

Computer Fundamentals

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Lecture 5





Numbering Systems

- ➤ Numbering system in common use → decimal
- ➤ Numbering system in computers → binary
- ➤ Other numbering systems → with different bases
- > Conversion from one system to another





Digits in Numbering Systems

- Binary numbering system (base 2)
 - **0**, 1
- > Octal numbering system (base 8)
 - **1** 0, 1, 2, 3, 4, 5, 6, 7
- > Decimal numbering system (base 10)
 - **1** 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
- > Hexadecimal numbering system (base 16)
 - □ 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F





Conversion Table

Binary	Octal	Decimal	Hexadecimal	
0	0	0	0	
1	1	1	1	
10	2	2	2	
11	3	3	3	
100	4	4	4	
101	5	5	5	
110	6	6	6	
111	7	7	7	
1000	10	8	8	
1001	11	9	9	
1010	12	10	Α	





Decimal System

> Decimal (base 10) numbers expressed in positional notation

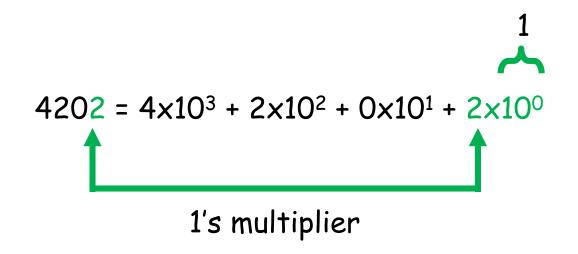
The right-most is the least significant digit

$$4202 = 4 \times 10^3 + 2 \times 10^2 + 0 \times 10^1 + 2 \times 10^0$$

The left-most is the most significant digit

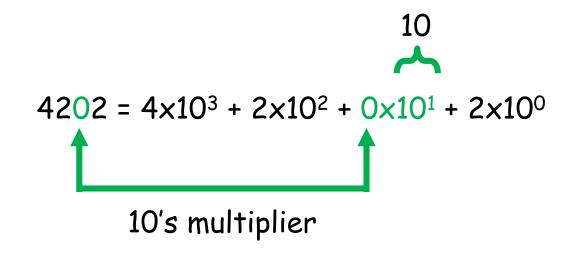






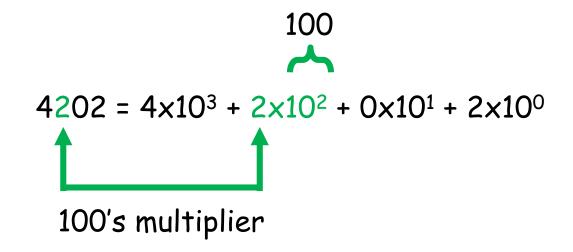






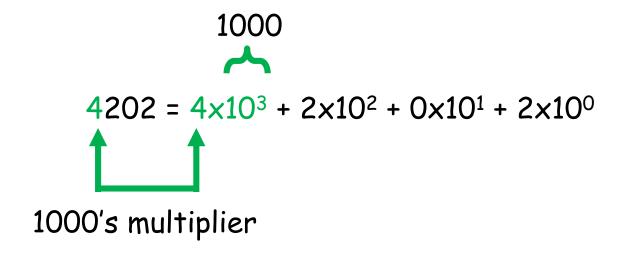
















Binary System

> Binary (base 2) numbers also expressed in positional notation

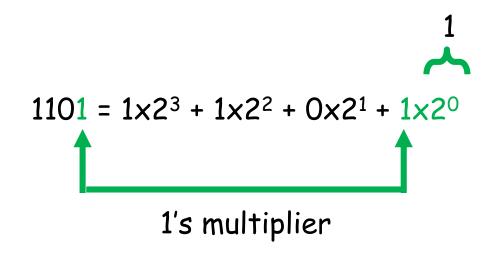
The right-most is the least significant digit

