# Essential Maths Skills

## for AS/A-level

# Computer Science

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# Contents

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# 2 Number bases

## Decimal, binary and hexadecimal number base

'Number base' means the number of different symbols that are used. So if you have base 10 (known as decimal, or denary), there are 10 different symbols: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. These symbols are then combined to represent any number, e.g. 12, 99, 386.

Binary is base 2 and there are two different symbols: 0 and 1.

Hexadecimal is base 16 and there are 16 different symbols: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F. Letters are used in hexadecimal instead of two digit numbers.

A = 10
B = 11
C = 12
D = 13
E = 14
F = 15

The base of a number can be identified by its subscript:

- If the subscript is 10, e.g. $9_{10}$, this means it is a base 10 number (decimal).
- If the subscript is 2, e.g. $1011_2$, this means it is a base 2 number (binary).
- If the subscript is 16, e.g. $281_{16}$, this means it is a base 16 number (hexadecimal) .

## Converting a base 2 or base 16 number to base 10

Each digit in a number can be converted into its decimal (base 10) value using four steps. Table 2.1 shows how the digits are divided. In computer science we start counting at 0. The first digit (on the right) is Digit 0 (D0). This is multiplied by its base to the power of 0 ($base^0$). Digit 1 (D1) is multiplied by its base to the power of 1 ($base^1$). Digit 2 (D2) is multiplied by its base to the power of 2 ($base^2$) and so on.

**Table 2.1**

| D4 | D3 | D2 | D1 | D0 |
|---|---|---|---|---|
| $\times$ $base^4$ | $\times$ $base^3$ | $\times$ $base^2$ | $\times$ $base^1$ | $\times$ $base^0$ |

Multiplying to the power of 2 means the number multiplied by itself, i.e. $4^2 = 4 \times 4$.

Multiplying to the power of 3 means the number multiplied by itself, multiplied by itself, i.e. $4^3 = 4 \times 4 \times 4$.

## A Worked examples

**a Convert the binary number 0101 to decimal.**

Step 1: put the binary number into the table format as shown in Table 2.1.

**Table 2.2**

| | | | |
|---|---|---|---|
| 0 | 1 | 0 | 1 |
| $\times$ base$^3$ | $\times$ base$^2$ | $\times$ base$^1$ | $\times$ base$^0$ |

Step 2: binary is base 2, so replace the word 'base' with 2.

**Table 2.3**

| | | | |
|---|---|---|---|
| 0 | 1 | 0 | 1 |
| $\times 2^3$ | $\times 2^2$ | $\times 2^1$ | $\times 2^0$ |

Step 3: calculate each column.

**Table 2.4**

| | | | |
|---|---|---|---|
| $0 \times 2^3 = 0$ | $1 \times 2^2 = 4$ | $0 \times 2^1 = 0$ | $1 \times 2^0 = 1$ |

Step 4: Add the columns together.

$0 + 4 + 0 + 1 = 5$

**b Convert the hexadecimal number 1D9 to decimal.**

Step 1: put the hexadecimal number into the table format as shown in Table 2.1.

**Table 2.5**

| | | |
|---|---|---|
| 0 | D | 9 |
| $\times$ base$^2$ | $\times$ base$^1$ | $\times$ base$^0$ |

Step 2: hexadecimal is base 16, so replace the word 'base' with 16.

**Table 2.6**

| | | |
|---|---|---|
| 0 | D | 9 |
| $\times 16^2$ | $\times 16^1$ | $\times 16^0$ |

Step 3: Calculate each column, replacing any letters with their numerical equivalent. (D = 13; see box on the previous page)

**Table 2.7**

| | | |
|---|---|---|
| $1 \times 16^2 = 256$ | $13 \times 16^1 = 208$ | $9 \times 16^0 = 9$ |

Step 4: add the columns together.

$256 + 208 + 9 = 473$

## B Guided questions

Copy out the workings and complete the answers on a separate piece of paper.

1 **Convert the binary number 11100 to denary. Show your working.**

Step 1: fill in the number base for binary in each column. The first one has been done for you.

**Table 2.8**

| | | | | |
|---|---|---|---|---|
| 1 | 1 | 1 | 0 | 0 |
| × $2^4$ | × $\_\_^3$ | × $\_\_^2$ | × $\_\_^1$ | × $\_\_^0$ |

Step 2: complete the calculation for each column. Again, the first one has been done for you.

16 + _______ + _______ + _______ + _______

The answer is ______________.

2 **Convert the hexadecimal number 3F to denary. Show your working.**

Step 1: fill in the second hexadecimal number on the top row and the bases on the bottom row.

**Table 2.9**

| | |
|---|---|
| 3 | ___ |
| × $\_\_^1$ | × $\_\_^0$ |

Step 2: complete the calculation for each column.

_______ + _______

The answer is ______________.

## C Practice questions

3 Convert the binary number 1011 to decimal.

4 Convert the hexadecimal number 29 to decimal.

5 Convert the binary number 10111 to decimal.

6 Convert the hexadecimal number AB to decimal.

7 Convert the binary number 10110110 to decimal.

8 Convert the hexadecimal number 32F1 to decimal.