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Programming in C: Basics

Types of variables

- We must declare the type of every variable we use in C.
- Every variable has a type (e.g. int) and a name.
- This prevents some bugs caused by spelling errors (misspelling variable names).
- Declarations of types should always be together at the top of main or a function (see later).
- Other types are char, signed, unsigned, long, short and const.

Identifiers and Keywords

- Identifiers
  - Names given to various program elements (variables, constants, functions, etc.)
  - May consist of letters, digits and the underscore ('_') character, with no space between.
  - First character must be a letter or underscore.
  - An identifier can be arbitrary long.
  - Some C compilers recognize only the first few characters of the name (16 or 31).
  - Case sensitive
    - 'area', 'AREA' and 'Area' are all different.

Valid and Invalid Identifiers

Valid identifiers	Invalid identifiers
X	10abc
abc	my-name
simple_interest	"hello"
a123	simple interest
LIST	(area)
stud_name	%rate

Example: Adding two numbers

```c
#include <stdio.h>
main() {
    int a, b, c;
    scanf("%d %d",&a, &b);
    c = a + b;
    printf("%d",c);
}
```

Example: Largest of three numbers

```c
#include <stdio.h>
/* FIND THE LARGEST OF THREE NUMBERS */
main() {
    int a, b, c, max;
    scanf ("%d %d %d", &x, &y, &z);
    if (x>y)
        max = x;
    else
        max = y;
    if (max > z)
        printf("Largest is %d", max);
    else
        printf("Largest is %d", z);
}
```

Data Types in C

- **int :** integer quantity
  Typically occupies 4 bytes (32 bits) in memory.
- **char :** single character
  Typically occupies 1 bye (8 bits) in memory.
- **float :** floating-point number (a number with a decimal point)
  Typically occupies 4 bytes (32 bits) in memory.
- **double :** double-precision floating-point number

Some of the basic data types can be augmented by using certain data type qualifiers:

- short
- long
- signed
- unsigned

Typical examples:

- short int
- long int
- unsigned int

Constants

- Numeric Constants
  - Integer Constants
  - Floating-point Constants
- Character Constants
  - Single character
  - String

Integer Constants

- Consists of a sequence of digits, with possibly a plus or a minus sign before it.
- Embedded spaces, commas and non-digit characters are not permitted between digits.
- Maximum and minimum values (for 32-bit representations)
  Maximum :: 2147483647
  Minimum :: –2147483648

Floating-point Constants

- Can contain fractional parts.
- Very large or very small numbers can be represented.
  23000000 can be represented as 2.3e7
- Two different notations:
  1. Decimal notation
     25.0, 0.0034, .84, -2.234
  2. Exponential (scientific) notation
     3.45e23, 0.123e-12, 123E2
     e means "10 to the power of"

Single Character Constants

- Contains a single character enclosed within a pair of single quote marks.
  - Examples :: '2', '+', 'Z'
- Some special backslash characters
  '\n' new line
  '\t' horizontal tab
  ''' single quote
  '"' double quote
  '\' backslash
  '\0' null

String Constants

- Sequence of characters enclosed in double quotes.
  - The characters may be letters, numbers, special characters and blank spaces.
- Examples:
  "nice", "Good Morning", "3+6", "3", "C"
- Differences from character constants:
  - 'C' and "C" are not equivalent.
  - 'C' has an equivalent integer value while "C" does not.

Declaration of Variables

- There are two purposes:
  1. It tells the compiler what the variable name is.
  2. It specifies what type of data the variable will hold.
- General syntax:
  data-type variable-list;

- Examples:

```
int velocity, distance;
int a, b, c, d;
float temp;
char flag, option;
```

A First Look at Pointers

- A variable is assigned a specific memory location.
  - For example, a variable speed is assigned memory location 1350.
  - Also assume that the memory location contains the data value 100.
  - When we use the name speed in an expression, it refers to the value 100 stored in the memory location.

```
distance = speed * time;
```

- Thus every variable has an address (in memory), and its contents.
- In C terminology, in an expression
  speed refers to the contents of the memory location.
  &speed refers to the address of the memory location.
- Examples:

```
printf ("%f %f %f", speed, time, distance);
scanf ("%f %f", &speed, &time);
```

Assignment Statement

- Used to assign values to variables, using the assignment operator (=).
- General syntax:
  variable_name = expression;
- Examples:

```
velocity = 20;
b = 15; temp = 12.5;
A = A + 10;
v = u + f * t;
s = u * t + 0.5 * f * t * t;
```

- A value can be assigned to a variable at the time the variable is declared.

```
int speed = 30;
char flag = 'y';
```

- Several variables can be assigned the same value using multiple assignment operators.

```
a = b = c = 5;
flag1 = flag2 = 'y';
speed = flow = 0.0;
```

Operators in Expressions

- Arithmetic Operators
- Relational Operators
- Logical Operators

Arithmetic Operators

- Addition :: +
- Subtraction :: –
- Division :: /
- Multiplication :: *
- Modulus :: %

Examples:

```
distance = rate * time ;
netIncome = income - tax ;
speed = distance / time ;
area = PI * radius * radius;
y = a * x * x + b*x + c;
quotient = dividend / divisor;
remain = dividend % divisor;
```

Suppose x and y are two integer variables, whose values are 13 and 5 respectively.

```
x + y   18
x – y   8
x * y   65
x / y   2
x % y   3
```

Operator Precedence

In decreasing order of priority:

1. Parentheses :: ( )
2. Unary minus :: –5
3. Multiplication, Division, and Modulus
4. Addition and Subtraction

- For operators of the same priority, evaluation is from left to right as they appear.
- Parenthesis may be used to change the precedence of operator evaluation.

