6. Octal Numbers

Octal numbers are base-8 ($8=2^3$ digits, which means 3 bits per digit).

7. Conversion from Octal to Decimal

To convert octal numbers to decimal numbers:

- Multiply each bit by 8^n, where n is the "weight" of the bit
- The weight is the position of the bit, starting from 0 on the right
- Add the results

Example 9: Convert (724_8) to decimal number

$$724_8 \Rightarrow \begin{array}{rcl} 4 \times 8^0 & = & 4 \\ 2 \times 8^1 & = & 16 \\ 7 \times 8^2 & = & 448 \\ \hline & & 468_{10} \end{array}$$

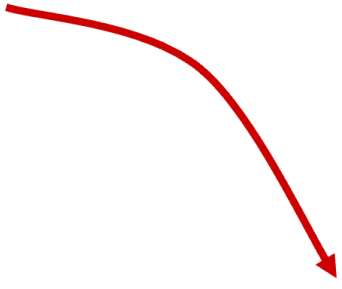
8. Conversion from Decimal to Octal

To convert octal numbers to decimal numbers:

- Divide by 8
- Keep track of the remainder

Example 10: Convert (1234_{10}) to octal

8 |	1234	
8 |	154	2
8 |	19	2
8 |	2	3
	0	2



$$1234_{10} = 2322_8$$

9. Hexadecimal Numbers

In addition to binary, another number base that is commonly used in digital systems is **base 16**. This number system is called **hexadecimal**, and each digit position represents a **power of 16**. For any number base greater than ten, a problem occurs because there are more than ten symbols needed to represent the numerals for that number base.

It is customary in these cases to use the **ten decimal numerals followed by the letters of the alphabet** beginning with A to provide the needed numerals. Since the hexadecimal system is base 16, there are sixteen numerals required. The following are the hexadecimal numerals:

0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F

Example 11: Hexadecimal numbers would be written like this:

$$\mathbf{10_{16}} \quad \mathbf{47_{16}} \quad \mathbf{3FA_{16}} \quad \mathbf{A03F_{16}}$$

Note: The reason for the common use of hexadecimal numbers is the relationship between the numbers 2 and 16. Sixteen is a **power of 2 (16 = 24)**. Because of this relationship, **four digits in a binary number can be represented with a single hexadecimal digit**.

This makes conversion between binary and hexadecimal numbers very easy, and hexadecimal can be used to write large binary numbers with much fewer digits.

10. Conversion from Binary to Hexadecimal

To convert a binary number to hexadecimal:

- divide it into groups of four digits starting with the rightmost digit.
- If the number of digits isn't a multiple of 4, prefix the number with 0's so that each group contains 4 digits.
- For each four-digit group, convert the 4-bit binary number into an equivalent hexadecimal digit.

Example 12: Convert the binary number **10110101** to a hexadecimal number

1. Divide into groups for 4 digits	1011	0101
2. Equivalent decimal number	11	5
3. Convert each group to hex digit	B	5
4. Hexadecimal number	$B5_{16}$	

Example 13: Convert the binary number **0110101110001100** to hexadecimal

1. Divide into groups for 4 digits	0110	1011	1000	1100
2. Equivalent decimal number	6	11	8	12
3. Convert each group to hex digit	6	B	8	C
4. Hexadecimal number	$6B8C_{16}$			

11. Conversion from Hexadecimal to Binary

To convert a hexadecimal number to a binary number, convert each hexadecimal digit into a group of 4 binary digits.

Example 14: Convert the hex number **374F** into binary

```
 3    7    4    F
0011 0111 0100 1111
```

0011011101001111_2

Note: Because we constantly slip between binary and hex, we have a special marker for hexadecimal (hex) with 0x (zero-X).

Example 15: What does **0xBD** represent?

Hexadecimal (Hex)	Decimal (Dec)	Binary (Bin)
B	11	1011
D	13	1101
Result is:	$11x16^1 + 13x16^0 = 189_{10}$ or 10111101_2	