# Number Systems (Chapter 3)

#### **Decimal Number**



### **Binary Number**

Repeatedly divide by two and record the remainder for each division then read the answer upwards

**Example:** Rewrite the decimal number 500<sub>10</sub> as a binary number

$$500/2 = 250 + 0$$
 $250/2 = 125 + 0$ 
 $125/2 = 62 + 1$ 
 $62/2 = 31 + 0$ 
 $31/2 = 15 + 1$ 
 $15/2 = 7 + 1$ 
 $7/2 = 3 + 1$ 
 $3/2 = 1 + 1$ 
 $1/2 = 0 + 1$ 

Read the reminders upwards

The answer is  $500_{10} = 111110100_2$ , we can check the answer by transferring the result back to decimal number

$$111110100_2 = 1 * 2^8 + 1 * 2^7 + 1 * 2^6 + 1 * 2^5 + 1 * 2^4 + 0 * 2^3 + 1 * 2^2 + 0 * 2^1 + 0 * 2^0 = 500_{10}$$

#### **Decimal Number**



#### **Octal Number**

Repeatedly divide by eight and record the remainder for each division then read the answer upwards

**Example:** Rewrite the decimal number 263<sub>10</sub> as an octal number

$$263/8 = 32 + 7$$
 $32/8 = 4 + 0$ 
 $4/8 = 0 + 4$ 
 $0/8 = 0 + 0$ 
Read the reminders upwards

The answer is  $263_{10} = 407_8$ , we can check the answer by transferring the result back to decimal number

$$407_8 = 4 * 8^2 + 0 * 8^1 + 7 * 8^0 = 256 + 0 + 7 = 263_{10}$$

Note that we did not consider the 0 on the left because it dose not effect the answer 0407<sub>8</sub>=407<sub>8</sub>

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#### **Decimal Number**



#### **Hexadecimal Number**

Repeatedly divide by eight and record the remainder for each division then read the answer upwards

**Example:** Rewrite the decimal number 6121<sub>10</sub> as a hexadecimal number

$$612/16 = 382 + 9$$

$$382/16 = 23 + 14$$

$$23/16 = 1 + 7$$

$$1/16 = 0 + 1$$

Note that  $14_{10} = E_{16}$ 

Read the reminders upwards and replace 14 by

The answer is  $6121_{10} = 17E9_{16}$ , we can check the answer by transferring the result back to decimal number

$$17E9_{16} = 1 * 16^3 + 7 * 16^2 + 14 * 16^1 + 9 * 16^0 = 4096 + 1792 + 224 + 9 = 6121$$

Note that  $10_{10} = A_{16}$ ,  $11_{10} = B_{16}$ ,  $12_{10} = C_{16}$ ,  $13_{10} = D_{16}$ ,  $14_{10} = E_{16}$ ,  $15_{10} = F_{16}$ .

# **Binary Number**



#### **Octal Number**

Note  $8 = 2^3$  that means we need only 3 bits to represent 8 possibilities  $\{0,1,2,3,4,5,6,7\}$ 

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Count off from right to left by three and translate each triad into base 10.

**Example:** Rewrite the binary number 1101101011<sub>2</sub> as an octal number



The answer is  $1101101011_2 = 1553_8$ , We change an octal number to a binary number by changing each digit of octal number to 3 bits binary number, e.g.,  $643_8 = 110 100 011_2$ .

# **Binary Number**



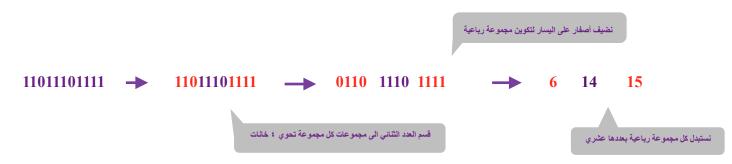
# **Hexadecimal Number**

Note  $16 = 2^4$  that means we need only 4 bits to represent 16 possibilities  $\{0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F\}$ 

0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
$A_{16}=10$	1010
$B_{16}=11$	1011
$C_{16}=12$	1100
$D_{16}=13$	1101
$E_{16}=14$	1110
$F_{16}=15$	1111

Count off from right to left by four and translate each quad into base 10.

Example: Rewrite the binary number 110111011112 as a hexadecimal number



The answer is  $11011101111_2 = 6EF_{16}$ , We change an octal number to a binary number by changing each digit of binary number to 4 bits binary number, e.g,  $5A2_{16} = 0101 \ 1010 \ 0010_2$ .

# Octal Number Hexadecimal Number

We can changing an Octal number to/from a Hexadecimal number by simply transfer the number to binary number then use the methods above to change it to the requested base.

**Example:** Rewrite the octal number 374<sub>8</sub> as a hexadecimal number.

$$374_8 = 0111111100_2 = 0$$
  $11111100_2 = 0$  F C  $_{16} = FC_{16}$ 

To check your answer change both octal and hexadecimal to decimal number:

$$374_8 = 3 * 8^2 + 7 * 8^1 + 4 * 8^0 = 192 + 56 + 4 = 252$$
  
 $FC_{16} = 15 * 16^1 + 12 * 16^0 = 240 + 12 = 252$