IN3200/IN4200: C Programming Tutorial

A drastically simplified version of https://www.tutorialspoint.com/cprogramming/

Target audience: new beginners of C programming

First things first

- A program in C is made up of
  - Preprocessor commands
  - Variables
  - Statements and expressions
  - Functions
  - Comments
- A program in C can be as simple as having only 3 lines, or as comprehensive as being composed of millions of lines
- A program in C can be stored in one file with name extension `.c` (or spread over many `.h` and `.c` files)
- Use of libraries—groups of already-coded functions and declarations—actually happens all the time

Hello-World example

```
#include <stdio.h>

int main() {
   /* my first program in C */
   printf("Hello, World! \n");

   return 0;
}
```

Hello-World example explained

- `#include <stdio.h>` is a preprocessor command, which tells a C compiler to include the header file `stdio.h`
- `int main()` defines the main function where the program execution begins
- `/*...*/` is a comment
- `printf(...)` is a standard library function available in C (found in `<stdio.h>`, for sending formatted output to the standard output stream)
- `return 0;` terminates the `main()` function and returns the value 0

Demo of compilation and execution

Identifiers

- An identifier is a name used to identify a variable, function, or any other user-defined item
- Examples of acceptable identifiers

```
mohd        zara     abc    move_name   a_123
myname50    _temp    j      a23b9       retVal
```

- C is a case-sensitive programming language

Keywords – reserved words

auto	else	long	switch
break	enum	register	typedef
case	extern	return	union
char	float	short	unsigned
const	for	signed	void
continue	goto	sizeof	volatile
default	if	static	while
do	int	struct	_Packed
double			

Keywords can not be used as identifiers.

C data types

- **Basic Types**
  They are arithmetic types and are further classified into: (a) integer types and (b) floating-point types
- **Derived types**
  They include (a) Pointer types, (b) Array types, (c) Structure types, (d) Union types and (e) Function types

Integer types

Type	Storage size	Value range
`char`	1 byte	-128 to 127 or 0 to 255
`unsigned char`	1 byte	0 to 255
`signed char`	1 byte	-128 to 127
`int`	2 or 4 bytes	-32,768 to 32,767 or -2,147,483,648 to 2,147,483,647
`unsigned int`	2 or 4 bytes	0 to 65,535 or 0 to 4,294,967,295
`short`	2 bytes	-32,768 to 32,767
`unsigned short`	2 bytes	0 to 65,535
`long`	4 bytes	-2,147,483,648 to 2,147,483,647
`unsigned long`	4 bytes	0 to 4,294,967,295

The `sizeof` operator

To get the exact size of a type or a variable on a particular platform, you can use the `sizeof` operator. The expression `sizeof(type)` yields the storage size of the object or type in number of bytes.

```
#include <stdio.h>

int main() {
   printf("Storage size for int : %d \n", sizeof(int));

   return 0;
}
```

Floating-point types

Type	Storage size	Value range	Precision
`float`	4 bytes	1.2E-38 to 3.4E+38	6 decimal places
`double`	8 bytes	2.2E-308 to 1.8E+308	15 decimal places
`long double`	16 bytes	3.4E-4932 to 1.2E+4932	18 decimal places

Note: The actual values can be machine-dependent!

Header file `float.h`

The header file `float.h` defines macros that allow you to use these values and other details about the binary representation of real numbers in your programs

```
#include <stdio.h>
#include <float.h>

int main() {
   printf("Storage size for float : %lu \n", sizeof(float));
   printf("Minimum float positive value: %E\n", FLT_MIN );
   printf("Maximum float positive value: %E\n", FLT_MAX );
   printf("Precision value: %d\n", FLT_DIG );

   return 0;
}
```

C variables

A variable is a name given to a storage area that a C program can manipulate. Each variable in C has a specific type, which determines the size and layout of the variable's memory; the range of values that can be stored within that memory; and the set of operations that can be applied to the variable.

