**Computer Number Systems – Teacher Notes for the board**

**Objective: Understanding Binary, Octal, Decimal and Hexadecimal number systems and how to convert from any number system to another.**

Three types we are discussing today:

1. Decimal (base 10)
2. Binary (base 2)
3. Octal (base 8)
4. Hexadecimal (base 16)

Some characteristics common among all number systems:

* Always start counting from 0
* Always end at base – 1

Binary – uses only 2 digits, 0 and 1

Let’s count in binary

Binary Decimal

Number Equivalent

000 0

001 1

010 2

011 3

100 4

101 5 



Octal – uses 8 digits, 0, 1, 2, 3, 4, 5, 6, 7

Do the same as binary

Hexadecimal – uses 10 digits and 6 letters, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F

Do the same as binary

|  |  |  |  |
| --- | --- | --- | --- |
| **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** | **A** |
| **1011** | **13** | **11** | **B** |
| **1100** | **14** | **12** | **C** |
| **1101** | **15** | **13** | **D** |
| **1110** | **16** | **14** | **E** |
| **1111** | **17** | **15** | **F** |

**Converting Binary to Decimal - Each digit in binary represents a power of 2**

Ex: Convert 1010112 to decimal

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Binary | 1 | 0 | 1 | 0 | 1 | 1 |
| Power of 2 | 25 | 24 | 23 | 22 | 21 | 20 |
| Decimal equivalent | 32 | 0 | 8 | 0 | 2 | 1 |

Answer: 1010112 = 32 + 8 + 2 + 1 = 4310

**Converting Octal to Decimal – Each digit represents a power of 8**

Ex: Convert 21358 to decimal

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Octal | 2 | 1 | 3 | 5 |
| Power of 8 | 83 | 82 | 81 | 80 |
| Decimal equivalent | 1024 | 64 | 24 | 5 |

Answer: 21358 = 1024 + 64 + 24 + 5 = 111710

**Convert Hexadecimal to Decimal – Each digit represents a power of 16**

Ex: Convert 3B4F16 to decimal

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Hex | 3 | B | 4 | F |
| Power of 16 | 163 | 162 | 161 | 160 |
| Decimal equivalent | 3x4096 | 11x256 | 4x16 | 15X1 |

Answer: 3B4F16 = 12288 + 2816 + 64 + 15 = 15,18310



**Converting Octal to Binary - convert each octal digit to 3 binary digits then group together**

Ex: Convert 1178 to binary

001 001 111

Answer: 1178 = 1001111

**Converting Hexadecimal to Binary – convert each hex digit to 4 binary digits then group together**

Ex: Convert AF816 to binary

1010 1111 1000

Answer: AF816 = 101011111000

**Converting Decimal to Binary – Divide by 2, each remainder is the answer, starting from the right**

Ex: Convert 4310 to binary

Divide, remainder is the right-most digit

43/2= 21 R1

21/2= 10 R1

10/2= 5 R0

5/2=2 R1

2/2=1 R0

1/2 = 0 R1

Answer: 4310 = 1010112



**Convert Decimal to Hexadecimal**

Ex: Convert 83010 to Hex

830/16 = 51 R 14 

51/16 = 3 R3

3/16 = 0 R 3

3 3 E

Answer: 83010 = 33E16

**Converting Octal to Hexadecimal (special shortcut )**

Convert each octal digit into 3 binary digits, then regroup into 4 binary digits

Ex: Convert 3458 to Hex

011 100 101

Rewrite as: 0 1110 0101

E 5 16

Answer: 3458 = E516



**Converting Binary to Octal – group the binary digits into groups of 3 digits, then convert each group to octal**

Ex: 1010110012 to octal

101 011 001

5 3 1

Answer: 1010110012 = 5318

**Converting Decimal to Octal**

Divide by 8, each remainder becomes a digit in octal, starting from the right.

Ex: Convert 75110 to octal

751/8 = 93 R 7

93/8 = 11 R 5

11/8 = 1 R 3

1/8 = 0 R 1

Answer: 75110 = 13578

**Converting Hex to Octal – (special shortcut)**

Convert each hex digit into 4 binary digits, then regroup into groups of 3 binary digits

Example: Convert A2DE16 to Octal 

1010 0010 1101 1110

Rewrite in groups of 3: 1 010 001 011 011 110

1 2 1 3 3 6 = 1213368