$$1101 = 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$$

The left-most is the most significant digit

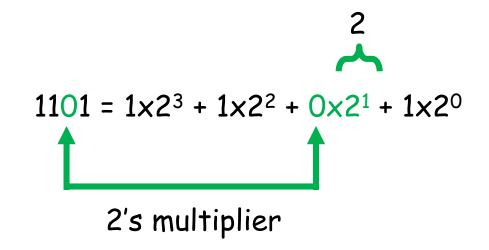






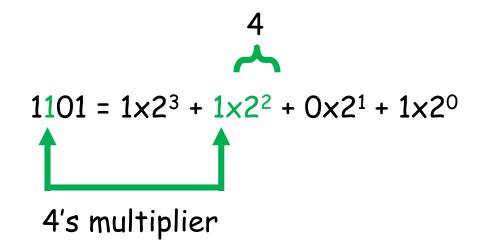






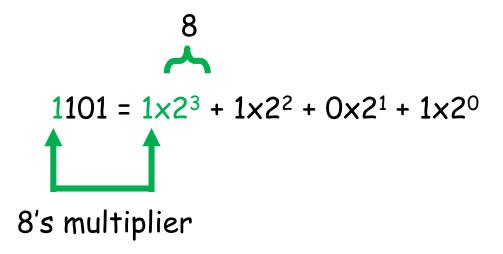














Why Binary?

- Natural for digital computers
- > Fundamental building block of a digital computer
 - □ Switch possesses two natural states, ON & OFF
- Easy to represent these states binary system
 - ☐ Only two symbols, 1 and 0
- > In some ways, the binary number system is natural to us humans. How?
- BIT = BInary digiT
- > BYTE = 8 bits





Binary - Decimal Conversion

> Convert 75 from decimal to binary

2	75	remainder	
2	37	1	
2	18	1	
2	9	0	
2	4	1	
2	2	0	
2	1	0	
	0	1	



1001011



Binary - Decimal Conversion (cont.)

> Convert 1001011 from binary to decimal

$$1001011 = 1 \times 2^{6} + 0 \times 2^{5} + 0 \times 2^{4} + 1 \times 2^{3} + 0 \times 2^{2} + 1 \times 2^{1} + 1 \times 2^{0}$$

$$= 64 + 0 + 0 + 8 + 0 + 2 + 1$$

$$= 75$$





Binary - Octal Conversion

- > Convert 1001011 from binary to octal
- Make groups of three bits from right
- > Add additional zeroes on the left side (if required)
- > Convert each group into corresponding number

> Convert from octal to binary in similar fashion





Binary - Hexadecimal Conversion

- > Convert 1001011 from binary to hexadecimal
- > Make groups of four bits from right
- > Add additional zeroes on the left side (if required)
- > Convert each group into corresponding number

> Convert from hexadecimal to binary in similar fashion





Binary Numbers with Fractions

- Decimal numbers have decimal point
 E. g. 43.781
- ➤ Similarly binary numbers have binary points
 □ E. g. 10111.1011
- > Decimal binary conversion possible





Binary Numbers with Fractions (cont.)

> Convert 75.56 from decimal to binary up to 5 binary points

2	75	remainder
2	37	1
2	18	1
2	9	0
2	4	1
2	2	0
2	1	0
	0	1

2 × 0.56 =	1 .12
2 × 0.12 =	0.24
2 x 0.24 =	0 .48
2 × 0.48 =	0.96
2 x 0.96 =	1.92
1.	7



1001011.10001



Binary Numbers with Fractions (cont.)

> Convert 1011.11 from binary to decimal

$$1011.11 = 1 \times 2^{3} + 0 \times 2^{2} + 1 \times 2^{1} + 1 \times 2^{0} + 1 \times 2^{-1} + 1 \times 2^{-2}$$

$$= 8 + 0 + 2 + 1 + 0.5 + 0.25$$

$$= 11.75$$





Binary Addition

> Basic addition

$$\bigcirc$$
 0 + 0 = 0

$$\bigcirc$$
 0 + 1 = 1

$$\Box$$
 1 + 0 = 1

$$\Box$$
 1 + 1 = 10

$$\Box$$
 1 + 1 + 1 = 11

Add 1011.1101 with 11.001

1011.1101

+ 11.0010

= 1110.11 11





Binary Subtraction

Basic subtractions

- □ 0 0 = 0
- □ 1 0 = 1
- □ 1 1 = 0
- **□** 10 1 = 1
- □ 11 1 = 10

Subtract 11.001 from 1110.1111

1110.11 11

- 11.0010

= 1011.1101





Binary Multiplication

Basic Multiplications

$$\bigcirc$$
 0 x 0 = 0

$$\bigcirc 0 \times 1 = 0$$

$$\square$$
 1 × 0 = 0

$$\square$$
 1 × 1 = 1

Multiply 101 by 1110

1	1	1	0
_	_	_	

1 110

0000x

1 1 10 x x

1000110





Binary Division

- > Basic Divisions
 - **□** 0 / 1 = 0
 - **□** 1 / 1 = 1
- > Divide 11010 by 101

