Tokens in C

Keywords

- These are reserved words of the C language. For example **`int, float, if, else, for, while`** etc.

Identifiers

- An Identifier is a sequence of letters and digits, but must start with a letter. Underscore (_) is treated as a letter. Identifiers are case sensitive. Identifiers are used to name variables, functions etc.
- Valid: **`Root, _getchar, __sin, x1, x2, x3, x_1, If`**
- Invalid: **`324, short, price$, My Name`**

Constants

- Constants like 13, ‘a’, 1.3e-5 etc.

Tokens in C

String Literals

- A sequence of characters enclosed in double quotes as "…". For example "13" is a string literal and not number 13. 'a' and "a" are different.

Operators

- Arithmetic operators like `+, -, *, / ,%` etc.
- Logical operators like `||, &&, !` etc. and so on.

White Spaces

- Spaces, new lines, tabs, comments (A sequence of characters enclosed in /* and */) etc. These are used to separate the adjacent identifiers, kewords and constants.

Basic Data Types

Integral Types

- Integers are stored in various sizes. They can be signed or unsigned.
- **Example**

  Suppose an integer is represented by a byte (8 bits). Leftmost bit is sign bit. If the sign bit is 0, the number is treated as positive.

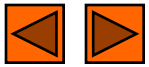
  Bit pattern 01001011 = 75 (decimal).

  The largest positive number is 01111111 = $2^7 - 1 = 127$.

  Negative numbers are stored as two's complement or as one's complement.

  -75 = 10110100 (one's complement).

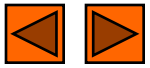
  -75 = 10110101 (two's complement).



Basic Data Types

Integral Types

- **`char`** — Stored as 8 bits. Unsigned 0 to 255. Signed -128 to 127.
- **`short int`** — Stored as 16 bits. Unsigned 0 to 65535. Signed -32768 to 32767.
- **`int`** — Same as either short or long int.
- **`long int`** — Stored as 32 bits. Unsigned 0 to 4294967295. Signed -2147483648 to 2147483647



Basic Data Types

Floating Point Numbers

- Floating point numbers are rational numbers. Always signed numbers.
- **`float`** Approximate precision of 6 decimal digits .
  - Typically stored in 4 bytes with 24 bits of signed mantissa and 8 bits of signed exponent.
- **`double`** Approximate precision of 14 decimal digits.
  - Typically stored in 8 bytes with 56 bits of signed mantissa and 8 bits of signed exponent.

- One should check the file limits.h to what is implemented on a particular machine.

Constants

Numerical Constants

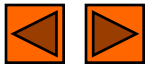
- Constants like 12, 253 are stored as **`int type. No decimal point.`**
- 12L or 12l are stored as **`long int`**.
- 12U or 12u are stored as **`unsigned int`**.
- 12UL or 12ul are stored as **`unsigned long int`**.
- Numbers with a decimal point (12.34) are stored as double.
- Numbers with exponent ($12e\text{-}3 = 12 \times 10^{-3}$) are stored as double.
- 12.34f or 1.234e1f are stored as **`float`**.
- These are not valid constants:

`25,000  7.1e 4  $200  2.3e-3.4 etc.`

Constants

Character and string constants

- `'c'` , a single character in single quotes are stored as char.
  Some special character are represented as two characters in single quotes.
  `'\n'` = newline, `'\t'` = tab, `'\\'` = backlash, `'\"'` = double quotes.
  Char constants also can be written in terms of their ASCII code.
  `'\060' = '0'` (Decimal code is 48).
- A sequence of characters enclosed in double quotes is called a string constant or string literal. For example
  `"Charu"`
  `"A"`
  `"3/9"`
  `"x = 5"`



Variables

Naming a Variable

- Must be a valid identifier.
- Must not be a keyword
- Names are case sensitive.
- Variables are identified by only first 32 characters.
- Library commonly uses names beginning with _.
- Naming Styles: Uppercase style and Underscore style
- **`lowerLimit`** **`lower_limit`**
- **`incomeTax`** **`income_tax`**

Declarations

Declaring a Variable

- Each variable used must be declared.
- A form of a declaration statement is

```
data-type var1, var2,…;
```

