Denary and Binary

The Binary System

The **Binary System** is a way of writing numbers using only the digits 0 and 1. This is the method used by the (**digital**) computer.

The system we, humans, use to write numbers is called **decimal** (or **denary**).

In the DECIMAL system "fifty two" is written as 52.
In the BINARY system "fifty two" is written as 110100.

Converting from Binary to Decimal

Follow this example. We have 10110011. Note that this number is a sequence of 8 **bits**, so it is a **byte**. Add the weights as seen in the diagram. Add all weights that are associated with the bits that are equal to 1.

Weights	128	64	32	16	8	4	2	1
Number	1	0	0	1	0	1	1	0

Add 128 + 16 + 4 + 2. This amounts to 150.

Sometimes we use **subscripts** to indicate whether a number is binary of decimal as shown here:

A binary number: 10010110_2
A decimal number: 150_{10}

The method we have seen here is called the **positional notation method**.

Converting from Decimal to Binary

Suppose we want to convert the decimal number 149 to binary. One way we can do this is by repeatedly dividing the number by 2 and then taking the remainder digits to get the solution. An example is shown here:

2	149		
2	74	remainder	1
2	37	remainder	0
2	18	remainder	1
2	9	remainder	0
2	4	remainder	1
2	2	remainder	0
2	1	remainder	0
	0	remainder	1
	Quotient after dividing by 2		Remainder after dividing by 2

After performing this process you have to read the remainders FROM BOTTOM TO TOP. This gives us that the decimal number 149 is equal to the binary number 10010101.

Number Bases

Positional number systems depend on a special number called a **base**. A **positional** number system (like the decimal and binary systems) is such that a digit represents a number according to the position where it is e.g. in the number 2725 the first ‘2’ (from the left) represents 2000 while the second ‘2’ represents 20.

Note that:

2725 = 2x1000 + 7x100 + 2x10 + 5.

$$2725 = 2\text{x}\mathbf{10^3} + 7\text{x}\mathbf{10^2} + 2\text{x}\mathbf{10^1} + 5\text{x}\mathbf{10^0}.$$

The base number of the decimal system is 10.

Working on the same principles we can show that the base number of the binary system is 2.

Let us investigate the number 10010110_2.

$$10010110 = 1x128 + 0x64 + 0x32 + 1x16 + 0x8 + 1x4 + 1x2 + 0x1.$$

$$10010110 = 1x2^7 + 0x2^6 + 0x2^5 + 1x2^4 + 0x2^3 + 1x2^2 + 1x2^1 + 0x2^0.$$

Note also that the base number shows us how many different **symbols** are required to express a number i.e. in the decimal system we need 10 symbols (0, 1, 2, 3, 4, 5, 6, 7, 8 and 9) while in the binary system we need 2 (0 and 1).

Exercise

1) Convert the following binary numbers to decimal. (a) 11001, (b) 11011101 and (c) 1110010
2) Convert the following decimal numbers to binary.
    a. 108
    b. 53
    c. 74
3) What do we mean by the base of a number system?
4) What is the relationship between the base and the number of symbols required by a number system?