Examples: Arithmetic expressions

```
a + b * c – d / e        → a + (b * c) – (d / e)
a * – b + d % e – f      → a * (– b) + (d % e) – f
a – b + c + d            → (((a – b) + c) + d)
x * y * z                → ((x * y) * z)
a + b + c * d * e        → (a + b) + ((c * d) * e)
```

Integer Arithmetic

- When the operands in an arithmetic expression are integers, the expression is called integer expression, and the operation is called integer arithmetic.
- Integer arithmetic always yields integer values.

Real Arithmetic

- Arithmetic operations involving only real or floating-point operands.
- Since floating-point values are rounded to the number of significant digits permissible, the final value is an approximation of the final result.
  1.0 / 3.0 * 3.0 will have the value 0.99999 and not 1.0
- The modulus operator cannot be used with real operands.

Mixed-mode Arithmetic

- When one of the operands is integer and the other is real, the expression is called a mixed-mode arithmetic expression.
- If either operand is of the real type, then only real arithmetic is performed, and the result is a real number.
  25 / 10 → 2
  25 / 10.0 → 2.5

Type Casting

```
int a=10, b=4, c;
float x, y;
c = a / b;
x = a / b;
y = (float) a / b;
```

The value of c will be 2
The value of x will be 2.0
The value of y will be 2.5

Relational Operators

Used to compare two quantities.

- < is less than
- '>' is greater than
- <= is less than or equal to
- '>=' is greater than or equal to
- == is equal to
- != is not equal to

Examples:

```
10 > 20 is false
25 < 35.5 is true
12 > (7 + 5) is false
```

When arithmetic expressions are used on either side of a relational operator, the arithmetic expressions will be evaluated first and then the results compared.

a + b > c – d is the same as (a+b) > (c+d)

Example:

```
if (x > y)
    printf ("%d is larger\n", x);
else
    printf ("%d is larger\n", y);
```

Logical Operators

There are two logical operators in C (also called logical connectives).

- && → Logical AND
- || → Logical OR

What they do?

- They act upon operands that are themselves logical expressions.
- The individual logical expressions get combined into more complex conditions that are true or false.

Logical AND

- Result is true if both the operands are true.

Logical OR

- Result is true if at least one of the operands are true.

```
| X     | Y     | X && Y | X || Y |
|-------|-------|--------|-------|
| FALSE | FALSE | FALSE  | FALSE |
| FALSE | TRUE  | FALSE  | TRUE  |
| TRUE  | FALSE | FALSE  | TRUE  |
| TRUE  | TRUE  | TRUE   | TRUE  |
```

- **Unary Operators:** These operators work with only **one** operand (a value or variable).
  - Examples from the source:
    - **Unary Minus (`-`)**: As in `-5`, this operator negates the value of its operand.
- **Binary Operators:** The most common type, these operators work with **two** operands.
  - Examples from the source (these cover arithmetic, relational, and logical operators as discussed earlier):
    - **Addition (`+`)**: `x + y`
    - **Subtraction (`-`)**: `x - y`
    - **Multiplication (`*`)**: `x * y`
    - **Division (`/`)**: `x / y`
    - **Modulus (`%`)**: `x % y`
    - **Less than (`<`)**: `x < y`
    - **Greater than (`>`)**: `x > y`
    - **Less than or equal to (`<=`)**: `x <= y`
    - **Greater than or equal to (`>=`)**: `x >= y`
    - **Equal to (`==`)**: `x == y`
    - **Not equal to (`!=`)**: `x != y`
    - **Logical AND (`&&`)**: `x > 0 && y < 10`
    - **Logical OR (`||`)**: `x == 5 || y == 10`
- **Ternary Operators:** These operators work with **three** operands. C has one primary ternary operator:
  - **Conditional Operator (`?:`)**: This operator evaluates a condition and chooses between two expressions based on the result. Its general form is: `condition ? expression1 : expression2`.

Input / Output

printf

- Performs output to the standard output device (typically defined to be the screen).
- It requires a format string in which we can specify:
  - The text to be printed out.
  - Specifications on how to print the values.

```
printf ("The number is %d.\n", num) ;
```

- The format specification %d causes the value listed after the format string to be embedded in the output as a decimal number in place of %d.
- Output will appear as: The number is 125.

scanf

- Performs input from the standard input device, which is the keyboard by default.
- It requires a format string and a list of variables into which the value received from the input device will be stored.
- It is required to put an ampersand (&) before the names of the variables.

```
scanf ("%d", &size) ;
scanf ("%c", &nextchar) ;
scanf ("%f", &length) ;
scanf ("%d %d", &a, &b);
```