- Declaration announces the data type of a variable and allocates appropriate memory location. No initial value (like 0 for integers) should be assumed.
- It is possible to assign an initial value to a variable in the declaration itself.

```
data-type var = expression;
```

- **Examples**

```
int sum = 0;
char newLine = '\n';
float epsilon = 1.0e-6;
```

Global and Local Variables

Global Variables

- These variables are declared outside all functions.
- Life time of a global variable is the entire execution period of the program.
- Can be accessed by any function defined below the declaration, in a file.

```
/* Compute Area and Perimeter of  a
   circle */
#include <stdio.h>
float pi = 3.14159;  /* Global */

main() {
  float  rad;     /* Local */

  printf( "Enter the radius " );
  scanf("%f" , &rad);

  if ( rad > 0.0 ) {
    float area = pi * rad * rad;
    float peri = 2 * pi * rad;

    printf( "Area = %f\n" , area );
    printf( "Peri = %f\n" , peri );
  }
  else
    printf( "Negative radius\n");

  printf( "Area = %f\n" , area );
}
```

Global and Local Variables

Local Variables

- These variables are declared inside some functions.
- Life time of a local variable is the entire execution period of the function in which it is defined.
- Cannot be accessed by any other function.
- In general variables declared inside a block are accessible only in that block.

```
/* Compute Area and Perimeter of  a
   circle */
#include <stdio.h>
float pi = 3.14159;  /* Global */

main() {
  float  rad;     /* Local */

  printf( "Enter the radius " );
  scanf("%f" , &rad);

  if ( rad > 0.0 ) {
    float area = pi * rad * rad;
    float peri = 2 * pi * rad;

    printf( "Area = %f\n" , area );
    printf( "Peri = %f\n" , peri );
  }
  else
    printf( "Negative radius\n");

  printf( "Area = %f\n" , area );
}
```

Operators

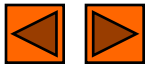
Arithmetic Operators

- `+, - , *, /` and the modulus operator %.
- + and – have the same precedence and associate left to right.

```
3 – 5 + 7 = ( 3 – 5 ) + 7 ≠ 3 – ( 5 + 7 )
3 + 7 – 5 + 2 = ( ( 3 + 7 ) – 5 ) + 2
```

- `*, /, %` have the same precedence and associate left to right.
- The `+, –` group has lower precendence than the `*, / %` group.

```
3 – 5 * 7 / 8 + 6 / 2
3 – 35 / 8 + 6 / 2
3 – 4.375 + 6 / 2
3 – 4.375 + 3
-1.375 + 3
1.625
```



Operators

Arithmetic Operators

- % is a modulus operator. x % y results in the remainder when x is divided by y and is zero when x is divisible by y.
- Cannot be applied to float or double variables.
- Example

```
if ( num % 2 == 0 )
   printf("%d is an even number\n", num)';
else
   printf("%d is an odd number\n", num);
```

Type Conversions

- The operands of a binary operator must have a the same type and the result is also of the same type.
- Integer division:

```
c = (9 / 5)*(f - 32)
```

The operands of the division are both int and hence the result also would be int. For correct results, one may write

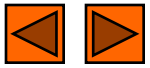
```
c = (9.0 / 5.0)*(f - 32)
```

- In case the two operands of a binary operator are different, but compatible, then they are converted to the same type by the compiler. The mechanism (set of rules) is called Automatic Type Casting.

```
c = (9.0 / 5)*(f - 32)
```

- It is possible to force a conversion of an operand. This is called Explicit Type casting.

```
c = ((float) 9 / 5)*(f - 32)
```



Automatic Type Casting

1. char and short operands are converted to int
2. Lower data types are converted to the higher data types and result is of higher type.
3. The conversions between unsigned and signed types may not yield intuitive results.
4. Example

```
float f; double d; long l;
int i; short s;
d + f    f will be converted to double
i / s    s will be converted to int
l / i    i is converted to long; long result
```

Hierarchy

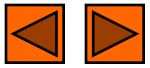
Double

float

long

Int

Short and char

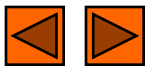


Explicit Type Casting

- The general form of a type casting operator is
- (type-name) expression
- It is generally a good practice to use explicit casts than to rely on automatic type conversions.
- Example

```
C = (float)9 / 5 * ( f - 32 )
```

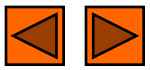
- `float` to `int` conversion causes truncation of fractional part
- `double` to `float` conversion causes rounding of digits
- `long int` to `int` causes dropping of the higher order bits.



