Hexadecimal notation

Rather than deal with long streams of ones and zeros it is easier for us to write complex patterns of binary in base 16, or hexadecimal. This is a standard way of entering information, particularly when dealing with assembly or machine code. Remember that internally the hexadecimal code is stored as binary.

Base two uses the following two symbols: 0, 1
Base ten uses the following ten symbols: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
Base 16 uses the following sixteen symbols: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F

In Hexadecimal notation the symbols A through to F represent the numbers 10 through to 15.

Sample hexadecimal numbers: $A098_{16}$, $56BA_{16}$, $C2_{16}$, AF_{16}, 672_{16}

Converting a binary number to hexadecimal

Use the following table to convert each four digits of the binary number into the equivalent hexadecimal digit:

Binary	Hex
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F

Example: Converting the number $10110101001001001010010_2$ to Hex

Divide into groups of four (starting at the right):
0101 1010 1001 0010 0101 0010

Note that a leading 0 has to be added to the first block to make a group of four.

Write down the Hexadecimal digit for each block:

0101 1010 1001 0010 0101 0010
5 A 9 2 5 2

Construct the number - the answer is $5A9252_{16}$

Converting a hexadecimal number to binary

Reverse the process above:

Example: Converting the number $7A9F_{16}$ to binary

Write down the four digit binary code required for each hexadecimal digit:

7 A 9 F
0111 1010 1001 1111

Construct the number - **the answer is 0111101010011111_2.**

Converting hexadecimal to denary

A hexadecimal number is converted to base ten by laying it out in a grid, similar to the grid used for base two. Different grid headings are required.

In base ten the grid used for our number bases is calculated by using successive powers of ten:-

10^7	10^6	10^5	10^4	10^3	10^2	10^1	10^0

Which gives:

10000000	1000000	100000	10000	1000	100	10	1

In base two, successive powers of two are used:-

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Which gives:

128	64	32	16	8	4	2	1

Similarly then for hexadecimal:-

16^7	16^6	16^5	16^4	16^3	16^2	16^1	16^0

giving:-

268435456	16777216	1048576	65536	4096	256	16	1

These are used as shown in the next example:

Example: Find $A45F_{16}$ in base ten.

Draw the grid with the appropriate column headings, then add up each column as required.

4096	256	16	1
A	4	5	F

Giving (A * 4096) + (4 * 256) + (16 * 5) + (F * 1)

or rather (10 * 4096) + (4 * 256) + (16 * 5) + (15 * 1) = **42079_{10}**

Converting denary to hexadecimal

A mathematical approach using successive divisions by sixteen is used. At each stage the remainder must be noted.

Example: Convert 42079 into hexadecimal

42079 divide 16	= 2629 remainder 15
2629 divide 16	= 164 remainder 5
164 divide 16	= 10 remainder 4
10 divider 16	= 0 remainder 10

The solution is found by reading the remainders in reverse order, converting numbers over 9 into the appropriate hexadecimal digit.

Giving	10	4	5	15
or rather	A	4	5	F

So 42079_{10} is A45F in hexadecimal.

Note that a similar approach can be used to convert from base ten into binary by dividing by two.

Example: Convert 856 into binary

856 divide 2	= 428 remainder 0
428 divide 2	= 214 remainder 0
214 divide 2	= 107 remainder 0
107 divide 2	= 53 remainder 1
53 divide 2	= 26 remainder 1
26 divide 2	= 13 remainder 0
13 divide 2	= 6 remainder 1
6 divide 2	= 3 remainder 0
3 divide 2	= 1 remainder 1
1 divide 2	= 0 remainder 1

So 856_{10} is 1101011000 in binary.

Activities

Convert 10100100101111_2 to Hexadecimal and Denary.

What (even) parity would be required on the number $7A_{16}$?

Perform the addition $A48F_{16} + 5BC3_{16}$ using 16-bit twos complement notation. Show the answer as a denary number.