The name of a variable can be composed of letters, digits, and the underscore character. It must begin with either a letter or an underscore. Upper and lowercase letters are distinct because C is case-sensitive.

```
int    i, j, k;
char   c, ch;
float  f, salary;
double d;
```

C operators

An operator is a symbol that tells the compiler to perform specific mathematical or logical functions. C language is rich in built-in operators:

- Arithmetic operators `+` `-` `*` `/` `%` `++` `--`
- Relational operators `==` `!=` `>` `<` `>=` `<=`
- Logical operators `&&` `||` `!`
- Bitwise operators
- Assignment operators

Bitwise operators

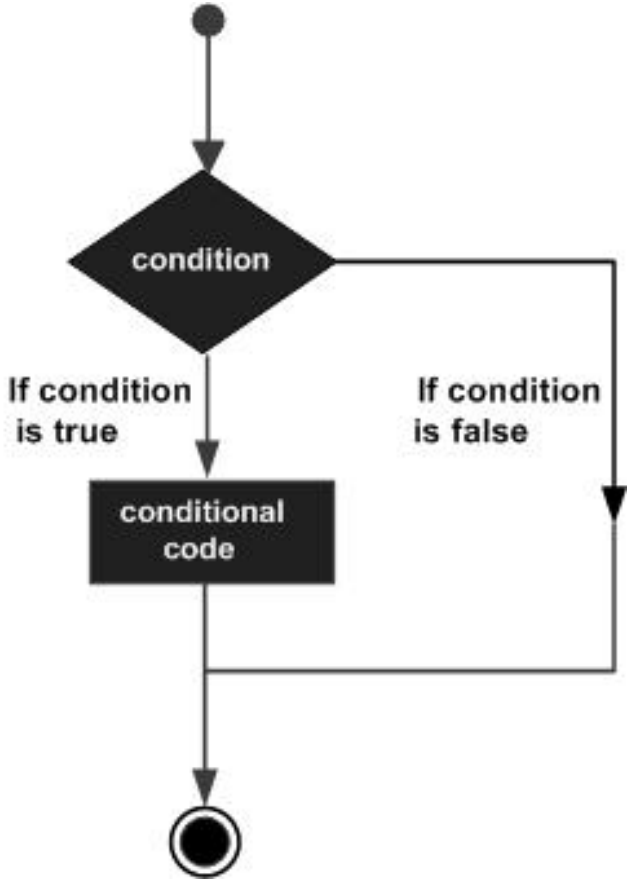
A bitwise operator works on bits and performs bit-by-bit operation

Some examples:

p	**q**	**p&q**	**p|q**	**p^q**
0	0	0	0	0
0	1	0	1	1
1	1	1	1	0
1	0	0	1	1

Decision making

Decision making structures require that the programmer specifies one or more conditions to be evaluated or tested by the program, along with a statement or statements to be executed if the condition is determined to be true, and optionally, other statements to be executed if the condition is determined to be false.



Loops

To execute a statement or a group of statements multiple times:

- `for`
- `while`
- `do ... while`

Functions

A function is a group of statements that together perform a task. Every C program has at least one function, which is `main()`, and you can define additional functions.

A function **declaration** tells the compiler about a function's name, return type, and parameters. A function **definition** provides the actual body of the function.

The general form of a function definition in C programming language:

```
return_type function_name( parameter list ) {
   body of the function
}
```

Function arguments

If a function is to use arguments, it must declare variables that accept the values of the arguments. These variables are called the **formal parameters** of the function.

Formal parameters behave like other local variables inside the function and are created upon entry into the function and destroyed upon exit.

While calling a function, the formal parameters get the values (that is, copies) of the **actual parameters**.

