Digital Data

The fundamental unit of memory is the bit. Each bit can store a 0 or a 1 (switch is on/off).

- **For convenience, on a PC groups of 8 bits are treated as units of bytes.**
- **Groups of 2 bytes (16 bits) are treated as words by MS-DOS and earlier versions of MS-Windows.**
- **32 and 64 bit word PCs are now readily available. Most our WinTel PCs have 32 bit words and can therefore address 2^{32} = 4,294,967,296 or 4 GB or memory.**

Because 10 is not an even power of 2, the decimal system is not very efficient for storing binary numbers. Many computer systems use octal (base 8) or hexadecimal (base 16) notation.

Decimal	Binary	Octal	Hexadecimal
0	0000	0	0
1	0001	1	1
2	0010	2	2
3	0011	3	3
4	0100	4	4
5	0101	5	5
6	0110	6	6
7	0111	7	7
8	1000	10	8
9	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F

Alphanumeric information is stored in memory as ASCII (American Standard Code for Information Interchange) codes. Each character has an 8 (or sometimes 7) bit code which is sent to the display controller or printer to draw the character.

- **With 7 bits there are $2^7 = 128$ possibilities**
- **With 8 bits there are $2^8 = 256$.**

Ex: E is represented by $69_D = 45_H$

The length of a word may vary from 4 to 128 bits, depending on the device. Bits are generally grouped in sets of 4, and hexadecimal notation is frequently used since it is an efficient way of expressing binary numbers grouped in 8 bit bytes.

In any binary number, the leftmost bit is the most significant bit and the rightmost is the least significant bit.

In a word containing M bits, the M-1 bit has a value 2^{M-1}.

The decimal value of a binary word is

$$D = \sum_{M=1}^{Length-1} 2^{M-1} B_M \quad where \quad B_M = \begin{matrix} 0 \\ 1 \end{matrix}$$

Bit (M)	5	4	3	2	1
M-1	4	3	2	1	0
2^{M-1}	16	8	4	2	1
	0	1	0	1	1

The word length affects the precision with which numbers can be calculated and stored.

Since binary numbers are used to address memory locations as well as in arithmetic operations, the word length of a computer affects the maximum amount of memory which can be addressed:

Word Length	Largest Decimal Integer
4	$2^4 - 1 = 15$
8	$2^8 - 1 = 255$
12	$2^{12} - 1 = 4,095$
16	$2^{16} - 1 = 65,535$
32	$2^{32} - 1 = 4,294,967,295$

Indirect addressing schemes can be used to augment the amount of addressable memory to some extent.

Current versions of the Windows XP can address up to 4 GB of memory directly and use extended addressing schemes to address more.

Quantization

The process of converting an analog value into a digital number.

For our purposes analog signal is assumed to be a:

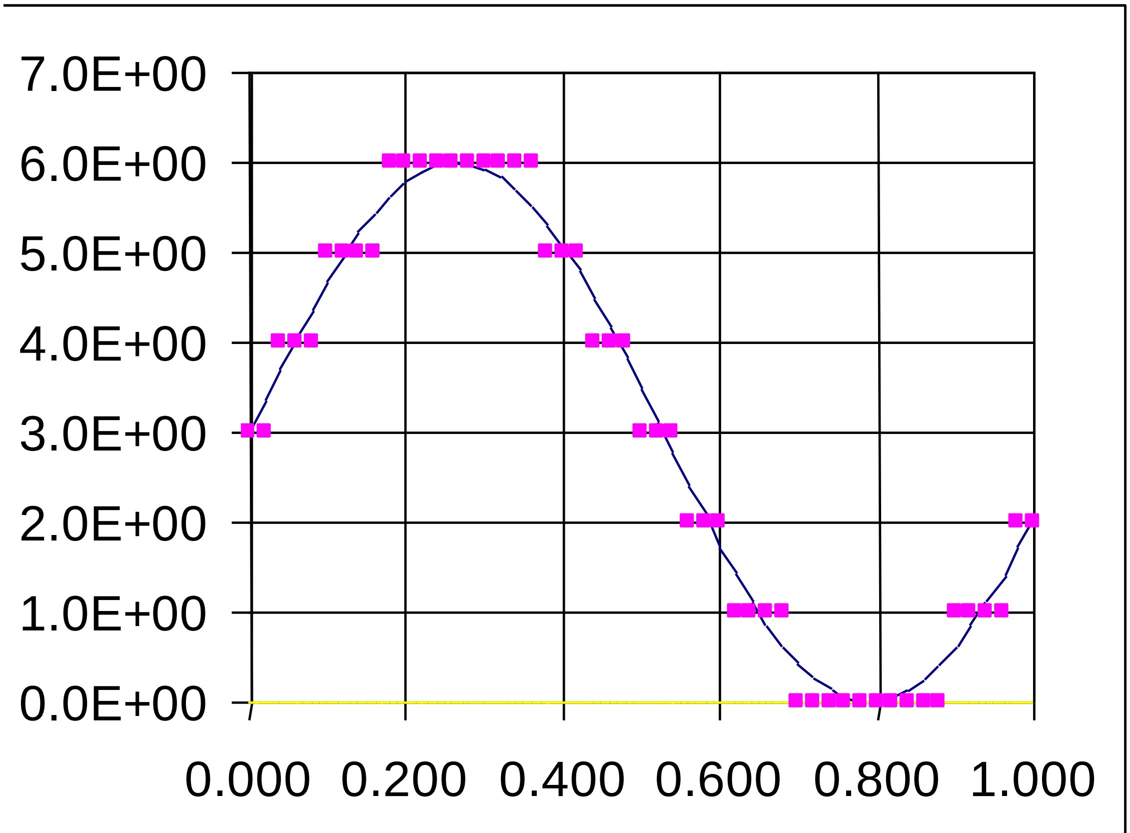
- **continuous function**
- **have infinite resolution**

Computers have finite resolution!

When is the resolution sufficient to represent a continuous function?

Example:

Plot the continuous function *3sin(x)+3* in Excel. Vary *x* from 0 to 2 pi in 50 equally spaced intervals. Plot the same data as if were stored as integers by a 3 bit computer.



Make an Excel spreadsheet which plots a sine wave of arbitrary frequency, starting phase angle, offset and amplitude. The frequency is to be in cycles per second, the phase angle in degrees and the offset and amplitude in volts. The plot is to be in volts vs. time.