

PH502: Scientific Programming Concepts

Irish Centre for High End Computing (ICHEC)

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- In this lecture we will discuss variables, in the programming sense.
- In programming there are certain things over which the programmer has no control.
- One of these is memory access.
- In FORTRAN and C the programmer is responsible for reserving the memory that the program needs.
- However the system controls where (in memory) information is stored.
- The programmer accesses reserved regions of memory through the use of variables.

- Each location in memory is addressed by a number but in the program we give memory locations a name, called a variable. Each variable has two numbers associated with it, its location or *l – value* and its value or *r – value*. Commands within a program set the *r – value*, the *l – value* is determined automatically.
- Each variable also has a type. There are four main variable types:
 1. integer,
 2. real,
 3. character,
 4. logical.
- Declaring variables means to give it a unique type. This in turn decides how much memory (how many bytes) are reserved to hold it.
- All variables in C must be declared before use.

- As we have stated already computers naturally use a binary numbering system. However for our convenience, in a program, numbers are expressed in base 10.

- ▶ Decimal representation: base 10, needs numerals 0 - 9.

$$233 = 2 \times 10^2 + 3 \times 10^1 + 3 \times 10^0$$

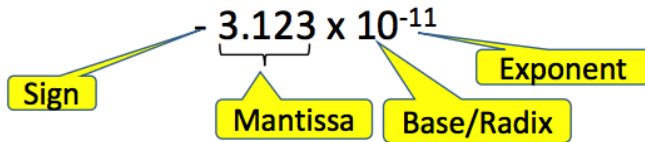
- ▶ Binary representation: base 2, need numerals 0 - 1.

$$(110)_2 = 1 \times 2^2 + 1 \times 2^1 + 0 \times 2^0 = (6)_{10}$$

- Ex: Convert from 6 to Base 2.

- Numbers that can be written without a fractional component.
- Typically integers are represented by four bytes, which means that $2^{8 \times 4} = 2^{32}$ numbers can be represented.
- However, 1-bit is needed to determine whether the number is positive or negative, thus the maximum absolute value is $2^{31} \sim 4 \times 10^9$.
- An integer variable can store a value in the range -2147483648 to 2147483647 .
- Creating an integer variable which has a value out of this range limit may have unpredictable results.

- Real numbers are stored differently to integers. The sign, mantissa and exponent must all be held in this space. The advantage in this, is that a larger range of numbers can be stored.



- There are two typical types of real number single precision, which is held in 4-bytes, and double precision, held in 8-bytes.
- Single precision has an approximate range of $10^{-44} \rightarrow 10^{+38}$. The range of double precision numbers is $\sim 10^{-323} \rightarrow 10^{+308}$. (Negative numbers can also be represented.)

- A character variable is 1 byte. That makes $2^8 = 256$ possible characters.
- In the computer, character variables are stored as numbers.
- There is a conversion table to convert the numerical value to the character called the ASCII (American Standard Code for Information Interchange) table. You can see the table on <http://www.asciitable.com>.
 - ASCII Encoding: 'A' = 65, 'B' = 66, '.' = 46, ' ' = 32
- A string is a sequence (array) of characters. It is terminated by a special end-of-string character in C.

G	i	v	e		i	n	p	u	t	:		\0
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To store "Give input: " (12 characters), the array size must be 13 or more.

- Logical variables have only two values TRUE and FALSE.
- A logical variable could be represented in 1 bit but the smallest addressable memory unit is 1 byte.
- As we shall see later logical variables/expressions are useful in directing the flow of the program's execution.