One example

```
#include<stdio.h>
void func_1(int);

int main()
{
    int x = 10;

    printf("Before function call\n");
    printf("x = %d\n", x);

    func_1(x);

    printf("After function call\n");
    printf("x = %d\n", x);

    return 0;
}

void func_1(int a)
{
    a += 1;
    a++;
    printf("\na = %d\n\n", a);
}
```

Scope rules

A scope in any programming is a region of the program where a defined variable can have its existence and beyond that variable it cannot be accessed. There are three places where variables can be declared in C programming language:

- Inside a function or a block: **local** variables.
- Outside of all functions: **global** variables.
- In the definition of function parameters: **formal** parameters.

Global variables

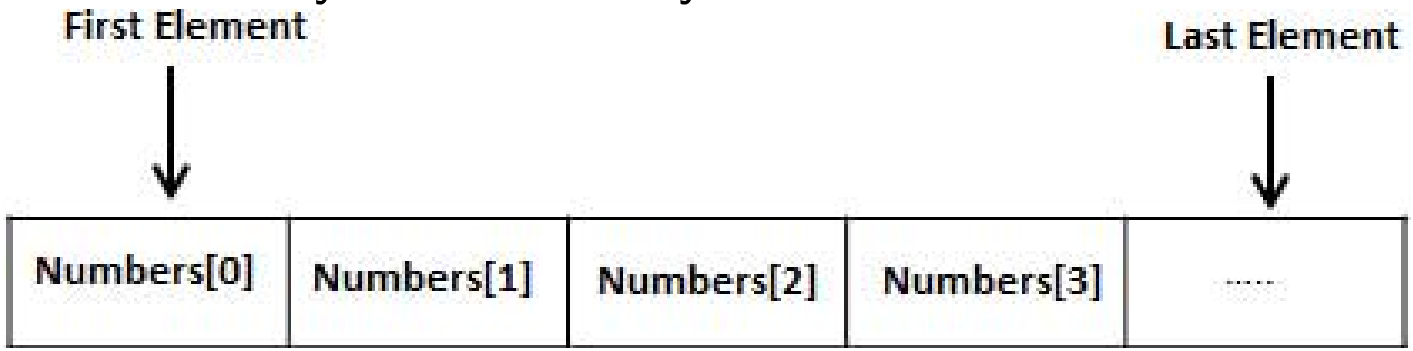
Global variables hold their values throughout the lifetime of your program and they can be accessed inside any of the functions defined for the program. **Should be used with care!**

```
#include <stdio.h>

/* global variable declaration */
int g;

int main () {

  /* local variable declaration */
  int a, b;

  /* actual initialization */
  a = 10;
  b = 20;
  g = a + b;

  printf ("value of a = %d, b = %d and g = %d\n", a, b, g);

  return 0;
}
```

Arrays

An array is one kind of data structure that can store a sequential collection of elements of the same type.

Instead of declaring individual variables, such as `Number0`, `Number1`, ..., and `Number99`, you can declare one array variable, named such as `Numbers`, and use `Numbers[0]`, `Numbers[1]`, ..., and `Numbers[99]` to represent individual variables. A specific element in an array is accessed by an index.



Fix-sized arrays

A programmer can specify the type of the elements and the number of elements required by an array

```
type arrayName [ arraySize ];
```

`arraySize` must be an integer constant greater than zero.

Address in memory

Every variable is a memory location and every memory location has its address defined which can be accessed using ampersand (&) operator, which denotes an address in memory.

```
#include <stdio.h>

int main () {

   int  var1;
   char var2[10];

   printf("Address of var1 variable: %x\n", &var1);
   printf("Address of var2 variable: %x\n", &var2);

   return 0;
}
```

Pointers

A pointer is a variable whose value is the address of another variable, i.e., direct address of the memory location. Like any variable or constant, you must declare a pointer variable before using it to store any variable address.

```
int    *ip;    /* pointer to an integer */
double *dp;    /* pointer to a double */
float  *fp;    /* pointer to a float */
char   *ch     /* pointer to a character */
```

How to use pointers?

