Base 8)	Hexadecimal (Base 16)
(i)	25	....	....	....
(ii)	47	....	....	....
(iii)	58	....	....	....
(iv)	73	....	....	....
(v)	99	....	....	....
(vi)	125	....	....	....
(vii)	256	....	....	....
(viii)	512	....	....	....
(ix)	1023	....	....	....
(x)	4095	....	....	....

2. Convert Binary to Other Number Systems

	Binary (Base 2)	Decimal (Base 10)	Octal (Base 8)	Hexadecimal (Base 16)
(i)	1011	....	....	....
(ii)	11101	....	....	....
(iii)	100110	....	....	....
(iv)	1011011	....	....	....
(v)	1100101	....	....	....
(vi)	111111	....	....	....
(vii)	1000000	....	....	....
(viii)	10011111	....	....	....
(ix)	101010101	....	....	....
(x)	1111111111	....	....	....

3. Convert Octal to Other Number Systems

	Octal (Base 8)	Decimal (Base 10)	Binary (Base 2)	Hexadecimal (Base 16)
(i)	17	....	....	....
(ii)	25	....	....	....
(iii)	36	....	....	....
(iv)	57	....	....	....
(v)	123	....	....	....
(vi)	245	....	....	....
(vii)	377	....	....	....
(viii)	512	....	....	....
(ix)	643	....	....	....
(x)	777	....	....	....

4. Convert Hexadecimal to Other Number Systems

	Hexadecimal (Base 16)	Decimal (Base 10)	Binary (Base 2)	Octal (Base 8)
(i)	1A	....	....	....
(ii)	2F	....	....	....
(iii)	3C	....	....	....
(iv)	4D	....	....	....
(v)	5F	....	....	....
(vi)	7A	....	....	....
(vii)	9B	....	....	....
(viii)	AF	....	....	....
(ix)	C3	....	....	....
(x)	FF	....	....	....

Answer Keys

1. Decimal to Other Number Systems

	Decimal	Binary (Base 2)	Octal (Base 8)	Hexadecimal (Base 16)
(i)	25	11001	31	19
(ii)	47	101111	57	2F
(iii)	58	111010	72	3A
(iv)	73	1001001	111	49
(v)	99	1100011	143	63
(vi)	125	1111101	175	7D
(vii)	256	100000000	400	100
(viii)	512	1000000000	1000	200
(ix)	1023	1111111111	1777	3FF
(x)	4095	111111111111	7777	FFF

2. Binary to Other Number Systems

	Binary	Decimal	Octal	Hexadecimal
(i)	1011	11	13	B
(ii)	11101	29	35	1D
(iii)	100110	38	46	26
(iv)	1011011	91	133	5B
(v)	1100101	101	145	65
(vi)	111111	63	77	3F
(vii)	1000000	64	100	40
(viii)	10011111	159	237	9F
(ix)	101010101	341	525	155
(x)	1111111111	1023	1777	3FF

3. Octal to Other Number Systems

	Octal	Decimal	Binary	Hexadecimal
(i)	17	15	1111	F
(ii)	25	21	10101	15
(iii)	36	30	11110	1E
(iv)	57	47	101111	2F
(v)	123	83	1010011	53
(vi)	245	165	10100101	A5
(vii)	377	255	11111111	FF
(viii)	312	330	101001010	14A
(ix)	645	421	110100101	1A5
(x)	777	511	111111111	1FF

4. Hexadecimal to Other Number Systems

	Hexadecimal	Decimal	Binary	Octal
(i)	1A	26	00011010	32
(ii)	2F	47	00101111	57
(iii)	3C	60	00111100	74
(iv)	4D	77	01001101	115
(v)	5F	95	01011111	137
(vi)	7A	122	01111010	132
(vii)	9B	155	10011011	233
(viii)	AF	175	10101111	257
(ix)	C3	195	11000011	303
(x)	FF	255	11111111	377

Number System and Codes

EXERCISE – NUMBER SYSTEM CONVERSION

Exercise : Convert the following numbers from one number system to another.

A. Convert the following DECIMAL numbers to BINARY, OCTAL and HEXADECIMAL.

1. $(25)_{10}$
2. $(57)_{10}$
3. $(89)_{10}$
4. $(125)_{10}$
5. $(256)_{10}$
6. $(511)_{10}$
7. $(1023)_{10}$
8. $(4095)_{10}$

B. Convert the following BINARY numbers to DECIMAL, OCTAL and HEXADECIMAL.

1. $(1011)_2$
2. $(11001)_2$
3. $(111100)_2$
4. $(1001011)_2$
5. $(10101010)_2$
6. $(11111111)_2$
7. $(100000000)_2$
8. $(1010101010)_2$

C. Convert the following OCTAL numbers to DECIMAL, BINARY and HEXADECIMAL.

1. $(17)_8$
2. $(25)_8$
3. $(36)_8$
4. $(57)_8$
5. $(123)_8$
6. $(245)_8$
7. $(377)_8$
8. $(777)_8$

D. Convert the following HEXADECIMAL numbers to DECIMAL, BINARY and OCTAL.

1. $(1A)_{16}$
2. $(2F)_{16}$
3. $(3C)_{16}$
4. $(4D)_{16}$
5. $(5F)_{16}$
6. $(7A)_{16}$
7. $(AF)_{16}$
8. $(FF)_{16}$

E. Convert the following BINARY numbers to OCTAL and HEXADECIMAL.

1. $(101010)_2$
2. $(111001)_2$
3. $(1001111)_2$
4. $(11010101)_2$
5. $(100110011)_2$