Precedence and Order of evaluation

Table 3.8 Summary of C Operators

OPERATOR	DESCRIPTION	ASSOCIATIVITY	RANK
( ) [ ]	Function call Array element reference	Left to right	1
+ − ++ −− ! ~ * & sizeof (type)	Unary plus Unary minus Increment Decrement Logical negation Ones complement Pointer reference (indirection) Address Size of an object Type cast (conversion)	Right to left	2
* / %	Multiplication Division Modulus	Left to right	3
+ −	Addition Subtraction	Left to right	4



Precedence and Order of evaluation

OPERATOR	DESCRIPTION	ASSOCIATIVITY
<< >>	Left shift Right shift	Left to right
< <= > >=	Less than Less than or equal to Greater than Greater than or equal to	Left to right
== !=	Equality Inequality	Left to right
&	Bitwise AND	Left to right
^	Bitwise XOR	Left to right
|	Bitwise OR	Left to right
&&	Logical AND	Left to right
||	Logical OR	Left to right
?:	Conditional expression	Right to left
= *= /= %= += -= &= ^= |= <<= >>=	Assignment operators	Right to left
,	Comma operator	Left to right

Operators

Relational Operators

- <, <=, > >=, ==, != are the relational operators. The expression

```
operand1 relational-operator operand2
```

takes a value of 1(int) if the relationship is true and 0(int) if relationship is false.

- Example

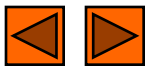
```
int a = 25, b = 30, c, d;
c = a < b;
d = a > b;
```

value of c will be 1 and that of d will be 0.

Operators

Logical Operators

- `&&, ||` and `!` are the three logical operators.
- `expr1 && expr2` has a value 1 if `expr1` and `expr2` both are nonzero.
- `expr1 || expr2` has a value 1 if `expr1` and `expr2` both are nonzero.
- `!expr1` has a value 1 if expr1 is zero else 0.
- Example
- `if ( marks >= 40 && attendance >= 75 ) grade = 'P'`
- `If ( marks < 40 || attendance < 75 ) grade = 'N'`

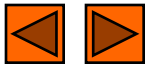


Operators

Assignment operators

- The general form of an assignment operator is
- `v op= exp`
- Where v is a variable and op is a binary arithmetic operator. This statement is equivalent to
- `v = v op (exp)`

`a = a + b`	can be written as	`a += b`
`a = a * b`	can be written as	`a *= b`
`a = a / b`	can be written as	`a /= b`
`a = a - b`	can be written as	`a -= b`



Operators

Increment and Decrement Operators

- The operators `++` and `--` are called increment and decrement operators.
- `a++` and `++a` are equivalent to `a += 1`.
- `a--` and `--a` are equivalent to `a -= 1`.
- `++a op b` is equivalent to `a ++; a op b;`
- `a++ op b` is equivalent to `a op b; a++;`
- `Example`

```
Let b = 10 then
(++b)+b+b = 33
b+(++b)+b = 33
b+b+(++b) = 31
b+b*(++b) = 132
```

Floating Point Arithmetic

Representation

- All floating point numbers are stored as

$$\pm 0.d_1 d_2 \cdots d_p \times B^e$$

- such that d_1 is nonzero. B is the base. p is the precision or number of significant digits. e is the exponent. All these put together have finite number of bits (usually 32 or 64 bits) of storage.
- Example
- Assume B = 10 and p = 3.
- `23.7      = +0.237E2`
- `23.74     = +0.237E2`
- `37000     = +0.370E5`
- `37028     = +0.370E5`
- `-0.000124       = -0.124E-4`

Floating Point Arithmetic

Representation

- $S_k = \{ x \mid B^{k-1} <= x < B^k \}$. Number of elements in each Sk is same. In the previous example it is 900.
- Gap between seuccessive numbers of Sk is B^{k-p}.
- B1-p is called machine epsilon. It is the gap between 1 and next representable number.
- Underflow and Overflow occur when number cannot be represented because it is too small or too big.
- Two floating points are added by aligning decimal points.
- Floating point arithmetic is not associative and distributive.