- Define a pointer variable
- Assign the address of a variable to a pointer variable
- Access the value at the address stored in the pointer variable (via operator *)

```
#include <stdio.h>

int main () {
   int  var = 20;   /* actual variable declaration */
   int  *ip;        /* pointer variable declaration */

   ip = &var;  /* store address of var in pointer variable*/

   printf("Address of var variable: %x\n", &var  );

   /* address stored in pointer variable */
   printf("Address stored in ip variable: %x\n", ip );

   /* access the value using the pointer */
   printf("Value of *ip variable: %d\n", *ip );

   return 0;
}
```

More pointer concepts

- **Pointer arithmetic**: Four arithmetic operators can be used on pointers: ++, --, +, -
- **Array of pointers**: You can define an array to hold a sequence of pointers.
- **Pointer to pointer**: C allows you to have pointer on a pointer and so on.
- **Passing pointers to functions in C**: Passing an argument by address allows the passed argument to be changed.
- **Return pointer from functions in C**: C allows a function to return a pointer to the local variable, static variable, and dynamically allocated memory as well. (**Be very careful with such usage!!!!!!**)

An example of function returning a pointer

```
#include <stdio.h>

int *getMax(int *m, int *n) {
  /* if the value pointed by pointer m is greater than n
   * then, return the address stored in the pointer variable m */
  if (*m > *n) {
    return m;
  }
  else {
    return n;
  }
}

int main(void) {
  // integer variables
  int x = 100;
  int y = 200;

  // pointer variable
  int *max = NULL;

  /* get the variable address that holds the greater value
   * for this we are passing the address of x and y
   * to the function getMax() */
  max = getMax(&x, &y);

  // print the greater value
  printf("Max value: %d\n", *max);

  return 0;
}
```

C structures

structure is a user defined data type available in C that allows to combine data items of different kinds.

To define a structure, you must use the `struct` statement:

```
struct Books {
   char  title[50];
   char  author[50];
   char  subject[100];
   int   book_id;
} book;
```

Dynamic memory management

The C programming language provides several functions for memory allocation and management. These functions can be found in the `<stdlib.h>` header file.

- `void *calloc(int num, int size);` – allocates an array of num elements each of which size in bytes will be size.
- `void free(void *address);` – releases a block of memory block specified by address.
- `void *malloc(int num);` – allocates an array of num bytes and leave them uninitialized.
- `void *realloc(void *address, int newsize);` – re-allocates memory extending it upto newsize.

Example of dynamic memory allocation

```
#include <stdio.h>
#include <stdlib.h>

int main()
{
    int n, i, *ptr, sum = 0;

    printf("Enter number of elements: ");
    scanf("%d", &n);

    ptr = (int*) malloc(n * sizeof(int));
    if(ptr == NULL) {
        printf("Error! memory not allocated."); exit(-1);
    }

    printf("Enter elements: ");
    for (i = 0; i < n; ++i) {
        scanf("%d", &(ptr[i]));
        sum += ptr[i];
    }

    printf("Sum = %d\n", sum);
    free(ptr);
    return 0;
}
```

Command-line arguments

Input arguments to the `main` function:

```
#include <stdio.h>

int main( int argc, char *argv[] )  {

   if( argc == 2 ) {
      printf("The argument supplied is %s\n", argv[1]);
   }
   else if( argc > 2 ) {
      printf("Too many arguments supplied.\n");
   }
   else {
      printf("One argument expected.\n");
   }
}
```

Simple I/O

A file represents a sequence of bytes, regardless of it being a text file or a binary file. C programming language provides both high-level functions and low-level function calls to handle files.

- Opening a file

```
FILE *fopen(const char *filename, const char *mode);
```

- Closing a file

```
int fclose(FILE *fp);
```

- Writing to a file (many different functions available)
- Reading to a file (many different functions available)
- Binary I/O functions

```
size_t fread(void *ptr, size_t size_of_elements,
             size_t number_of_elements, FILE *a_file);
size_t fwrite(const void *ptr, size_t size_of_elements,
             size_t number_of_elements, FILE *a_file);
```