F. Convert the following HEXADECIMAL numbers to BINARY and OCTAL.

1. $(2A)_{16}$
2. $(3E)_{16}$
3. $(7B)_{16}$
4. $(1C3)_{16}$
5. $(2F7)_{16}$

ANSWER KEY

A. DECIMAL → BINARY, OCTAL, HEXADECIMAL

Decimal	Binary	Octal	Hexadecimal
1. $(25)_{10}$	$(11001)_2$	$(31)_8$	$(19)_{16}$
2. $(57)_{10}$	$(111001)_2$	$(71)_8$	$(39)_{16}$
3. $(89)_{10}$	$(1011001)_2$	$(131)_8$	$(59)_{16}$
4. $(125)_{10}$	$(1111101)_2$	$(175)_8$	$(7D)_{16}$
5. $(256)_{10}$	$(100000000)_2$	$(400)_8$	$(100)_{16}$
6. $(511)_{10}$	$(111111111)_2$	$(777)_8$	$(1FF)_{16}$
7. $(1023)_{10}$	$(1111111111)_2$	$(1777)_8$	$(3FF)_{16}$
8. $(4095)_{10}$	$(111111111111)_2$	$(7777)_8$	$(FFF)_{16}$

B. BINARY → DECIMAL, OCTAL, HEXADECIMAL

Binary	Decimal	Octal	Hexadecimal
1. $(1011)_2$	$(11)_{10}$	$(13)_8$	$(B)_{16}$
2. $(11001)_2$	$(25)_{10}$	$(31)_8$	$(19)_{16}$
3. $(111100)_2$	$(60)_{10}$	$(74)_8$	$(3C)_{16}$
4. $(1001011)_2$	$(75)_{10}$	$(113)_8$	$(4B)_{16}$
5. $(10101010)_2$	$(170)_{10}$	$(252)_8$	$(AA)_{16}$
6. $(11111111)_2$	$(255)_{10}$	$(377)_8$	$(FF)_{16}$
7. $(100000000)_2$	$(256)_{10}$	$(400)_8$	$(100)_{16}$
8. $(1010101010)_2$	$(682)_{10}$	$(1252)_8$	$(2AA)_{16}$

C. OCTAL → DECIMAL, BINARY, HEXADECIMAL

Octal	Decimal	Binary	Hexadecimal
1. $(17)_8$	$(15)_{10}$	$(1111)_2$	$(F)_{16}$
2. $(25)_8$	$(21)_{10}$	$(10101)_2$	$(15)_{16}$
3. $(36)_8$	$(30)_{10}$	$(11110)_2$	$(1E)_{16}$
4. $(57)_8$	$(47)_{10}$	$(101111)_2$	$(2F)_{16}$
5. $(123)_8$	$(83)_{10}$	$(1010011)_2$	$(53)_{16}$
6. $(245)_8$	$(165)_{10}$	$(10100101)_2$	$(A5)_{16}$
7. $(377)_8$	$(255)_{10}$	$(11111111)_2$	$(FF)_{16}$
8. $(777)_8$	$(511)_{10}$	$(111111111)_2$	$(1FF)_{16}$

D. HEXADECIMAL → DECIMAL, BINARY, OCTAL

Hexadecimal	Decimal	Binary	Octal
1. $(1A)_{16}$	$(26)_{10}$	$(11010)_2$	$(32)_8$
2. $(2F)_{16}$	$(47)_{10}$	$(101111)_2$	$(57)_8$
3. $(3C)_{16}$	$(60)_{10}$	$(111100)_2$	$(74)_8$
4. $(4D)_{16}$	$(77)_{10}$	$(1001101)_2$	$(115)_8$
5. $(5F)_{16}$	$(95)_{10}$	$(1011111)_2$	$(137)_8$
6. $(7A)_{16}$	$(122)_{10}$	$(1111010)_2$	$(172)_8$
7. $(AF)_{16}$	$(175)_{10}$	$(10101111)_2$	$(257)_8$
8. $(FF)_{16}$	$(255)_{10}$	$(11111111)_2$	$(377)_8$

E. BINARY → OCTAL, HEXADECIMAL

Binary	Octal	Hexadecimal
1. $(101010)_2$	$(52)_8$	$(2A)_{16}$
2. $(111001)_2$	$(71)_8$	$(39)_{16}$
3. $(1001111)_2$	$(117)_8$	$(4F)_{16}$
4. $(11010101)_2$	$(325)_8$	$(D5)_{16}$
5. $(100110011)_2$	$(463)_8$	$(133)_{16}$

F. HEXADECIMAL → BINARY, OCTAL

Hexadecimal	Binary	Octal
1. $(2A)_{16}$	$(101010)_2$	$(52)_8$
2. $(3E)_{16}$	$(00111110)_2$	$(76)_8$
3. $(7B)_{16}$	$(01111011)_2$	$(173)_8$
4. $(1C3)_{16}$	$(000111000011)_2$	$(703)_8$
5. $(2F7)_{16}$	$(001011110111)_2$	$(1367)_8$

Important Notes

- Group binary digits from right in sets of 3 for Octal and in sets of 4 for Hexadecimal.
- Add leading 0's if required.
- For reverse conversion, multiply each digit by its corresponding power and add the results.

Quick Reference Table

Decimal	Binary	Octal	Hex
0	0000	0	0
1	0001	1	1
2	0010	2	2
3	0011	3	3
4	0100	4	4
5	0101	5	5
6	0110	6	6
7	0111	7	7
8	1000	10	8
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